Prepared for

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Santa Susana Site
5800 Woolsey Canyon Road
Canoga Park, California, 91304-1148

Santa Susana Field Laboratory

Site-Wide Stormwater Annual Report

2015/2016 Reporting Year

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SB0363W
October 2016

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Appendix A: 2015/2016 Reporting Year Sampling and Analysis Plan

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Acronyms

BAF	Bioaccumulation Factor
BMP	Best Management Practice
CASQA	California Stormwater Quality Association
CDFW	California Department of Fish and Wildlife
CM	Culvert Modification
COC	Constituent of Concern
DMR	Discharge Monitoring Report
DTSC	Department of Toxic Substances Control
DNQ	Detected not Quantified
DOE	Department of Energy
ELV	Expendable Launch Vehicle
GET	Groundwater Extraction and Treatment
HDPE	High Density Polyethylene
HHRA	Human Health Risk Assessment
ISRA	Interim Source Removal Action
LARWQCB	Los Angeles Regional Water Quality Control Board
LOX	Liquid Oxygen Plant
µg/L	micrograms per liter
NASA	National Aeronautics and Space Administration
NPDES	National Pollutant Discharge Elimination System
OF009	Outfall 009
RFI	RCRA Feasibility Investigation
RCRA	Resource Conservation and Recovery Act
RMMP	Restoration, Mitigation, and Monitoring Plan
SAP	Sampling and Analysis Plan
SSFL	Santa Susana Field Laboratory
SWPPP	Stormwater Pollution Prevention Plan
SWTS	Stormwater Treatment System
TCDD	Tetrachlorodibenzo-*p*-dioxin
TEQ	Toxic Equivalence
TSS	Total Suspended Solid
USACE	United States Army Corps of Engineers
WQBEL	Water Quality-Based Effluent Limit

1 Introduction

The Santa Susana Field Laboratory (SSFL) occupies approximately 2,850 acres and is located at the top of Woolsey Canyon Road in the Simi Hills, Ventura County, California. The SSFL has the potential to discharge stormwater runoff impacted by constituents from the facility. As such, discharges from SSFL are currently regulated by the Los Angeles Regional Water Quality Control Board (LARWQCB) under *National Pollutant Discharge Elimination System (NPDES) Permit No. CA0001309 for the Boeing Company, SSFL, Canoga Park, CA, Order No. R4-2015-0033* ("2015 Permit") (LARWQCB, 2015). The 2015 Permit[1] became effective on April 1, 2015 and states the following:

> *"The Discharger has agreed to maintain the Surface Water Expert Panel. With input from the Surface Water Expert Panel, the Discharger shall submit annual reports that describe the previous year's monitoring results, evaluation of existing BMP performance, and submit a workplan that includes recommendations for modified and/or new storm water controls and monitoring that will address exceedances from any outfall addressed by this permit. The Discharger shall also support the Surface Water Expert Panel in organizing periodic public interaction events and encouraging public communication involvement. The first annual report shall be due within 6 months of the effective date of this permit [October 1, 2015]."*

The *Site-Wide Stormwater Work Plan and 2014/15 Annual Report* ("2015 Work Plan") (Santa Susana Surface Water Expert Panel and Geosyntec Consultants, 2015a) was intended to meet the aforementioned requirements. This Annual Report is intended to meet the commitments outlined in the 2015 Work Plan.

1.1 Background

The SSFL is jointly owned by the Boeing Company (Boeing) and the federal government. The National Aeronautics and Space Administration (NASA) administers the portion of the property owned by the federal government. The site is divided into four administrative areas (Areas I, II, III, and IV, Figure 1) and undeveloped land areas to both the north and south. Administrative Areas I and III are operated by Boeing, which owns the majority of Area I and all of Area III. A portion of Area I (40 acres) and all of Area II are owned by the federal government and are administered by NASA. The land within Area IV is owned by Boeing, was formerly operated by Boeing for the Department of Energy (DOE). DOE owns specific facilities located on approximately 90 acres of Area IV. Industrial operations at the SSFL have ceased; current activities at the site include environmental monitoring and sampling, demolition, and remediation planning. The site also provides exceptional wildlife habitat and undeveloped land (open space).

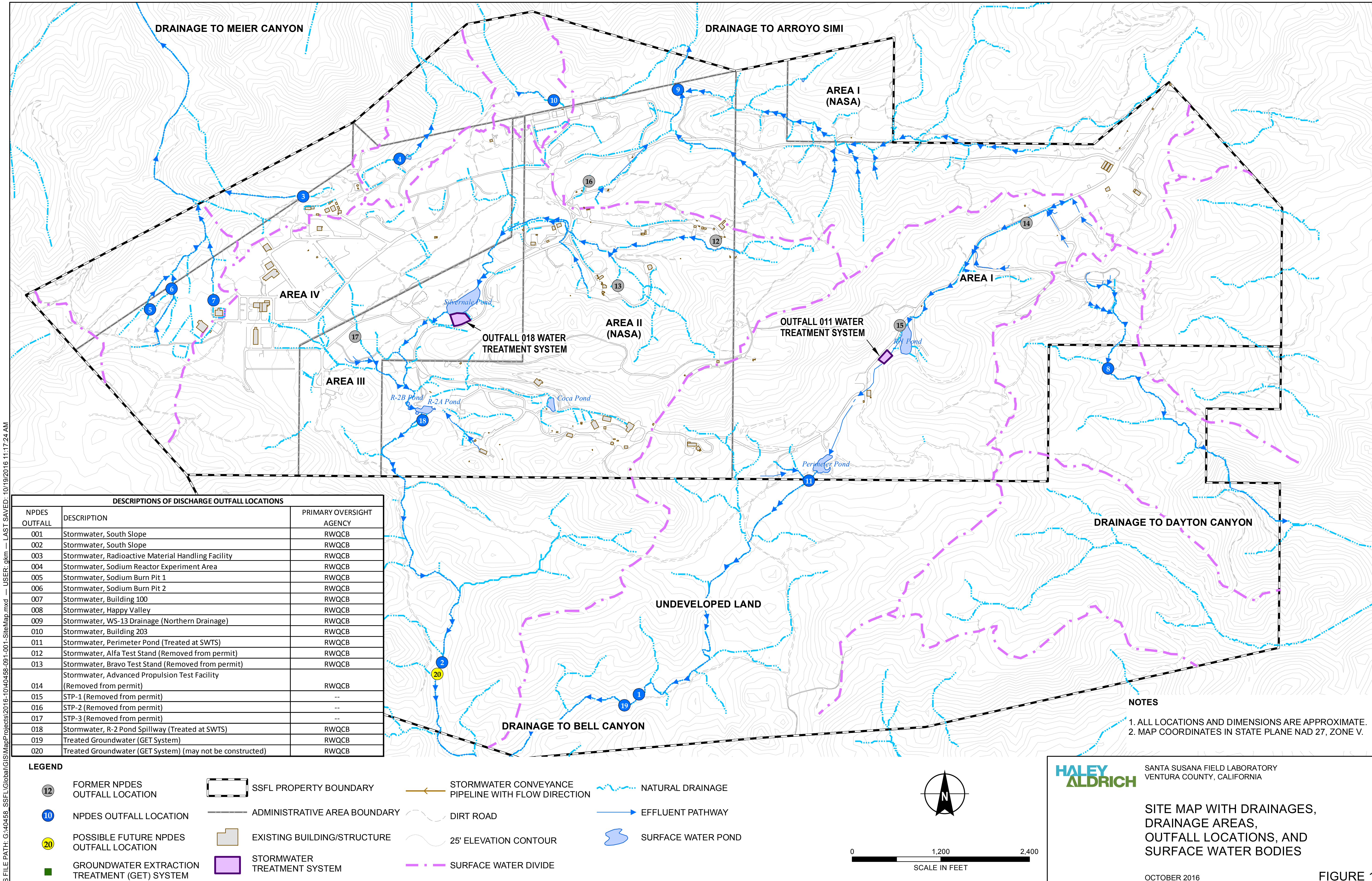
Stormwater discharges[2] from the SSFL are typically captured and treated upstream of or at the outfalls, up to a design storm size. An exception to this outfall-based treatment approach is at Outfalls 001 and 002 in the southern undeveloped land, where stormwater runoff consists of runoff from undeveloped

[1] Prior to April 1, 2015 this site was regulated since 2010 the under *National Pollutant Discharge Elimination System (NPDES) Permit No. CA0001309 for the Boeing Company, SSFL, Canoga Park, CA, Order No. R4-2010-0090* ("2010 Permit")

[2] Treated groundwater discharges are also covered in the 2015 Permit however these discharges are not addressed in this Work Plan.

areas with no or minimal history of industrial activity or known surface soil contamination, as well as treated stormwater from Outfalls 011 and 018, respectively. Runoff to Outfalls 001 and 002, downstream of Outfalls 011 and 018, is discharged without treatment. Another exception to this is at Outfalls 008 and 009, where the stormwater quality management strategy instead combines distributed source controls with natural treatment systems due to the challenge of treating stormwater at these canyon outfalls (i.e., outfall-based treatment would require construction of large dams with substantial associated environmental impact and potential risk to the public downstream). At Outfalls 008 and 009, Interim Source Removal Action (ISRA) and Best Management Practices (BMP) programs were implemented beginning in 2010 with oversight and participation of the LARWQCB to improve compliance with the 2010 Permit limits through the dual approach of remediation of surface soils that are above defined thresholds for NPDES constituents of concern, and through distributed control and/or treatment of stormwater runoff from prioritized subareas, respectively. The BMP Plan for the Outfall 008 and 009 Watersheds (MWH et al., 2010) (“2010 BMP Plan”) was developed under the oversight of the Surface Water Expert Panel. The 2015 Work Plan replaced the 2010 BMP Plan and provides an overall strategy for improving NPDES compliance for stormwater discharges site-wide, and continues the important process of public outreach and engagement on stormwater issues.

The Surface Water Expert Panel, consisting of Dr. Robert Pitt (University of Alabama), Dr. Robert Gearheart (Humboldt State University), Dr. Michael Stenstrom (University of California Los Angeles), Dr. Michael Josselyn (WRA Environmental Consultants), and Jonathan Jones (Wright Water Engineers), continues to oversee stormwater planning and design work at the SSFL, as well as provide input on monitoring, source removal activities and other NDPES Permit issues. The Surface Water Expert Panel also oversees scientific studies related to SSFL stormwater quality issues and BMP design, supports the ongoing stormwater Human Health Risk Assessment (HHRA), and interfaces with the public on SSFL stormwater activities and health risk communication. Their original mission, to improve stormwater at NPDES Outfalls 008 and 009, was expanded through the 2015 Work Plan to include all NPDES outfalls as required through the 2015 Permit.



DESCRIPTIONS OF DISCHARGE OUTFALL LOCATIONS

NPDES OUTFALL	DESCRIPTION	PRIMARY OVERSIGHT AGENCY
001	Stormwater, South Slope	RWQCB
002	Stormwater, South Slope	RWQCB
003	Stormwater, Radioactive Material Handling Facility	RWQCB
004	Stormwater, Sodium Reactor Experiment Area	RWQCB
005	Stormwater, Sodium Burn Pit 1	RWQCB
006	Stormwater, Sodium Burn Pit 2	RWQCB
007	Stormwater, Building 100	RWQCB
008	Stormwater, Happy Valley	RWQCB
009	Stormwater, WS-13 Drainage (Northern Drainage)	RWQCB
010	Stormwater, Building 203	RWQCB
011	Stormwater, Perimeter Pond (Treated at SWTS)	RWQCB
012	Stormwater, Alfa Test Stand (Removed from permit)	RWQCB
013	Stormwater, Bravo Test Stand (Removed from permit)	RWQCB
014	Stormwater, Advanced Propulsion Test Facility (Removed from permit)	RWQCB
015	STP-1 (Removed from permit)	--
016	STP-2 (Removed from permit)	--
017	STP-3 (Removed from permit)	--
018	Stormwater, R-2 Pond Spillway (Treated at SWTS)	RWQCB
019	Treated Groundwater (GET System)	RWQCB
020	Treated Groundwater (GET System) (may not be constructed)	RWQCB

NOTES

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
2. MAP COORDINATES IN STATE PLANE NAD 27, ZONE V.

HALEY ALDRICH

SANTA SUSANA FIELD LABORATORY
VENTURA COUNTY, CALIFORNIA

SITE MAP WITH DRAINAGES, DRAINAGE AREAS, OUTFALL LOCATIONS, AND SURFACE WATER BODIES

OCTOBER 2016

FIGURE 1

GIS FILE PATH: G:\40458_SSFL\Global\GIS\MapProjects\2016-10\40458-091-001-SiteMap.mxd — USER: gkm — LAST SAVED: 10/19/2016 11:17:24 AM

1.2 Site Overview

The outfalls regulated under the 2015 NPDES Permit are listed in Table 1 and depicted in Figure 1, 60% of the annual stormwater discharge from SSFL exits the property via two southerly discharge points (Outfalls 001 and 002) to Bell Creek, a tributary to the Los Angeles River. Upstream outfalls that contribute to the discharge at Outfalls 001 and 002 include Outfalls 011 and 018. Outfalls 019 and 020 (Outfall 020 is not yet operational) discharge treated groundwater downstream of Outfalls 001 and 002, respectively. The Surface Water Expert Panel's scope does not include groundwater; a separate Groundwater Expert Panel is available to oversee Boeing related tasks.

The stormwater from the northern boundary of the site is discharged via Outfalls 003 through 007 and 010, or it is transferred to Silvernale Pond for treatment prior to discharge at Outfall 018. At Outfalls 011 and 018, active treatment systems have been in place since 2012 for advanced treatment of stormwater which is modulated using storage ponds. Because of the location, size and terrain of the Outfall 008 and 009 watersheds, flows from these areas are not captured and treated by the active treatment systems[3], and instead a distributed stormwater treatment and iterative (or adaptive management-based) approach is employed in both the Outfall 008 and 009 watersheds, as described in the 2010 BMP Plan. Thus, Outfall 009 naturally flows to Arroyo Simi and stormwater runoff from Happy Valley (Outfall 008) naturally flows via Dayton Canyon Creek to Chatsworth Creek. Chatsworth Creek flows south to Bell Creek southwest of the intersection of Shoup Avenue and Sherman Way. Bell Creek subsequently flows southeast to the Los Angeles River.

Table 1. NPDES Outfall Descriptions

Outfall*	Status/Discharge Description
001	Downstream of Outfall 011; discharge to Bell Creek
002	Downstream of Outfall 018; discharge to Bell Creek
003	Runoff transferred to Silvernale for treatment prior to discharge at Outfall 018
004	Runoff transferred to Silvernale for treatment prior to discharge at Outfall 018
005	Runoff transferred to Silvernale for treatment prior to discharge at Outfall 018
006	Runoff transferred to Silvernale for treatment prior to discharge at Outfall 018
007	Runoff transferred to Silvernale for treatment prior to discharge at Outfall 018
008	Stormwater from Happy Valley; discharge to Dayton Creek
009	Stormwater from Northern Drainage; discharge to Arroyo Simi
010	Runoff transferred to Silvernale for treatment prior to discharge at Outfall 018
011	Stormwater and perimeter pond (treated at SWTS); discharge to Outfall 001
018	Stormwater and R-2 pond (treated at SWTS); discharge to Outfall 002
019	Treated groundwater (GET System)
020	Treated groundwater (GET System); new outfall location

*Outfalls 012 through 017 were excluded from the 2015 Permit

1.3 Existing Stormwater Treatment

BMPs have been implemented throughout the site to treat stormwater prior to discharge. The major structural treatment BMPs (i.e., excluding site-wide erosion controls, unpaved road control measures,

[3] An exception to this is at the helipad, located in Area II in the 009 watershed, where some runoff is captured and piped to Silvernale Pond for treatment in the 018 active treatment system.

and demolition of buildings and paved areas) are summarized in the *ISRA Performance Monitoring and BMP Monitoring for the Outfalls 008 and 009 Watersheds, 2014/2015 Rainy Season* ("2015 Annual Report for Outfalls 008 and 009") (MWH *et al.*, 2015b) and the 2015 BMP Plan (Haley & Aldrich, 2015) and include:

- Outfall 009 Culvert Modifications (CMs), completed in 2009
- Outfall 008 ISRA Excavations, completed in 2010
- Outfall 011 Stormwater Conveyance and Treatment System, completed in 2011
- Outfall 018 Stormwater Conveyance and Treatment System, completed in 2011
- Outfall 009 B-1 Sedimentation Basin and Media Filter, completed in 2011
- Outfall 009 Northern Drainage Restoration Measures, completed in 2012
- Outfall 009 Lower Parking Lot Biofilter, completed in 2013
- Outfall 009 ISRA Excavations, completed in 2013
- Outfall 009 ELV Treatment BMP, completed in 2013
- Outfall 009 B1436 Detention Bioswales, completed in 2014

Stormwater from Outfall 011 is pumped to a storage pond and, when volumes exceed the pond storage capacity, is treated using an advanced treatment system. The treated stormwater is then discharged to Outfall 001. All stormwater (up to a certain size design storm event that varies by outfall based on site-specific pumping and storage capacities) from Outfalls 003, 004, 005, 006, 007, 009[4], 010 and 018 is pumped to another storage pond and treated using an advanced treatment system. This treated stormwater is then discharged to Outfall 002. Since the implementation of these Stormwater Treatment Systems (SWTSs) in 2012, the discharge from these outfalls (excluding 009) has effectively been reduced to zero because of the drought combined with the significant storage capacity available in the onsite ponds. Therefore no or very few recent effluent monitoring results are available for these outfalls[5].

The various BMPs in Outfall 009 (e.g., widespread revegetation, erosion and sediment controls, natural treatment BMPs, etc.) have also been effective at reducing the concentrations of the constituents of concern (COCs) in the watershed. In general, the statistical evaluation of influent versus effluent BMP performance sample results included in the 2015 Annual Report for Outfalls 008 and 009 indicated that significant COC removal is occurring in these watersheds, particularly for BMP influent samples that exceed Permit limits. This annual data analysis has been submitted to the Regional Board as part of each year's annual report.

Limited runoff has occurred at Outfall 008 since the completion of ISRA activities and installation of the new erosion and sediment controls in 2012, with only two results with concentrations above the 2015 Permit limits during this period, suggesting positive performance of the ISRA soil removal activities, revegetation/restoration, and erosion controls targeting sediment-bound COCs, combined with effects of the ongoing drought which has resulted in below average rainfall at the SSFL.

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[4] Stormwater runoff from a small area within the Outfall 009 watershed (helipad area) is pumped to the storage pond for treatment prior to being discharged from Outfall 018, while stormwater runoff from the remaining, vast majority of the watershed flows to Outfall 009.

[5] With the one exception of a pump-related power failure at Outfall 010 on 2/28/2014 that resulted in discharge from the outfall and the concentrations of two parameters being measured above the 2015 Permit limits.

1.4 Constituents of Concern

The following NPDES outfall-COC combinations were identified based on the outfall data analysis presented in the 2015 Work Plan. These NPDES outfall-COC combinations were based solely on the 2012 to 2015 analysis of NPDES outfall monitoring data (relative to 2015 Permit limits and benchmarks), since BMP implementation since 2012 has improved water quality of all outfall locations. Based on data collected in the 2015/2016 reporting year, no COCs need to be added to this list. Therefore, this Annual Report will focus on these priority combinations:

- Outfall 001: Iron, lead, manganese, and gross alpha
- Outfall 002: Iron
- Outfall 008: Copper and lead
- Outfall 009: Dioxins and lead

1.5 Report Organization

This report is organized as follows:

- Section 2: Monitoring Activities
- Section 3: BMP Activities
- Section 4: Watershed-Specific Assessments
- Section 5: Recommendations
- Section 6: Milestones/Schedule
- Section 7: References

2 Monitoring Activities

This section describes the hydrologic characteristics of the past reporting year, as well as a summary of the results of samples collected at NPDES compliance outfalls, BMP monitoring in Watersheds 008 and 009, as well as a summary of monitoring activities conducted as part of the Northern Drainage assessment and the non-industrial sources special study.

2.1 2015/2016 Rainfall

The long-term average annual rainfall at SSFL from 1959 to 2016 is 16.8 inches[6], compared to 12.0 inches measured in the 2015/2016 reporting year (the reporting year is defined as June 1 – May 31). Thirteen rain events (where a "rain event" is defined as greater than 0.1 inches of rainfall in a 24-hour period and preceded by at least 72 hours of dry weather) occurred in the 2015/2016 reporting year, with nine of these storms producing observable flow at one or more BMP monitoring sites. For historical context, Table 2 summarizes the historical rainfall over the past seven reporting years, since the formation of the Surface Water Expert Panel Work Plan in 2010.

Table 2. Historical Rainfall at SSFL, since 2010 Surface Water Expert Panel Work Plan

Reporting Year	Annual Rainfall	Number of Rain Events
2015/2016	12.0	13
2014/2015	11.2	9
2013/2014	6.1	5
2012/2013	8.1	9
2011/2012	11.3	10
2010/2011	23.4	14
2009/2010	19.4	11

Table 3 summarizes the 2015/2016 rainfall event characteristics, as well as the number of NPDES outfall samples, and watershed 009 BMP subarea monitoring samples. Outfalls 002 and 018 also discharged in early February 2016, however, these discharges were not during a rain event; rather, treated stormwater that was stored in Silvernale Pond was discharged from the Outfall 018 treatment system, and no water quality exceedances were measured at either Outfall 018 or downstream at Outfall 002. As shown below, Outfall 009 discharged on three occasions, and a total of 113 watershed 009 BMP or subarea samples were collected.

[6] Data from the Simi Hills – Rocketdyne Lab gauge (Ventura County Watershed Protection District site 249) was used to determine annual rainfall from 1958/1959 through 2000/2001. However, rainfall data are not available at this gauge from 1977/1978 through 1984/1985. Data from the Area 4 gauge (which was moved to Area 1 on January 1, 2013) were used to determine annual rainfall from 2001/2002 through 2015/2016. This results in a period of record of 50 years.

Table 3. 2015/2016 Reporting Year and Monitoring Event Summary

Rain Event	Total Rainfall[1] (inches)	Average Rainfall Intensity[1] (inches/hour)	Maximum 1-Hour Rainfall Intensity[1] (inches/hour)	NPDES Outfall 009 Samples	Watershed 009 BMP Subarea Monitoring Samples
July 18 - 19, 2015	0.83	0.027	0.32	0	0
September 14 - 15, 2015	1.10	0.050	0.39	0	8
October 5 - 6, 2015	0.45	0.025	0.32	0	0
December 13, 2015	0.11	0.055	0.06	0	0
December 19 - 22, 2015	0.52	0.008	0.08	0	6
January 5 - 10, 2016	3.87	0.030	0.60	1	29
January 15, 2016[2]	0.02	0.005	0.01	0	0
January 18-20, 2016	0.20	0.005	0.02	0	0
January 31, 2016	0.86	0.108	0.27	0	17
February 17-18, 2016	0.57	0.027	0.10	0	4
March 5-7, 2016	1.57	0.029	0.29	1	15
March 11, 2016	0.44	0.088	0.34	1	16
March 28-30, 2016	0.10	0.005	0.07	0	0
April 7-9, 2016	0.52	0.010	0.10	0	11
May 6, 2016	0.77	0.128	0.22	0	7
Non Rain Event Total[3]	0.04	--	--	--	--
TOTAL	11.97	--	--	3	113

[1] Total rainfall, average rainfall intensity, and maximum 1-hour rainfall intensity were calculated based on rainfall recorded at a LARWQCB-approved weather station within Area I.

[2] Rainfall total from Station 436 used on January 15, 2016.

[3] On the following 4 days, rainfall was measured but was not considered a rain event per the NPDES Permit definition: August 11, 2015 (0.01" measured at Sage Ranch rain gauge), November 3, 2015 (0.01"), March 14, 2016 (0.01"), and May 9, 2016 (0.01").

2.2 2015/2016 Stormwater Sampling

2.2.1 NPDES Outfalls

This past reporting year, discharges were reported at Outfalls 002, 009, and 018. As mentioned above, Outfalls 002 and 018 did not discharge during a rain event, rather they discharged treated stormwater following a series of rain events that filled the storage capacity, after which active treatment started, resulting in discharge at a later time than the rain event. No NPDES Permit limit exceedances were measured at Outfall 002 or 018. Two NPDES Permit limit exceedances were measured at Outfall 009, one each for lead and dioxins, consistent with the COCs reported in the 2015 Work Plan. SSFL outfalls not listed in Table 4 did not discharge during the 2015/2016 reporting year.

Table 4. NPDES Outfalls – Reported 2015/2016 Stormwater Discharges and Exceedances

Outfall	Reported Discharges	Reported Effluent Limit Exceedances	Notes
002	1	0	Discharge occurred following a series of rain events
009	3	2	Reported exceedances: • 3/8/2016: Lead = 5.9 µg/L (Permit Limit = 5.2 µg/L) • 1/6/2016: 2,3,7,8-TCDD TEQ (no DNQ) = 8.71e-8 µg/L (Permit Limit = 2.80e-8 µg/L)
018	1	0	Discharge occurred following a series of rain events

2.2.2 BMP Monitoring

BMP monitoring in watersheds 008 and 009 was conducted throughout the 2015/2016 reporting year as outlined in the *2015/2016 Rainy Season Sampling and Analysis Plan (SAP) Updates, Best Management Practice (BMP) Monitoring Program* ("2015/2016 SAP") (Appendix A to this report) (MWH, 2015). Two addenda were prepared in March 2016, one to add selected road runoff BMP locations, and another to add two previously discontinued background sites. This SAP is updated on an annual basis, and has again been updated for the upcoming 2016/2017 monitoring season as later discussed in Section 5.2.1.

This past monitoring season, stormwater samples at BMP subarea monitoring locations were collected in watershed 009 only, as there was no sampleable runoff observed at the monitoring locations in watershed 008. Table 5 summarizes the number of samples collected at each BMP monitoring location in watershed 009 subareas, as well as the number of lead and dioxin (TCDD TEQ [excluding 'Detected not Quantified {"no DNQ"}]) results greater than the Outfall 009 permit limit, for reference only, as the permit limits only apply to the outfall samples. A total of 113 samples were collected within this watershed, with 22% and 62% of these samples having concentrations greater than the NPDES Permit limits for lead and dioxins, respectively. No other monitored constituents exceeded these reference permit limits. These data are further analyzed and discussed in Section 4.2. All data, including laboratory and validation reports, are provided as Appendix B to this report.

Table 5. BMP Stormwater Monitoring Results, 2015/2016 Reporting Year

Site	Site Description	Number of Samples	Results Greater than OF009 Permit Limit (reference only as permit limits only apply to permitted outfall locations)	
			Lead	TCDD TEQ (No DNQ)
A1BMP0002-A	CM-9 upstream toward A1LF (post-A1LF asphalt removal), before treatment	1	1	1
A1BMP0003	CM-9 downstream-underdrain outlet (post-perforated pipe and upper basin installed)	1	0	0
A1BMP0004	Area 2 Road Runoff, SD inlet on north side of road	2	1	1
A2BMP0010	Well 13 Road Runoff, west side	1	0	0
A2BMP0011	Well 13 and Area 2 Road Runoff	1	1	1
APBMP0001-A	Area II road runoff, post-ELV stormwater improvements	3	2	2
B1BMP0003	Upper parking lot / road runoff to B1 area culvert inlet	2	1	2
B1BMP0004	B1 media filter inlet north, before treatment	5	3	5
B1BMP0005	B1 media filter inlet south, before treatment	5	0	2
B1BMP0006	B1 media filter effluent (post-media filter reconstruction, post-curb cuts)	6	1	6
B1BMP0007	B1, vegetated channel	3	0	3
B1BMP0008	B-1 storm drain culvert outlet	2	0	2
EVBMP0002-B	Helipad (post-sandbag berms raised, post-drainage holes in asphalt)	2	2	2
EVBMP0003-A	CM-1 upstream west, post-ELV improvements, before treatment	3	0	0
EVBMP0007	Influent to ELV sedimentation, before treatment	3	0	1
EVBMP0008	Effluent from ELV treatment BMP	3	0	0
EVBMP0009	Influent to ELV media filter, before treatment	3	0	0
EVBMP0010	Area 2 Road Runoff, SD inlet on north side of road	1	0	0
ILBMP0001	Lower parking lot 24" storm drain bypass	3	1	2
ILBMP0002	Road runoff to CM-9, before treatment	3	3	3
ILBMP0004	Upstream 1 (B1436 Southern Detention Bioswale influent)	7	2	7
ILBMP0005	Downstream (B1436 Southern Detention Bioswale effluent)	7	0	4
ILBMP0005-7	B1436 Northern Detention Bioswales Composite	1	0	1
ILBMP0006	Upstream (B1436 Northern Detention Bioswale influent)	1	0	0
ILBMP0007	NE Detention Bioswale Effluent	7	0	0
ILBMP0008	Upstream 2 (B1436 Southern Detention Bioswale influent)	8	5	8

Site	Site Description	Number of Samples	Results Greater than OF009 Permit Limit (reference only as permit limits only apply to permitted outfall locations)	
			Lead	TCDD TEQ (No DNQ)
LPBMP0002	Lower parking lot influent to cistern, before treatment	8	1	8
LPBMP0003	Lower parking lot sediment basin outlet, before treatment	8	0	8
LPBMP0004	Lower parking lot biofilter outlet	8	0	0
LXBMP0006	LOX east, runoff along unpaved road	2	0	1
LXBMP0007	LOX, inlet to western slope drain	1	0	0
LXBMP0009	LOX, inlet to eastern slope drain	2	1	0
	Total	113	25	70

2.3 Northern Drainage Assessment

As identified in the *Northern Drainage Restoration, Mitigation, and Monitoring Plan* (RMMP) (Haley & Aldrich, 2011), recurring site investigations are performed annually along the Northern Drainage for a duration of five years (2011/2012 to 2016/2017). Per the RMMP, "the appropriate steps to adaptive management as they pertain to the Northern Drainage are to: (1) periodically monitor the channel for geomorphic changes; (2) review monitoring data and evaluate what management actions are needed; (3) implement management actions, as appropriate, based on available data; and (4) document monitoring data and management actions to establish a continuous record of the channel conditions, which will be used to inform future management actions."

A summary of recommended stabilization measure maintenance activities is prepared by Geosyntec and reviewed by the Surface Water Expert Panel for Boeing on an annual basis. The 2015/2016 report is currently in progress and will be completed in fall 2016. Table 6 summarizes the annual inspection activities, their typical recurrence, and most recent and future activity dates. Section 5.1.1 discussed recommendations for the Northern Drainage.

Table 6. Northern Drainage Stabilization Schedule of Inspection Activities

Activity	Recurrence	Last Date of Activity	Next Activity
Physical Survey	As needed	2013	Deferred unless necessary
Facies Mapping	As needed	2012	Deferred unless necessary
Photographic Survey	Annually	March 2016	2017
Stream Walk	Annually	March 2016	2017
Inspection of completed stabilization measures – informs maintenance actions	Quarterly during wet season	October 2015 December 2015 March 2016	September 2016, if necessary

2.4 Non-Industrial Sources Special Study

In an effort to address continued lead and dioxin exceedances at Outfall 009, despite the implementation of numerous BMPs in the upper watershed, the 2015 Work Plan posed the following questions as the basis for a new non-industrial sources special study:

1. Where (spatially) within Watershed 009 are dioxins and lead in stormwater predominantly coming from; and
2. What are the predominant pollutant sources to the paved subareas -- e.g., pavement material itself (weathered or newly resurfaced), vehicles, treated wood poles, and/or atmospheric deposition?

The Surface Water Expert Panel and Geosyntec developed the *Special Monitoring Studies for the 009 Watershed* ("Special Study Work Plan") (Santa Susana Surface Water Expert Panel and Geosyntec Consultants, 2015b), which proposes approaches to collect data to further investigate the causes and sources of dioxins and lead in stormwater at Outfall 009. As shown in Figure 2, proposed investigations include atmospheric deposition, pavement solids, soils near treated wood poles, and Northern Drainage sediment and stormwater sampling. The recurrence and past samples dates of these programs are provided in Table 7 .

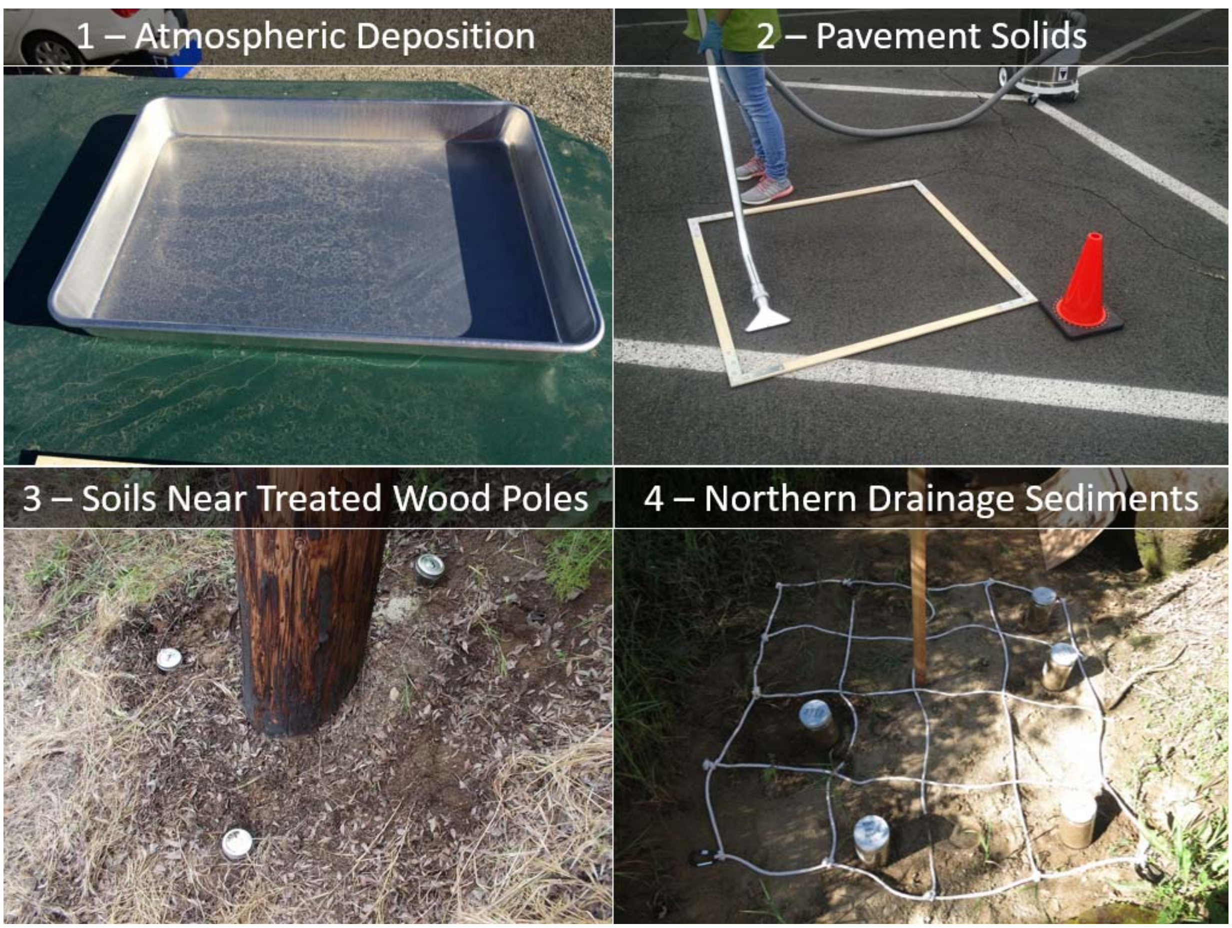

Figure 2. Non-Industrial Sources Special Study – Sampling Types

Table 7. Non-Industrial Sources Special Study – Monitoring Events, Planned and Completed

Activity	Event Frequency	Events Scoped	Events Completed	Completed Event Dates
Atmospheric Deposition	Monthly	12	3	6/14/2016 7/14/2016 8/16/2016 9/16/2016 10/17/2017
Pavement Solids	Quarterly	5	2	6/14-15/2016 7/28-29/2016 10/25-26/2017
Soils Near Treated Wood Poles	Single sampling event	1	1	5/11-12/2016
Northern Drainage Stormwater	Storm-based	Up to 8	1	3/7/2016
Northern Drainage Sediments	Single sampling event	1	1	3/25-28/2016

The Special Study Work Plan has since been updated to account for the following modifications, and is provided with this report as Appendix C. The following modifications to the 2015 version were made:

- Sampling locations were slightly modified based on observed site-specific constraints;
- Work Plan Figures 1 and 2, depicting lead and dioxins results from types of stormwater monitoring locations within watersheds 008 and 009, were updated with 2015-2016 monitoring results;
- Monitoring was extended into the 2016/2017 reporting year; and
- An extra pavement solids sampling event was performed in July to capture ash deposition from a nearby wildfire. This event is in addition to the 4 quarterly events previously planned.

A summary report will be made available in mid-2017, after all monitoring activities have been completed and the results analyzed.

3 BMP Activities

The following sections summarize the construction and demolition activities conducted at SSFL, the BMP activities within each watershed (e.g., new BMPs, inspections, maintenance, etc.), and public involvement within the past year.

3.1 Construction and Demolition

During the Third Quarter 2015, NASA completed a majority of Phase I of its planned demolition activities at SSFL. Site restoration activities completed during this quarter included placing temporary BMPs (sand bags and wattles) in the Employee Parking Lot southwest of the former B2207, installing BMPs (sand bags and wattles) around B2206 and B2207, and installing temporary BMPs (sand bags and wattles) at the Service Area.

During Fourth Quarter 2015, NASA also hydroseeded and placed wattles in areas where concrete/asphalt have been removed around former Buildings 2204, 2206, 2207, 2231, 2232, and 2760.

During the First Quarter 2016, NASA initiated concrete waste removal activities in the spillway portion of the Delta Test Stand Area. Soil disturbance activities included removal of F-listed hazardous waste (concrete) and non-hazardous waste (concrete, metal). BMPs including sandbags, wattles, and riprap have been placed in the lower Delta area.

During the Second Quarter 2016, NASA performed planned Phase II demolition activities in the Skyline Area which included removing inactive water pipelines emanating from Skyline toward the Alfa, Bravo, and Coca Areas. NASA placed wattles as linear sediment controls where needed and hydroseeded areas where construction activities had been completed. During the Second Quarter 2016, NASA began removing approximately two acres of asphalt and concrete building foundations near Buildings 2201, 2201, 2211, and 2203 in the Service Area. During the Third Quarter 2016, NASA completed these removals and installed BMPs (sand bags and wattles) and hydroseeded the entire area.

Future work will continue to adhere to the requirements of the site-specific Storm Water Pollution Prevention Plans (SWPPPs) and will be performed in accordance with the Construction General Permit.

As post-construction restoration plans for remediation projects are developed, especially those for creekside projects in Watersheds 008 and 009 which are without downstream treatment systems, NASA indicates that they will be made available for Surface Water Expert Panel review. This will include review of the design, construction, and operation/maintenance of such restoration measures.

3.2 Activities/Maintenance

BMP activities conducted at SSFL during the past year are incorporated by reference through the following quarterly NPDES Discharge Monitoring Reports (DMRs):

- The Boeing Company, 2015a. *Third Quarter 2015 NPDES Discharge Monitoring Report, Compliance File CI-6027 and NPDES No. CA0001309, Santa Susana Field Laboratory, Ventura County, California.* November 15.
- The Boeing Company, 2015b. *Fourth Quarter 2015 NPDES Discharge Monitoring Report, Compliance File CI-6027 and NPDES No. CA0001309, Santa Susana Field Laboratory, Ventura County, California.* February 15.

- The Boeing Company, 2016a. *First Quarter 2016 NPDES Discharge Monitoring Report, Compliance File CI-6027 and NPDES No. CA0001309, Santa Susana Field Laboratory, Ventura County, California.* May 15.
- The Boeing Company, 2016b. *Second Quarter 2016 NPDES Discharge Monitoring Report, Compliance File CI-6027 and NPDES No. CA0001309, Santa Susana Field Laboratory, Ventura County, California.* August 15.

3.3 Public Involvement

Numerous stakeholder groups and members of the general public have expressed interest in the stormwater issues at the SSFL at past public involvement activities and Regional Board hearings. In an effort to keep these groups and others apprised of progress, and provide an opportunity for public input, periodic public forum meetings or site tours will be held with the Surface Water Expert Panel throughout the duration of the 2015 Work Plan. Additionally, project status reports and submittal documents will also be posted on the Boeing project website after major project milestones and prior to public outreach meetings. Table 8 summarizes recent and planned public involvement activities that have occurred since the 2010 BMP Plan (MWH et al., 2010). Planning is currently underway for the next public meeting and tour, tentatively planned for early 2017.

Table 8. Recent and Planned Surface Water Expert Panel Public Involvement Activities

Date	Topic
Early 2017	Public meeting and tour
November 19, 2014	Community Action Group meeting
March 20, 2013	Public meeting and tour
October 6, 2013	Public meeting and tour
August 25, 2011	Public meeting
January 22, 2011	Public meeting and tour

4 Watershed-Specific Assessments

Sections 4.1 and 4.2 summarize the watershed-specific assessments performed during the 2015/2016 reporting year in watersheds 001 and 002, and watershed 008 and 009, respectively.

4.1 Watersheds 001 and 002

The 2015 Work Plan proposed that an unpaved road erosion control assessment be performed by a qualified erosion and sediment control specialist to control unpaved roads as sources of sediment in these undeveloped watersheds. A drainage stabilization assessment was also proposed to be performed along the drainages above Outfall 001 and 002 by a qualified fluvial geomorphologist, to assess the need for instream geomorphic control features to control instream sources of sediment to Outfalls 001 and 002. Findings from these assessments are discussed below.

4.1.1 Unpaved Road Erosion Assessment

A watershed road erosion assessment was performed along all paved, unpaved, gravel-coated, maintained, and non-maintained roads in watershed 001 and 002 on August 3 and 4, 2016 (Haley & Aldrich, 2016). The report entitled *Watershed Road Erosion Assessment, Outfalls 001 and 002, Santa Susana Field Laboratory* is provided as Appendix D to this report. In brief, findings are as follows:

- Some erosion was observed to have occurred along the unpaved road, underneath portions of the High Density Polyethylene (HDPE) pipe from the GET System to Outfall 019.
- Some previously installed BMPs are present and in general, appear to be functioning as intended (e.g., silt fence was observed to have collected some silt).
- Evidence of prior erosion, some rutting and gully development, and minor slope failure, was observed at various locations along shoulder of the unpaved road.
- A substantial amount of very fine, loose sediment was observed on the road surface and on both sides of the road, nearby and upstream of OF002, due to recent blading by the County of Ventura.
- Stabilization measures including site-specific applications of rip rap, fiber rolls, gravel bag check dams, water bars, and/or hydroseeding were recommended prior to the start of the 2016/2017 reporting year to reduce the amount of potential fine sediment that could be mobilized during a rain storm. Stabilization measures were completed in the Third Quarter of 2016 and hydroseeding is planned for the Fourth Quarter of 2016.

4.1.2 Drainage Stabilization Assessment

A drainage stabilization assessment was performed on August 19, 2016 along the main drainages between Outfalls 011 and 001, and between Outfalls 018 and 002 (Geosyntec Consultants, 2016b). The summary memorandum is provided as Appendix E to this report. In brief, findings are as follows:

- Channels appear to be relatively stable.
- Localized past bank erosion was observed, particularly on the outside of specific channel bends.
- Manmade features were observed within the channels. In the Outfall 001 channel, two riprap check structures and a portion of riprap lined channel were observed. In the Outfall 002 channel, a weir spanning the channel and well casings set in concrete were observed.
- Additional stabilization measures are not recommended within these drainages unless: (1) there are clearly elevated total suspended solids (TSS) levels in the downstream Outfalls (001 and 002)

relative to the associated upgradient Outfalls (011 and 018); and (2) the TSS levels at Outfalls 001 and 002 are at a level that compromise compliance with stormwater discharge requirements. If there is a clear TSS concern, then the installation of an in-stream check structure directly upstream of Outfall 001 and another upstream of Outfall 002 may be recommended to allow some settling of solids upstream of the Outfalls.

- However, since neither Outfall 001 nor 002 (downstream of Outfalls 011 and 018) discharged runoff in direct response to a rain event during the 2015/2016 reporting year, and no Permit limit exceedances were measured this season, additional stabilization measures are not found to be necessary at this time, but may be implemented on a case by case basis.

4.2 Watersheds 008 and 009

Watershed-specific assessments proposed by the 2015 Work Plan in watersheds 008 and 009 included the BMP subarea prioritization analysis and the BMP performance analysis, both of which were previously performed and reported upon annually under the 2010 BMP monitoring program. In addition to these assessments, a third analysis was performed comparing local stormwater background monitoring results to watershed 008 stormwater monitoring results.

4.2.1 BMP Subarea Prioritization Analysis

The BMP subarea prioritization approach, developed by the Surface Water Expert Panel and Geosyntec in 2010, uses stormwater monitoring results for prioritizing potential BMP subareas and assessing the performance of existing BMPs. This process was completed on a yearly basis, 2010 through 2015, which was the end of the 2010 BMP Plan coverage period. The 2015 Work Plan included the continuation of the Outfall 008 and 009 annual subarea ranking process.

The purpose of this analysis is to rank subareas within Boeing's and NASA's 008 and 009 watersheds for potential implementation of new or enhanced stormwater controls and to evaluate existing measures, based on the most current available data and subarea specific considerations. The Expert Panel's recommended approach to this task is to rank potential BMP subarea monitoring locations based on the results of water quality sample comparisons between (a) stormwater concentrations and permit limits, and (b) subarea stormwater particulate strengths[8] and background stormwater particulate strengths. A statistical methodology was developed to rank the subareas based on these comparison results, while accounting for the number of useable data available at each subarea as well as number of data observations that fall above these thresholds (i.e., reflecting statistical confidence in how frequently each subarea will exceed the comparison thresholds). This methodology relied on "weighting factors" that are calculated for each COC for each subarea. In the end, the pollutant-specific weighting factors were summed to produce a multi-constituent score to allow for relative ranking amongst the potential BMP subareas. This approach was submitted to the LARWQCB on June 22, 2011 (Santa Susana Surface Water Expert Panel, 2011), presented at a public meeting on August 25, 2011, the California Stormwater Quality Association (CASQA) conference in 2011 (Steets, *et al.*, 2011), published in Stormwater Magazine in 2013 (Otto, *et al.*, 2013), and published in Water Resources Impact in March 2016 (Costa, *et al.*, 2016).

[8] Particulate strength is determined by taking the total concentrations of the compound minus its filtered concentrations and dividing by the total suspended solids, which provides a measure of the mass of particulate form of the compound per mass of suspended sediment. These values are useful in evaluating the relative strength of sediment-based pollutant sources in stormwater samples.

This year, as in previous years, the Surface Water Expert Panel has overseen and reviewed the BMP subarea prioritization analysis and evaluated the results to inform new BMP recommendations. Initial analysis results were presented to the Surface Water Expert Panel in a meeting held July 19-20, 2016. The Surface Water Expert Panel received the draft report in August 2016 and the revised draft in September 2016.

The final report, *2015/2016 Watershed 008 and 009 BMP Subarea Prioritization Analysis* (Santa Susana Surface Water Expert Panel and Geosyntec Consultants, 2016a), is provided as Appendix F to this report. Key findings are discussed in Section 4.2.4 below.

4.2.2 BMP Performance Analysis

The BMP Performance Analysis is conducted annually to evaluate the performance of existing treatment BMPs in the Outfall 009 watershed, through the use of statistical, temporal, and other data analysis approaches, incorporating the 2015/2016 reporting year data into a dataset that began in December 2009. Although other constituents were analyzed (e.g., mercury and cadmium), COCs are addressed in these analyses, and include TSS, total lead, total copper[9], and dioxins (TCDD TEQ, DNQ excluded, bioaccumulation factors [BAFs] included).

This year, as in previous years, similar to the subarea prioritization analysis, the Surface Water Expert Panel has overseen and reviewed the BMP performance analysis and evaluated the results to inform new BMP recommendations. Initial analysis results were presented to the Surface Water Expert Panel in a meeting held July 19-20, 2016. The Surface Water Expert Panel received the draft memo in August 2016 and the revised draft in September 2016.

The final report, *2015/2016 BMP Performance Analysis, Santa Susana Field Laboratory* (Santa Susana Surface Water Expert Panel and Geosyntec Consultants, 2016b), is provided as Appendix G to this report. Key findings are discussed in Section 4.2.4 below.

4.2.3 Background Analysis

The *Outfall 008 Stormwater Background Evaluation* (Santa Susana Surface Water Expert Panel and Geosyntec Consultants, 2016c) compares the quality of stormwater runoff at Outfall 008 to local background stormwater monitoring data collected within SSFL. "Background" is intended to represent stormwater runoff from areas without historical industrial operations, Resource Conservation and Recovery Act (RCRA) feasibility investigation (RFI) areas, or development surfaces (e.g., buildings, paved roads, or lots). This comparison is performed to assess whether the remedial and restoration activities completed by Boeing within the Happy Valley area (i.e., Department of Toxic Substances Control [DTSC] Interim Measure, ISRA, and BMP programs) have restored stormwater quality at Outfall 008 to natural background conditions. The Outfall 008 watershed is 62 acres, entirely owned by Boeing, and unlike most other SSFL watersheds, lacks paved roads, buildings, lots, and/or unaddressed RFI areas. The geology, topography, soils, drainage network, and vegetation in the 008 watershed are now very similar to reference watersheds in Ventura County.

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[9] Copper is not included as a pollutant of concern for the Outfall 009 watershed in the 2015 Expert Panel Work Plan. However, data for total copper are still presented in the paired line plots.

The final report, *Santa Susana Field Laboratory – Outfall 008 Stormwater Background Evaluation* (Santa Susana Surface Water Expert Panel and Geosyntec Consultants, 2016c), is provided as Appendix H to this report. Key findings are discussed in Section 4.2.4 below.

It is recommended that this analysis be updated next year if Outfall 008 samples are collected during the 2016/2017 reporting year.

4.2.4 Key Findings

Data supporting answers to the following questions are provided in the analyses referenced above. The following findings significantly shape the BMP and monitoring recommendations presented in Section 5. In some cases, most often due to a lack of data, the question posed may be unanswerable at this point in time. In such cases, the question will be reassessed in next year's annual report, leveraging the monitoring data collected during this upcoming reporting year.

a. Are the BMPs reducing the concentrations of lead, dioxin, and TSS and loads of these constituents between the untreated influent and the treated effluent?

As shown in Table 9 and Table 10, lead and dioxin reduction was observed at all BMP types, between paired influent and effluent samples. Performance analysis results (Appendix G) indicate that statistically significant ($p<0.05$) pollutant concentration reductions, as determined by the non-parametric one-tailed sign test, are occurring between influent and effluent for dioxins and lead at the CM-1, CM-9, and the B-1 media filter, and the detention bioswales. Statistically significant pollutant concentration reductions between influent and effluent were also observed for dioxins at the lower lot biofilter, and for lead at the ELV treatment BMP. Although not statistically significant, average concentration reductions between influent and effluent, as calculated based on the average influent and average effluent concentrations, were observed for dioxins at the ELV treatment BMP and for lead at the lower lot biofilter.

Table 9. Summary of TCDD TEQ (No DNQ) BMP Performance Stormwater Monitoring Results

BMP	Statistically Significant Removal?	Average % Reduction	% Greater than Permit Limit	
			Influent	Effluent
B-1, CM-9, and CM-1	Yes	95%	78%	57%
Lower Lot Biofilter	Yes	94%	93%	6.7%
ELV Treatment BMP	No	79%	50%	17%
Detention Bioswales	Yes	99%	88%	50%

Table 10. Summary of Lead BMP Performance Stormwater Monitoring Results

BMP	Statistically Significant Removal?	Average % Reduction	% Greater than Permit Limit	
			Influent	Effluent
B-1, CM-9, and CM-1	Yes	42%	38%	21%
Lower Lot Biofilter	No[1]	22%	20%	6.7%
ELV Treatment BMP	Yes	53%	17%	0%
Detention Bioswales	Yes	76%	63%	0%

[1] Can likely be attributed to the significantly lower influent concentrations to the lower lot biofilter in recent years (to be discussed further).

Figure 3 and Figure 4 present the influent and effluent monitoring results by BMP group, for summary purposes[10].

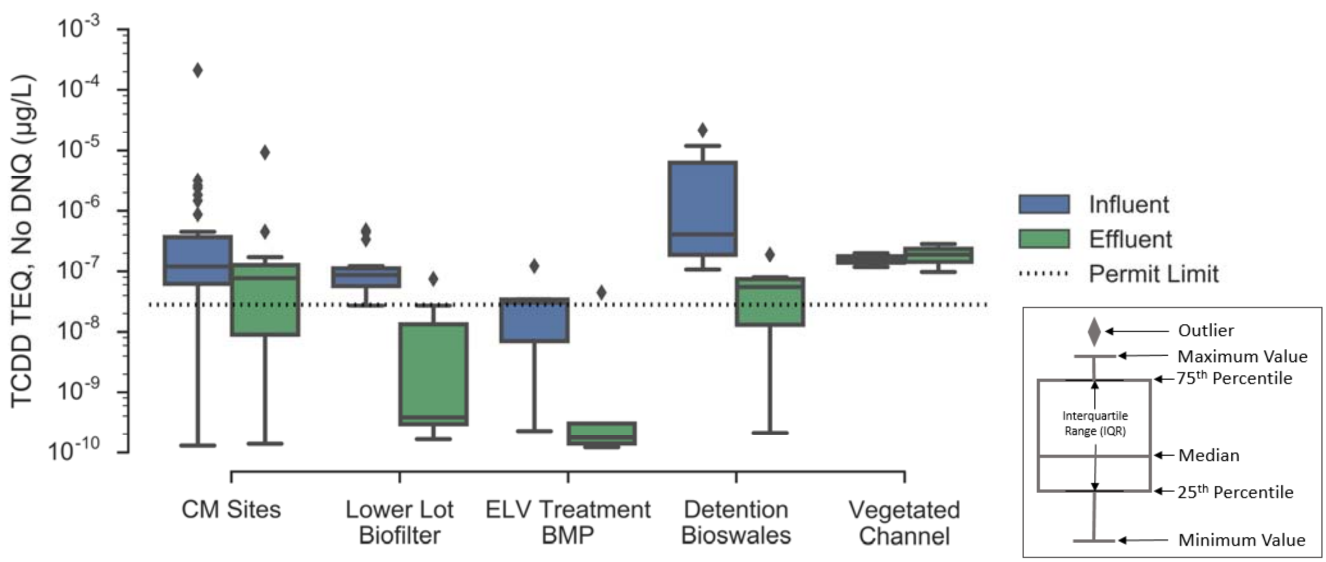


Figure 3. BMP Performance – Influent/Effluent Box Plot for Dioxins

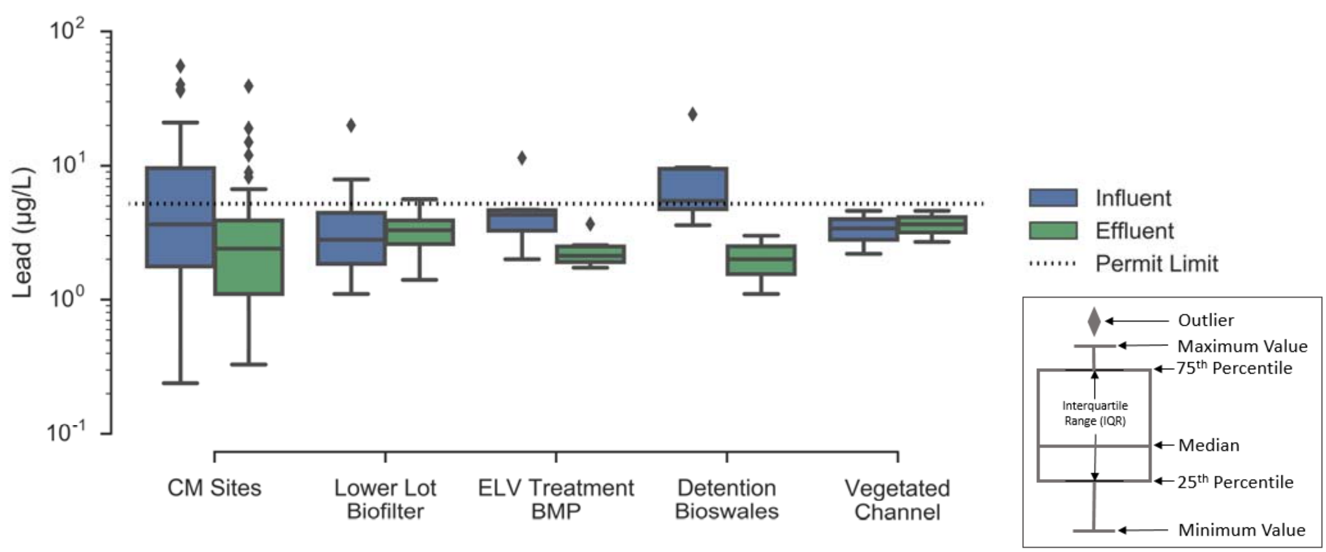


Figure 4. BMP Performance – Influent/Effluent Box Plot for Lead

The results of the BMP Subarea Prioritization Analysis (Appendix F) demonstrate a similar trend of improving water quality between BMP influent and effluent. Figure 5 summarizes the key subarea monitoring locations that have both an influent and effluent paired location, focusing

[10] The vegetated channel, while not a BMP, was included in the BMP Performance Analysis to assess whether any naturally occurring pollutant removal was occurring in the existing unlined channel. These results are discussed further in Appendix G.

on the locations ranked in the top 20 overall in the BMP subarea prioritization analysis. This comparison demonstrates that treatment through the BMPs resulted in improved water quality, as demonstrated by a decrease between the influent and effluent rank. For example, two influent streams within the B-1 area (ranked 14 and 42) are both more highly ranked than the associated B-1 effluent, which is ranked 43. A similar occurrence is observed for the influent/effluent ranks for CM-1, CM-9, the ELV treatment BMP, and the lower lot sedimentation basin and biofilter.

Constituent loads are also being reduced, both because concentrations are being reduced, but also because runoff volumes are being collectively reduced by upstream pavement and building removal, storage in BMPs, soil roughening with mulch and seed, and water bars, etc..

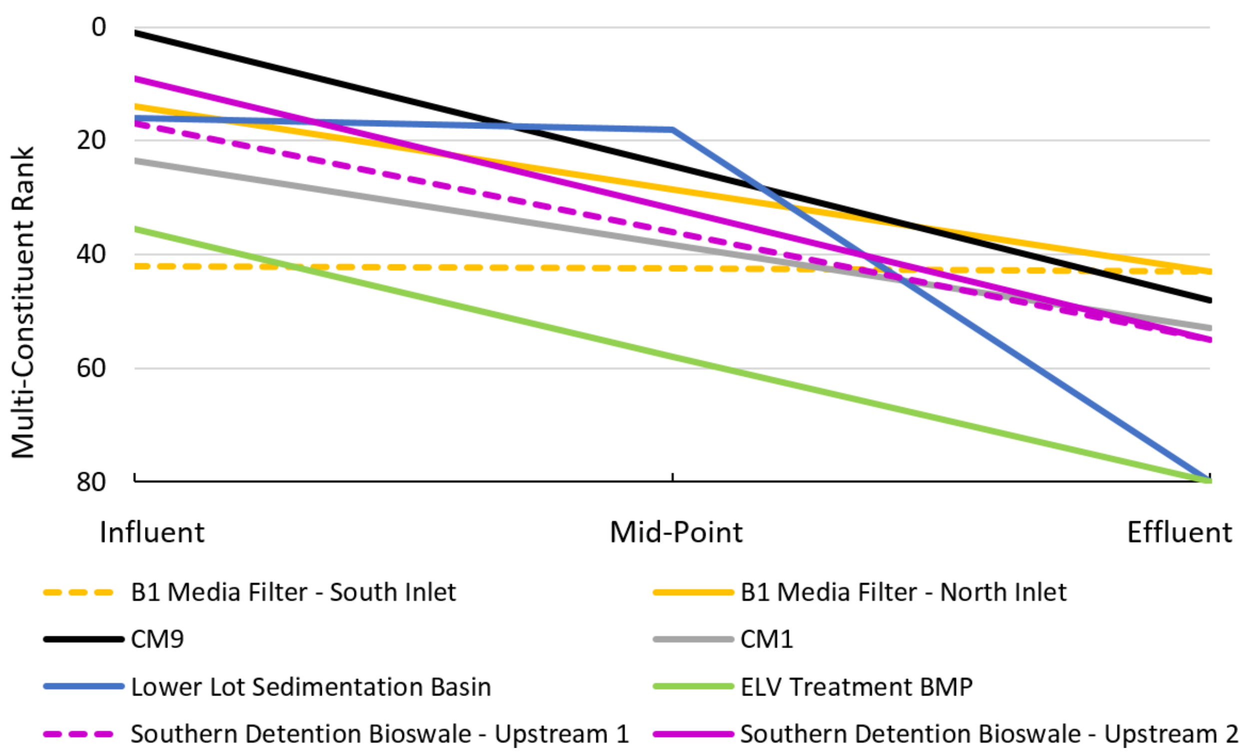


Figure 5. Graphical Comparison of BMP Influent/Effluent Monitoring Location Ranks

b. Are improvements/modifications made to individual BMPs improving their performance over time?

As reported in the BMP Subarea Prioritization Analysis (Appendix F), Figure 6 depicts a select subset of subarea monitoring locations ranked in the top 20 overall that are associated with BMP or drainage area modifications and/or improvements over time. In most cases, there was a decrease in the overall effluent rank after the BMP was implemented, or a modification to the BMP was made, demonstrating that BMP implementation and improvement has generally resulted in improved performance (effluent quality) over time. The lower lot sheetflow shows an increase in rank but was technically discontinued when the lower lot biofilter was constructed.

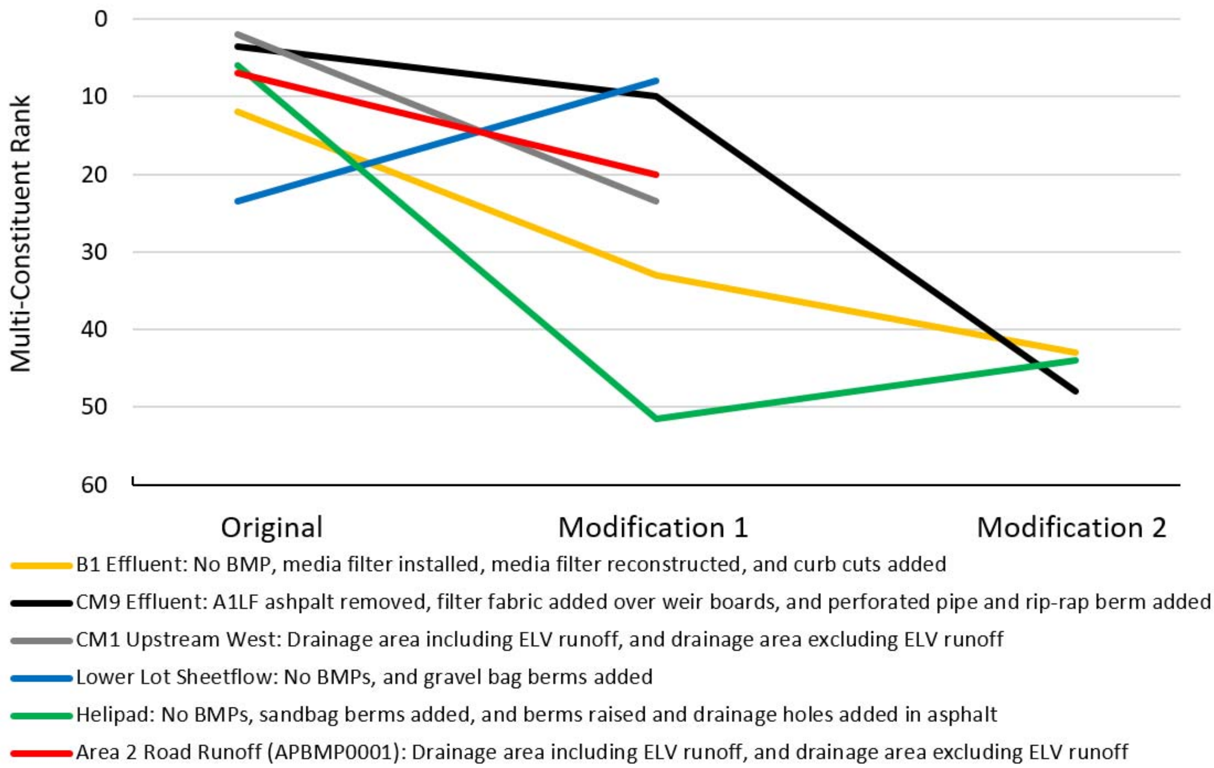


Figure 6. Graphical Comparison of Monitoring Locations Ranks, by Modification

c. Are the treatment controls aiding in compliance with NPDES permit limits at Outfall 009?

Collectively, the treatment controls are exhibiting BMP-specific water quality improvement (see Table 9 and Table 10) and are expected to also support NPDES compliance at Outfall 009, where lead and dioxin compliance challenges persist.

Additionally, the average paired influent concentrations for CM-1, CM-9, and the B-1 media filter were 3.2 and 20 times higher than average Outfall 009 concentrations for lead and dioxins, respectively, suggesting that the treatment control drainage areas (which include paved roads) are pollutant generating source areas that, without treatment, would have worsened water quality at the downstream NPDES compliance location.

This trend is further supported by the BMP Prioritization Analysis (Appendix F), which ranks Outfalls 008 and 009 lower than many of the potential source areas, based on their multi-pollutant rank, which is intended to indicate "quality" of runoff sampled. A lower rank indicates better runoff quality and Outfalls 008 and 009 are both ranked 80, which is the lowest possible rank in the 2015/2016 monitoring season.

d. Is the lower lot biofilter preventing stormwater runoff from discharging to the Northern Drainage?

Flow monitoring data at the lower lot biofilter were examined in the BMP Performance Analysis (Appendix G) to determine the low flow diversion's ability to prevent smaller storms from discharging to the Northern Drainage. As shown in Figure 7, the diversion to the lower lot biofilter successfully prevented 50% of all storms less than or equal to one inch from discharging to the Northern Drainage.

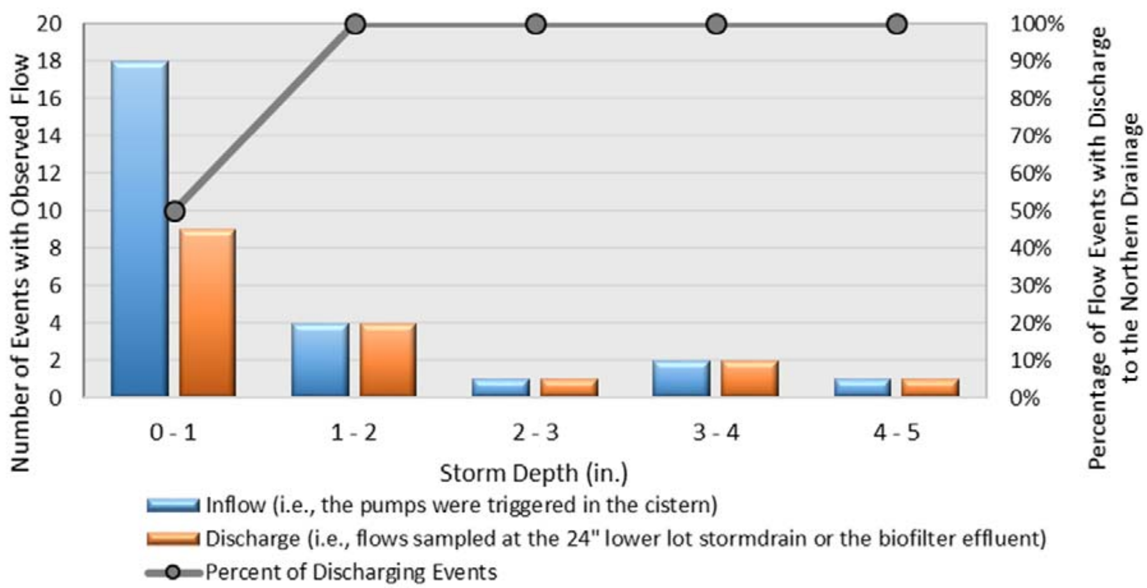


Figure 7. Binned Presence/Absence of Discharge at the SSFL Biofilter, 2013 to 2016

e. How much cumulative sediment loading has occurred at the BMPs, and how do these loads compare to when initial maintenance may be required based on lab column tests?

The BMP Performance Analysis (Appendix G) evaluated the cumulative TSS loading to the ELV treatment BMP, lower lot biofilter, B-1 media filter, CM-1, and CM-9, and compared each to the estimated value of cumulative sediment loading to the media before initial maintenance is needed based on column tests (Pitt, R.E. and Clark, S.E., 2010). The ELV treatment BMP and lower lot biofilter were only 5% and 6%, respectively, towards requiring initial maintenance, and it was estimated that maintenance would not be needed for another 17 and 23 years, respectively, assuming average rainfall years. Calculations showed that CM-1 had reached the cumulative sediment loading where maintenance was needed (132%). Maintenance was performed on CM-1 during this monitoring season. The filter fabric was re-attached to the weir boards and rip-rap and gravel were added to the check dam, to replace the sand bag berm. The media was not replaced, yet there has not been any observed flow associated with media clogging at CM-1. B-1 and CM-9 were estimated to be 24% and 74% respectively, towards media clogging, and initial maintenance is expected to be needed in 8 and 1–2 years, respectively, assuming average rainfall years. Maintenance will likely be required soon for CM-9, and observations of clogging, overflow, and underdrain flows should continue to be taken at each BMP. Potential for clogging at representative media filters will also be further confirmed using continuous stage sensors to directly measure infiltration as the pond water levels decrease (see Section 5.2.1).

f. Based on the BMP subarea prioritization results, where would new BMPs be most effective at reducing Permit limit exceedances at Outfall 009?

BMPs would be the most effective at the top-ranked locations that are both actively monitored (i.e., not discontinued[11]) and not upstream of an existing well-performing BMP (i.e., without downstream stormwater treatment). As reported in the BMP Prioritization Analysis (Appendix F), four of the top twenty ranked monitoring locations meet this criteria (see Figure 12 in Section 5.1 for locations):

- A2BMP0011: Well 13 and Area 2 Road Runoff;
- B1BMP0003: Upper parking lot/road runoff to B1 area culvert inlet;
- ILBMP0001: Lower parking lot 24" storm drain bypass; and
- APBMP0001-A: Area II road runoff, post-ELV stormwater improvements.

All four monitoring locations receive runoff from fully or partially paved areas, which as shown in Figure 8 and Figure 9, on average contain a higher concentration of both dioxins and lead, respectively, than other monitored locations (Non-Industrial Sources Special Study Work Plan; Appendix C). To address runoff from these subareas, the Surface Water Expert Panel has made BMP recommendations for each of these locations, as discussed in Section 5.1 of this report.

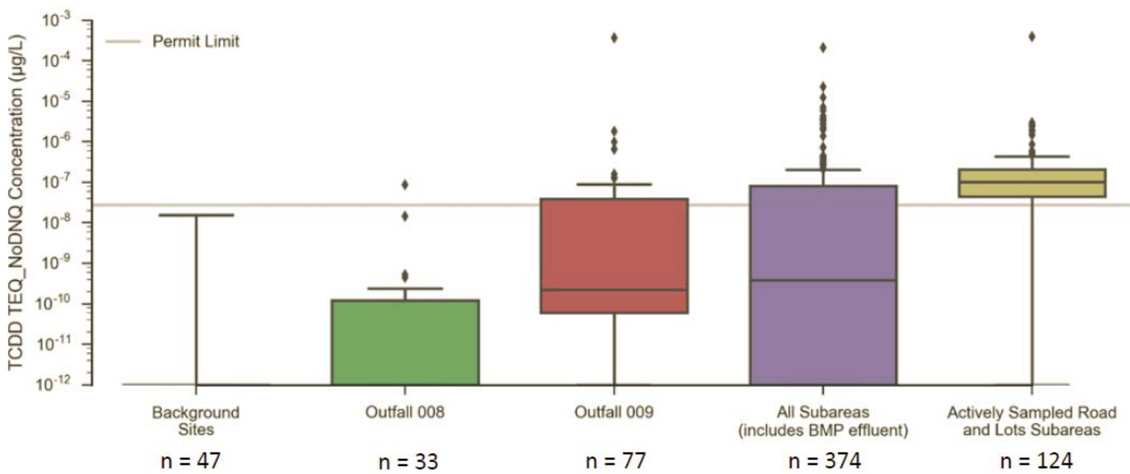


Figure 8. Dioxin TEQ Concentrations Measured in Stormwater Samples, 2004-2016[12]

[11] No site was discontinued if it had known water quality issues. Sites were typically discontinued due to reclassification due to upstream BMP implementation, redundancy, or termination of the required ISRA monitoring period.

[12] Boxes show the median value and the upper (75th percentile) and lower (25th percentile) quartiles. Whiskers represent 1.5 times the interquartile range and data points outside this are shown individually. Actively sampled road and lots subareas include samples collected from APBMP0001-A (n=5), BIBMP0002 (n=6), BIBMP0003 (n=17), B1BMP0004 (n=15), BIBMP0004-5 (n=10), BISW0015 (n=1), EVBMP0002-B (n=7), EVBMP0003-A (n=6), ILBMP0001 (n=26), ILMBP0002 (n=16) and LPBMP0002 (n=15).

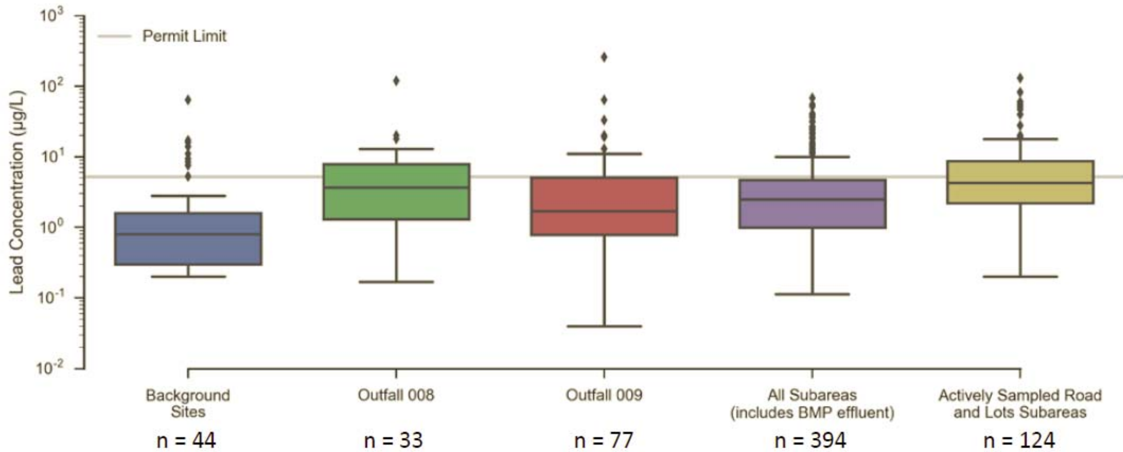


Figure 9. Total Lead Concentrations Measured in Stormwater Samples, 2004-2016[13]

g. Is the runoff quality at Outfall 008 approaching background?

As supported by analyses in the Outfall 008 Stormwater Background Evaluation (Appendix H), since Outfall 008 particulate strengths for copper, lead, and TCDD TEQ (no DNQ) are primarily below or similar to background particulate strengths, the few historical Outfall 008 Permit water quality-based effluent limit (WQBEL) exceedances may be due to natural background soils that are suspended in stormwater discharges. Therefore, based on the collective weight of evidence, in light of the limited data available, stormwater runoff from the Outfall 008 watershed appears to be trending toward a natural background condition; however, more data are needed to confirm this trend.

h. Have an adequate number of samples been collected at the B-1 media filer, CM-1, and CM-9, such that sampling can be discontinued at some locations?

The representativeness of stormwater data with respect to hydrologic conditions, was analyzed for the B-1 media filter, CM-1, and CM-9, as the oldest stormwater BMPs in the watershed 009. There have been 16 paired samples collected at the B-1 media filter since the installation of the curb cuts in 2012. As shown in Figure 10 and Figure 11 (Appendix G), these samples are well distributed across the average storm event intensities, maximum intensities, and total depths of the storms at the site since its installation. As shown in Figure 87 (Appendix G), 16 pairs of samples are suitable to allow significant differences to be quantified for at least 90% reductions, at high power and confidence). Therefore, sampling at B-1 is recommended to be discontinued.

There have been 21 paired samples collected at CM-1 (including both pre and post filter fabric installation), and 22 paired samples have been collected at CM-9 (pre and post improvements). These numbers of samples should allow the quantification of at least 80% differences between the influent an effluent locations, at high power and confidence. However, the number of paired samples collected at CM-1 post filter fabric installation and at CM-9 post improvements are much lower (i.e., seven paired samples at CM-1 and five paired samples at CM-9 vs. 16 paired samples at B-1) and less distributed, especially with respect total annual rainfall, and therefore do not represent a variety of average storm event intensities, maximum intensities, or total storm depths. It is recommended that stormwater sampling continue at these locations to better represent the long-term distribution of rainfall patterns at SSFL, and therefore more accurately assess the performance of these BMPs.

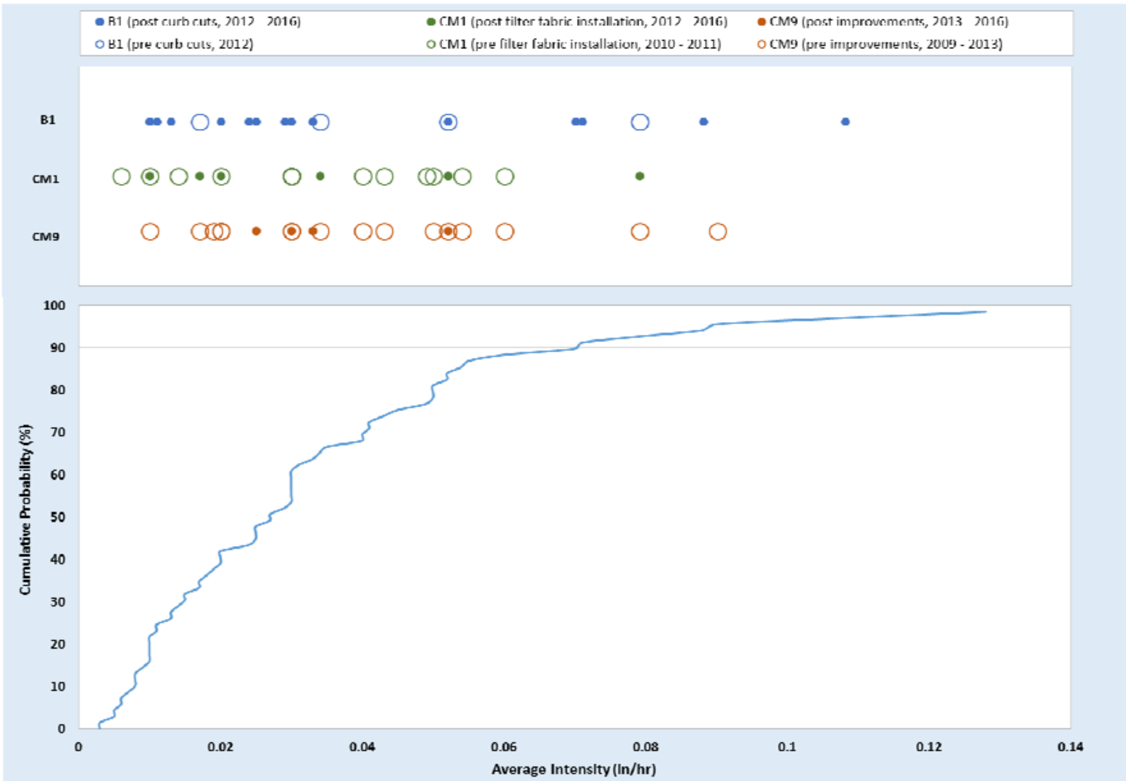


Figure 10. Paired Samples and Probability of Average Intensity during Storm

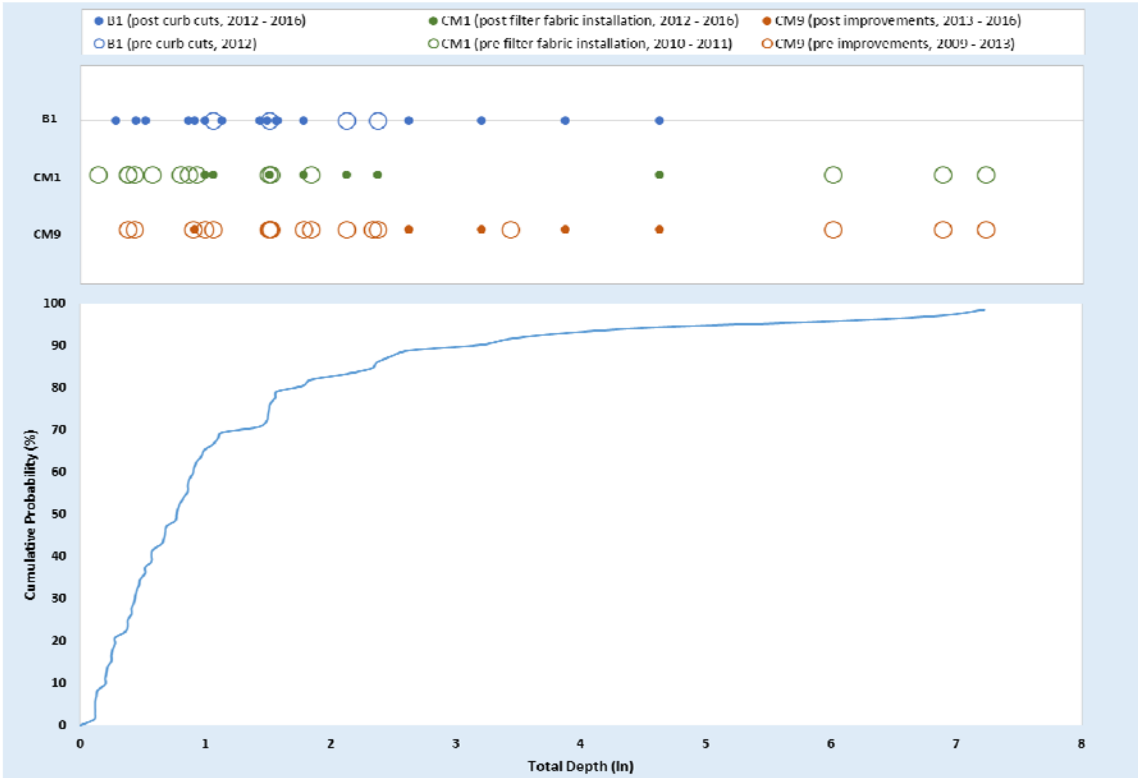


Figure 11. Paired Samples and Probability of Total Depth of Storm Event

5 Recommendations

5.1 BMP Recommendations

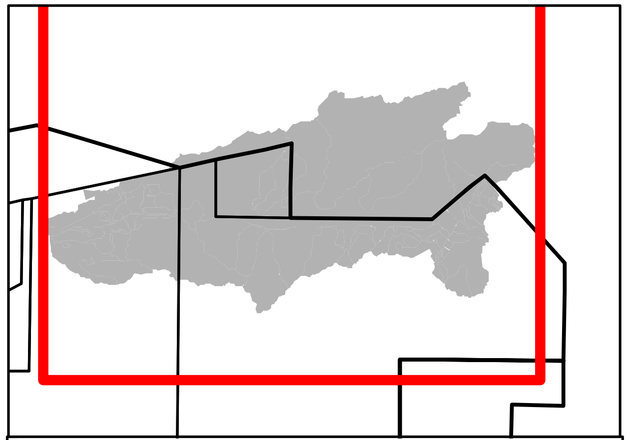
The following sections outline the proposed BMP recommendations for watershed 009, based on the findings from the watershed specific assessments outlined in Section 4. Since no other NPDES compliance outfalls exceeded Permit limits during the past monitoring season, recommendations are focused on areas upstream of Outfall 009.

Figure 12 depicts the areas referenced in the sub-sections below. If the recommended BMPs are implemented, the total area treated by BMPs within watershed 009 (shaded areas in Figure 12) would increase from 288 acres to 295 acres, or from 54% to 55% of the watershed (and from 65% to 69% of paved/developed areas). It should be noted that while runoff from the unshaded areas is not directly treated, downstream controls such as Northern Drainage restoration measures, do indirectly provide a treatment benefit to runoff from some of these areas. The new proposed BMPs are located in the highest priority unaddressed areas, based on the results of the BMP Subarea Prioritization Analysis (Appendix F).

5.1.1 Northern Drainage

The Northern Drainage Annual Geomorphic Monitoring Report, Water Year 2015 (Geosyntec Consultants, 2015b) outlined the geomorphic monitoring activities performed in the 2014/2015 reporting year and recommended specific routine and major maintenance actions. As noted previously, this report is currently being updated for the 2015/2016 reporting year, and will contain similar recommendations based on observations made this past season. In some cases, past recommendations were not able to be implemented due to permitting restrictions by California Department of Fish and Wildlife (CDFW) and US Army Corps of Engineers (USACE). It will again be recommended that these maintenance actions be completed. The eventual re-issued SAA 1600-2015-0079-R5 will be used for future activities in the Northern Drainage. If supplemental planting or additional mitigation is necessary, requirements in the new SAA will be followed to implement those activities.

Therefore, similar to the previous year's maintenance recommendations, these activities will be completed in accordance with existing permit conditions (in part, Corps National Permit General Condition 14) and conditions stipulated in the new SAA, which is in the final stages of approval. As required by the existing permits, all implemented activities should be reported in the annual report. This required reporting includes before and after photos, a description of the maintenance activities, and the locations of the activities.



Legend

- Treatment BMPs
- Completed ISRA Area
- Watershed 009
- Untreated Drainage Area
- Drainage Area to Priority Location
- Potentially Treated Drainage Area
- Drainage
- Storm Drain

Treated Drainage Area

- B1 Media Filter
- Biofilter
- CM-1
- CM-2
- CM-3
- CM-4
- CM-5
- CM-6
- CM-8
- CM-9
- CM-10
- CM-11
- CM-12
- Detention Bioswales
- ELV Treatment BMP
- Helipad BMP
- LOX BMP

0 395 790 1,580
Feet

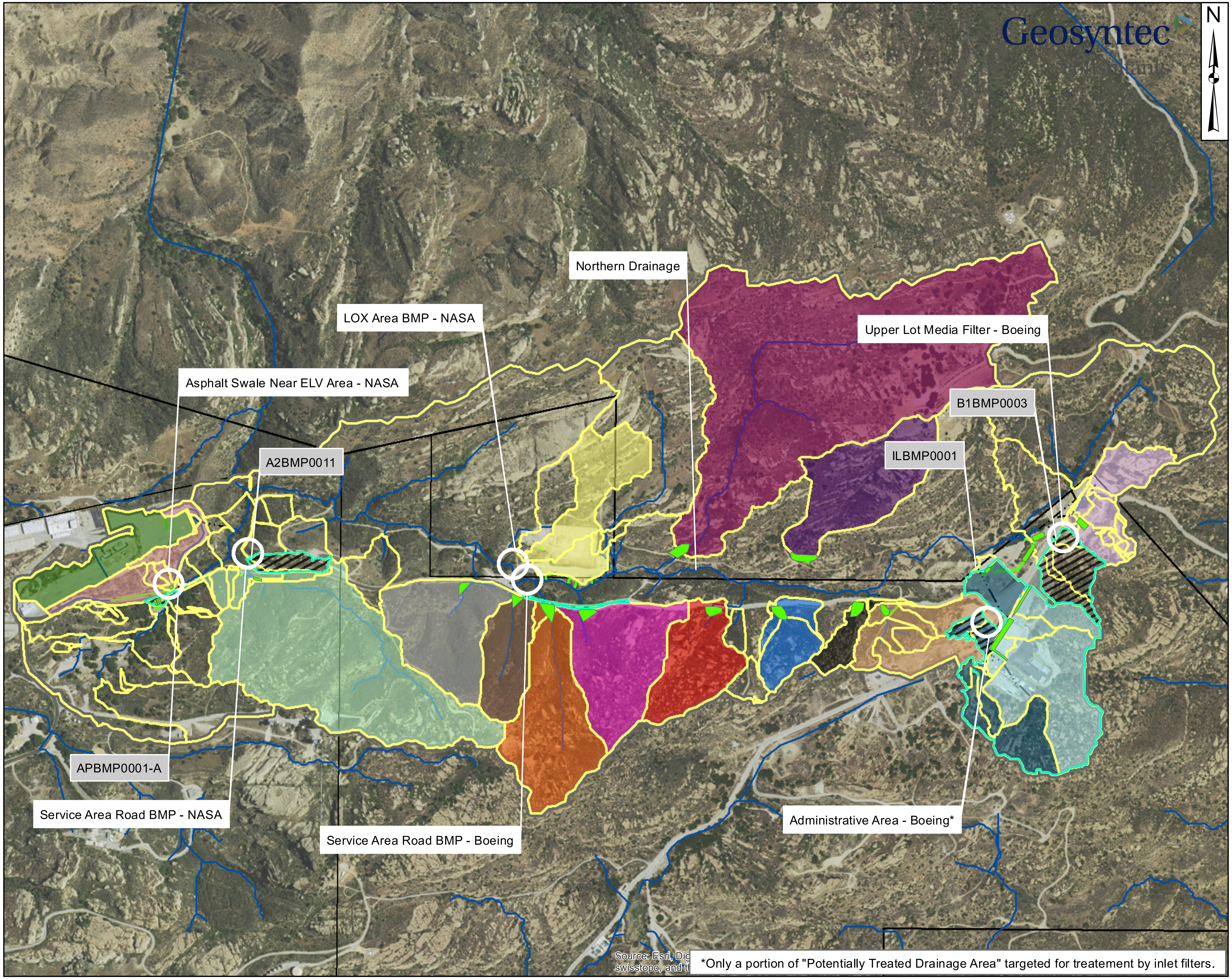


Figure 12

Treated Drainage Areas and BMP Recommendations

Santa Susana Field Laboratory
Ventura County, CA

October 2016

Date: 10/26/2016, Path: Z:\GIS\Projects\Boeing\SSFL\2016 SB0363W\Ranking Memo\2016 Priority Sites-BMP Recommend_Working6.mxd, User: OLincoln

5.1.2 Service Area Road BMPs – Boeing and NASA

In the *ISRA Performance Monitoring and BMP Monitoring for the Outfalls 008 and 009 Watersheds, 2014/2015 Rainy Season* (MWH et al., 2015), the Surface Water Expert Panel recommended comprehensively evaluating potential road runoff capture/treatment opportunities due to continued exceedances at Outfall 009 despite water quality improvement demonstrated at the individual BMPs. This recommendation was also made to address ranking results at APBMP0001-A (previously ranked 7.5) and B1BMP0003 (previously ranked 18), which both receive untreated runoff directly from paved surfaces. In August 2015, Geosyntec Consultants developed a memorandum for Boeing and the Surface Water Expert Panel summarizing the evaluation of stormwater BMP opportunities along the Service Area Road, which was determined to be the largest area of untreated roadway surface while having potential BMP siting opportunities nearby (Geosyntec Consultants, 2015a). During this evaluation, it was determined that 41% of this roadway area in the 009 watershed is currently treated and 59% is therefore untreated. This memorandum also evaluated potential placement of BMPs to capture as much of the untreated drainage area as possible. In February 2016, Geosyntec Consultants developed and submitted for review, conceptual designs to Boeing, NASA, and the Surface Water Expert Panel showing plan view and cross-sections of five proposed BMPs along the Service Area Road (see Figure 13 for an example cross section). Since February, additional developments have been made in the design process. These developments are described in the sub-sections below for the Boeing and NASA locations individually.

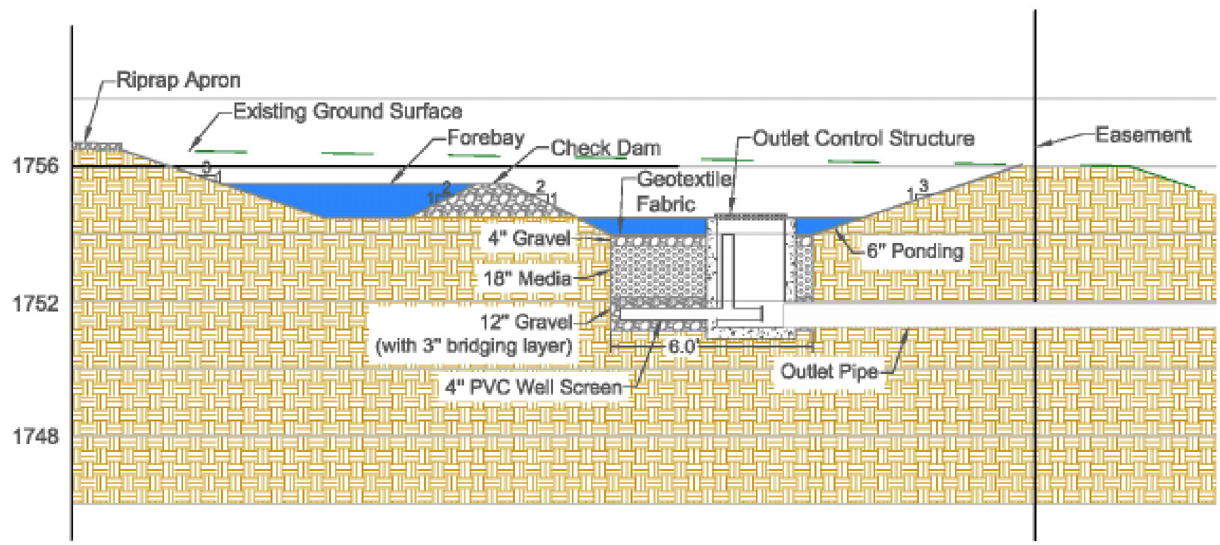


Figure 13. Proposed Service Area Road BMP Profile near the LOX Area

5.1.2.1 Service Area Road BMPs - Boeing

Three of the five originally proposed BMPs were on Boeing property. After a site visit in May 2016, Boeing and Geosyntec recommended a topographic survey to verify the drainage area to each BMP and determine whether the proposed BMPs could potentially be combined into one or two BMPs to provide a more cost-effective design. The topographic survey was carried out and completed in July 2016. The survey results showed that a portion of the roadway previously thought untreated, based on less detailed topographic information, actually drains south across the service area road and is treated by CM-4. The remaining untreated roadway area drains north; it was therefore recommended that runoff from this area be collected at one location near the LOX area, collected by a curb installed along the northern side of the road to prevent the runoff from discharging off the road into the Northern drainage directly. It was further recommended that Boeing install a drop inlet (see Figure 14), that would capture Service Area Runoff upstream and divert it South across the road to CM-10, for treatment through the existing media filter. This design was ultimately selected over a new media filter due to lower construction costs, no additional maintenance requirements, and the available hydraulic capacity at CM-10. To fully treat the Site design storm (1-year, 24-hour storm; 2.3 inches), it is also recommended that the existing weir boards of the CM-10 be extended to a height of two feet. The recommendations above were included in the memorandum *Evaluation of Stormwater BMP Opportunities at SSFL* (Geosyntec Consultants, 2016a).

The expanded CM-10 is expected to capture and treat 100% of the design storm, with effluent pollutant concentrations expected to be consistent with previous CM performance monitoring results. It is anticipated that additional runoff diverted to the CM will result in more frequent maintenance requirements than status quo conditions.

As a result of implementing this BMP, the amount of treated roadway throughout Service Area Road will increase from 60% to approximately 65%.

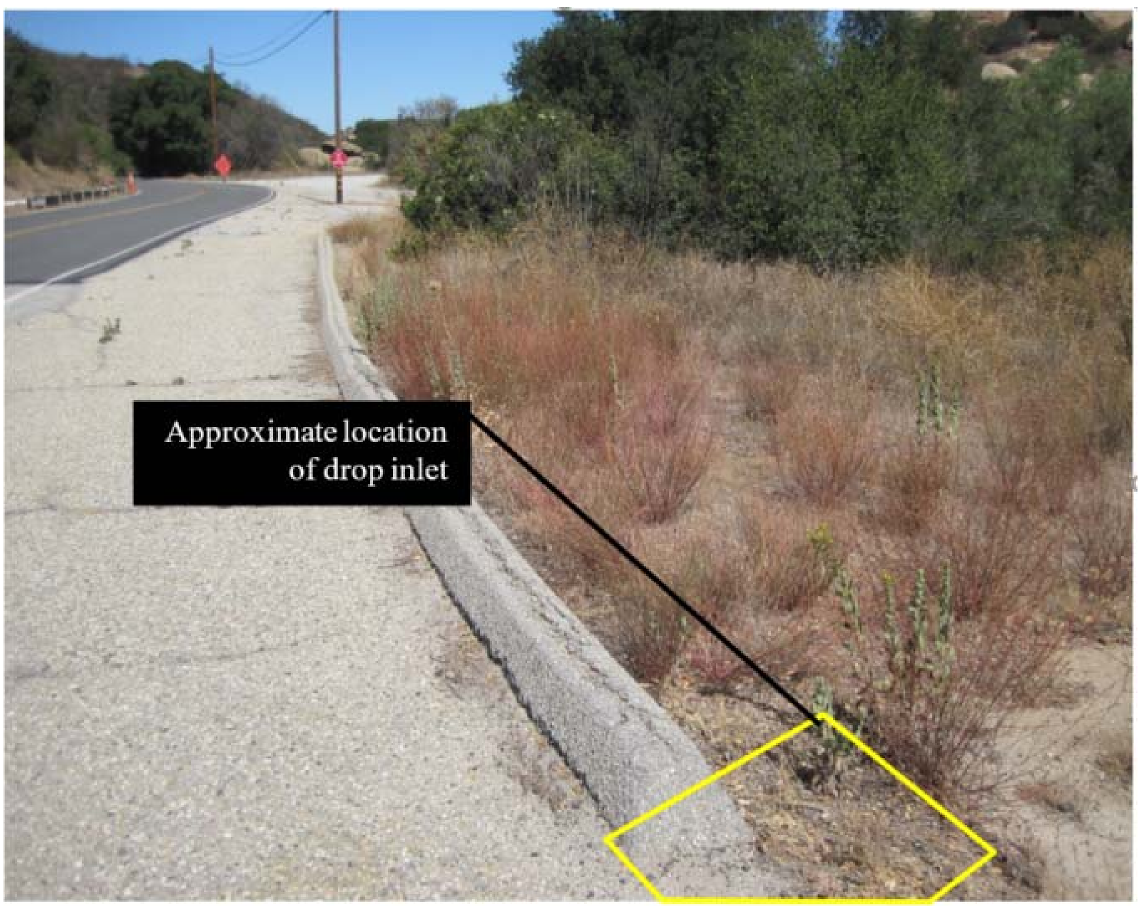


Figure 14. Proposed Location of Drop Inlet along Service Area Road

5.1.2.2 Service Area Road BMPs - NASA

Two of the proposed BMPs were on NASA property. It was later determined through observation during a rain event that one of the proposed BMP drainage areas drains across Service Area Road and is already being treated by CM – 2, rendering that BMP unnecessary. In July 2016, the Surface Water Expert Panel conducted a site visit with a representative of NASA at the location of the remaining proposed BMP. NASA has proposed to observe, evaluate, and continue to sample stormwater runoff in the area of Wells 13 Road during the upcoming reporting year. There are few real-time runoff observations of the area during rainfall events and further runoff evaluation will allow NASA to provide feedback to the Surface Water Expert Panel. The feedback will assist NASA in developing an appropriate type of BMP for the area. Following the upcoming reporting year, NASA will provide results of their observations to the Surface Water Expert Panel. Based on GIS analysis of BMP drainage areas, implementing a BMP in this area would increase the amount of Service Area Road that is treated from 60% to approximately 64%. In total, accounting for both the Boeing and NASA Service Area Road BMPs, the amount of treated roadway would increase to 69%.

5.1.3 B1 Upper Lot - Boeing

During the Surface Water Expert Panel meeting in July 2016, the Surface Water Expert Panel, Boeing, and Geosyntec performed a site walk to identify areas where additional BMPs could be installed to target unaddressed high priority areas, based on the results of the BMP Subarea Prioritization Analysis (Appendix F). In an area southwest of the B1 media filter and northeast of the upper parking lot, a shotcrete-lined sump was identified with two storm drain inlets, parking lot and roadway sheetflow inlets, and one storm drain outlet (see Figure 15).

The entrance to the storm drain outlet is where the B1BMP0003 sample is collected (ranked 15 overall, 3 for dioxins, 70.5 for metals, and 76.5 for TSS), which due to its relatively high rank has been targeted for treatment as noted in previous discussions. The drainage area to the proposed BMP reflects runoff from approximately 4.8 acres of mixed paved areas and unpaved open space. Runoff to the location enters the culvert that passes under the road, and flows untreated into the Northern Drainage. One of the storm drain inlets drains a largely open space area and therefore is not a priority for treatment, and will be bypassed; however, the other inlets drain roadway and parking lot areas which represent potential pollutant sources.

The Surface Water Expert Panel has recommended that similar media used in other BMPs (e.g., lower lot biofilter, B1, CMs) be installed within the sump along with a typical outlet structure and perforated underdrains to capture and treat runoff from the high priority roadway and parking lot areas (see Figure 16 for conceptual rendering of this BMP). Boeing is moving forward with the design and construction of this BMP. This design is consistent with the B1 media filter, and is expected to perform similarly.

Modeling results indicate that the proposed system is estimated to capture 95% of the Site design storm. Effluent concentrations are expected to be similar to results measured at the nearby B-1 media filter, proven to be effective for removal of dioxins and lead. Maintenance and inspection frequency is anticipated to be identical to what is performed at the B-1 media filter. This would include removal of debris, and long-term maintenance replacement of media as needed.

Figure 15. Proposed Location of the B1 Upper Lot BMP

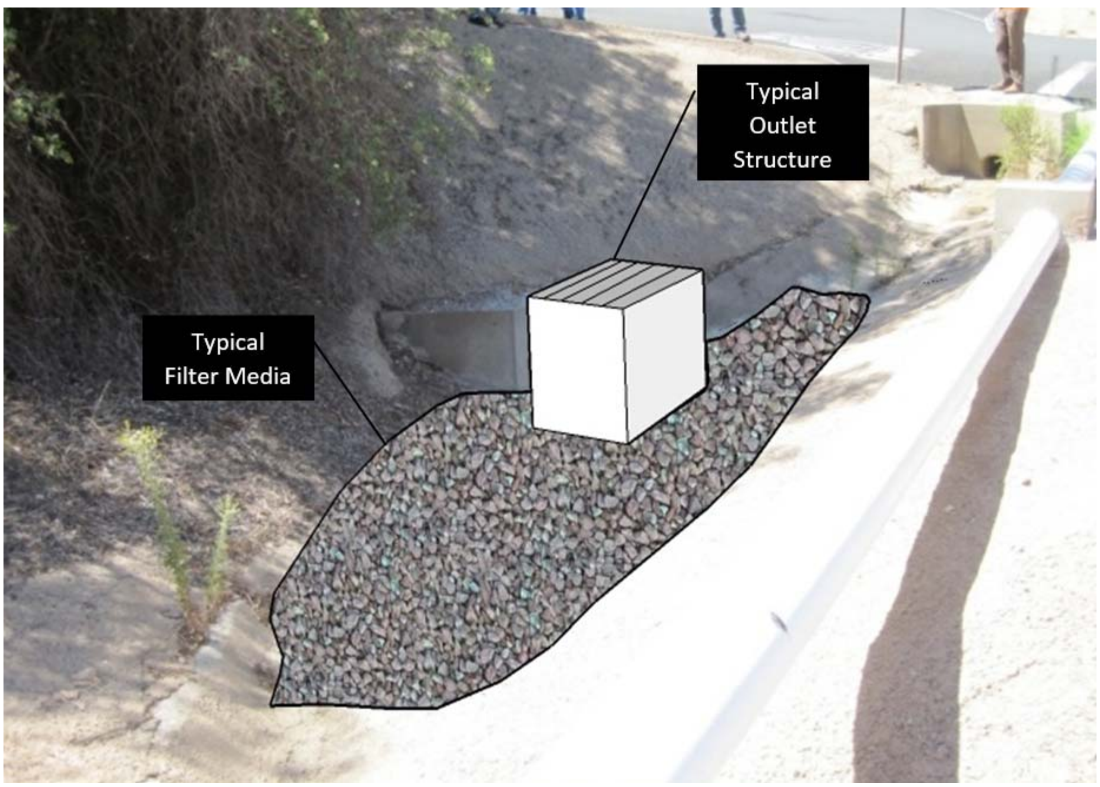


Figure 16. Proposed Rendering of the B1 Upper Lot BMP

5.1.4 Administrative Area - Boeing

Runoff from the paved Boeing Administrative area drains to the lower parking lot 24-inch storm drain, a portion of which is diverted to the lower lot cistern and media filter. As reported in the BMP Subarea Prioritization Analysis (Appendix F), stormwater monitoring location ILBMP0001 reflects the bypassed flow, and has continued to rank within the top 20 sites based on an overall score of 19 (ranked 11 for dioxins, 70.5 for metals, and 25 for TSS). To address this continued high rank, five storm drain inlets were identified around the Administration area for potential treatment. Since typical surface media filters cannot be installed upstream of these inlets due to space limitations, the Surface Water Expert Panel recommends initial installation of inlet filter bags to provide some filtering of coarse and medium sediments from this paved surface runoff at these locations.. The inlet filters are intended to reduce dioxin and lead concentrations measured at the 24" storm drain outlet, and to provide pretreatment for small storms routed to the biofilter. Boeing is currently evaluating and selecting these inlet filter bags and plans to install these in 2016 if possible. As shown in Figure 17 (bottom right), the inlet shown along the roadway is not conducive to a filter bag installation, therefore this location will include a sand bag berm upstream of the inlet to provide detention and capture of coarse sediments , to the extent feasible without resulting in flooding. Maintenance will require inspection after all large storms, and removal of debris/sediment as needed.

Figure 17. Administration Area Storm Drain Inlets Proposed for Filter Bags

5.1.5 Asphalt Swale near ELV Area – NASA

As documented in the BMP Subarea Prioritization Analysis (Appendix F), monitoring location APBMP001-A, which reflects runoff from a 0.32-acre section of the Area II road near the ELV treatment BMP, was ranked 20 overall, 37 for dioxins, 10.5 for metals, and 5 for TSS. Based on observations during storm events, runoff from the roadway just north of the ELV treatment BMP has been flowing into the adjacent asphalt swale along the southern side of the roadway, ultimately entering a culvert that passes under the road, flowing directly to outfall 009. The Surface Water Expert Panel recommended installing sand bags as shown in Figure 18 to redirect the runoff back onto Service Area Road, and east toward CM-1 for treatment. NASA completed this BMP in Second Quarter 2016. The treatment capacity of CM-1 is not anticipated to be heavily impacted, as diverting this runoff will result in a less than 1% increase to the existing contributing drainage area.

Figure 18. Sand Bags Proposed Across ELV Asphalt Swale

5.1.6 LOX Area - NASA

Resulting from observations made onsite during the July Surface Water Expert Panel meeting, the Surface Water Expert Panel has recommended that the sand bag berms at the entrance to the LOX site be extended southwest. The new sand bag berms are to border both sides of the road (at a typical curb height), where it crosses the Northern Drainage (Figure 19). This improvement is intended to detain runoff and lengthen flow paths prior to entry into the Northern Drainage. NASA completed this improvement in the Fourth Quarter of 2016.

Figure 19. Proposed Location of Sand Bags to Divert Stormwater to Adjacent Vegetated Areas

5.1.7 CM-1 Weir Board Maintenance

It is recommended that modifications to the CM-1 weir boards be made to prevent stormwater bypass around the CM-1 filter media mounds. Weir boards should continue to be inspected regularly, and replaced, or repaired on an as-needed basis. A needed repair was observed during the July 2016 Surface Water Expert Panel site visit, consisting of replacement of the CM-1 weir boards and filter fabric, which was observed to have a hole through it. NASA completed this repair in the Third Quarter 2016.

5.2 Monitoring Recommendations

The sections below outline recommendations made by the Surface Water Expert Panel, with respect to stormwater monitoring of potential and existing BMP subareas as well as water level and flow bypass monitoring at specific BMPs in watershed 009, continuation of the RMMP along the Northern Drainage, and potential additions to the non-industrial source special study.

5.2.1 Stormwater Monitoring

Informed by the data analyses performed above, the following recommendations are made for the 2016/2017 stormwater monitoring program, as documented in the *2016/2017 Sampling and Analysis Plan (SAP) Updates, Best Management Practice (BMP) Monitoring Program* (MWH, 2016):

- Discontinue sampling at the B-1 media filter since positive performance has been demonstrated with respect to improving water quality, and events sampled are well distributed across a variety of storm depths and average intensities (B1BMP0004 [influent north], B1BMP0005 [influent south], and B1BMP0006 [effluent]).
- Discontinue sampling at the vegetated channel since no notable water quality improvement has been demonstrated (B1BMP0008 [upstream] and B1BMP0007 [downstream]).
- Temporarily discontinue sampling at LOX monitoring locations until remediation begins (LXBMP0007, LXBMP0008, LXBMP0009, and LXBMP0006).
- At the proposed Service Area Road BMP at CM-10, add two influent monitoring locations to monitor runoff entering the drop inlet on the north side of the road (LXBMP0010) and along the drainage from the undeveloped hill slope south of CM-10 prior to reaching the basin area (LXBMP0011), and one effluent monitoring location at the underdrain (LXBMP0012).
- At the proposed BMP at the B-1 upper parking lot (a media filter), add two influent monitoring locations to monitor sheet flow from the upper lot (B1BMP0010) and the main road culvert (B1BMP0009), and one effluent monitoring location at the underdrains (B1BMP0011), and discontinue monitoring at the previous location (B1BMP0003).
- At the Helipad BMP monitoring location (EVBMP0002), only collect samples at this location when the sand bag berm is being overtopped and samples should be of the overflow.
- At the B1436 detention bioswales, prioritize monitoring at the northern swale (ILBMP0006 and ILBMP0007) to increase the BMP performance monitoring dataset for the northern swale.
- Continue inspection of all BMPs during storm events, including BMPs that do not have active sampling locations.
- In addition to data collected by the water level monitoring pressure transducers themselves, the day following the storm event, visual inspections of maximum ponding levels at all BMPs with such meters should be recorded (see Section 5.2.2).
- For all inspections (event-based and post-event), complete the standardized BMP inspection form, including observations of max depth of ponding on weir boards, nearby erosion, extended ponding (i.e., poor drainage), occurrence or indications of bypass or overflow, presence of underdrain flow, sediment accumulation (and need for removal), condition of filter fabric (e.g., excessively weathered/worn or sediment buildup), condition of inlet/outlet structures (e.g., debris clogging them), and any other maintenance needs. As specified on the form, a standardized framed photo should be taken at the same location, facing the same direction, at each site visit.

Two types of BMP-specific monitoring are also proposed for the 2016/2017 reporting year (approximately 5-month deployment for both):

- Media Filter Water Level Monitoring: To assess specific performance metrics of the media filters at representative locations, it is recommended that pressure transducers be installed to track the overflow frequency and BMP drain time. This data will inform the condition of the underlying media filter, specifically with respect to clogging, which could inhibit BMP performance.
- Bypass Monitoring: To assess the frequency of weir overflow and the volume of water that bypasses the lower lot biofilter treatment system, a velocity-depth probe is recommended to be installed in the 24-inch storm drain outlet.

5.2.2 Northern Drainage

As specified in the RMMP, channel monitoring will continue into the 2016/2017 reporting year (year 5 of 5).

5.2.3 Non-Industrial Source Special Study

Monitoring activities associated with the Non-Industrial Source Special Study will continue into the 2016/2017 reporting year, as specified in Section 2.4 and Appendix C.

6 Milestones/Schedule

Following BMPs/treatment control implementation, effectiveness of these measures will be evaluated primarily by the results of surface water samples collected at outfalls, supplemented by any subarea data collected as part of the 2015 Work Plan. These sampling results will continue to be reviewed annually to determine whether additional upgrades may be warranted. If required, a Work Plan Addendum may be submitted for LARWQCB review and approval. The following milestones are planned for the remainder of the NPDES Permit term.

2016:

2016/2017 Reporting Year	Perform monitoring as described in the 2015 Work Plan and any modifications identified in the 2015/16 Annual Report.
Summer – Fall 2016	Implement BMP, maintenance, and special study recommendations following approval of necessary permits, contractor selection and completion of required surveys. Work may be phased based on the scope of work identified in the Work Plan.

2017:

October 2017	Submit Site-wide Stormwater 2016/17 Annual Report.
2017/2018 Reporting Year	Perform monitoring as described in the 2015 Work Plan and any modifications identified in the 2016/17 Annual Report.
Summer – Fall 2017	Implement BMP, maintenance, and special study recommendations following approval of necessary permits, contractor selection and completion of required surveys. Work may be phased based on the scope of work identified in the Work Plan.

2018:

October 2018	Submit Site-wide Stormwater 2017/18 Annual Report.
2018/2019 Reporting Year	Perform monitoring as described in the 2015 Work Plan and any modifications identified in the 2017/18 Annual Report.
Summer – Fall 2018	Implement BMP, maintenance, and special study recommendations following approval of necessary permits, contractor selection and completion of required surveys. Work may be phased based on the scope of work identified in the Work Plan.

2019:

October 2019	Submit Site-wide Stormwater 2018/19 Annual Report.

2020:

March 2020	NPDES Permit Expires March 31, 2020
	Future activities to be determined based on Permit renewal

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Appendix A: 2015/2016 Reporting Year Sampling and Analysis Plan

BOEING

The Boeing Company
Santa Susana Field Laboratory
5800 Woolsey Canyon Road
Canoga Park, CA 91304-1148

Via E-Mail to losangeles@waterboards.ca.gov

November 11, 2015
In reply refer to SHEA-115350

Ms. Cassandra Owens
Regional Water Quality Control Board
Los Angeles Region
320 West 4th Street, Suite 200
Los Angeles, CA 90013

Dear Ms. Owens:

Subject: 2015/2016 Rainy Season Sampling and Analysis Plan (SAP) Updates, Best Management Practice (BMP) Monitoring Program
Compliance File CI No. 6027 and NPDES No. CA0001309
Santa Susana Field Laboratory, Ventura County, California

The Boeing Company (Boeing) is providing the attached BMP Monitoring Sampling and Analysis Plan for the Outfall 009 Watershed for the 2015/2016 rainy season, as referenced in the Site-Wide Stormwater Work Plan and 2014/15 Annual Report. This document has been developed with input and in accordance with recommendations from the Santa Susana Stormwater Expert Panel and prepared for Boeing and the National Aeronautics and Space Administration (NASA). The attached plan will be posted on the Boeing External website at the following address: http://www.boeing.com/principles/environment/santa-susana/interim-source-removal.page.

If you have any questions or require anything further, please contact Art Lenox at 818-466-8795.

Sincerely,

for:

Paul J. Costa
Environmental Operations and Compliance
Environment, Health and Safety

Attachment: 2015/2016 Rainy Season Sampling and Analysis Plan (SAP) Updates, Best Management Practice (BMP) Monitoring Program

Cc: Mr. Peter Raftery, RWQCB, e-copy only
Mr. Mazhar Ali, RWQCB, e-copy only
Mr. Buck King, DTSC, e-copy only
Mr. Allen Elliott, NASA, e-copy only
Mr. Peter Zorba, NASA, e-copy only
Dr. Michael Stenstrom, Surface Water Expert Panel, e-copy only
Mr. Jon Jones, Surface Water Expert Panel, e-copy only
Dr. Mike Josselyn, Surface Water Expert Panel, e-copy only
Dr. Robert Pitt, Surface Water Expert Panel, e-copy only
Dr. Robert Gearheart, Surface Water Expert Panel, e-copy only
Mr. Randy Dean, CH2M HILL, e-copy only
Mr. Brandon Steets, Geosyntec, e-copy only
Mr. Alex Fischl, MWH, e-copy only
Ms. Allison Ruotolo-Lo, e-copy only
Ms. Lissa Miller, Haley & Aldrich, e-copy only

BUILDING A BETTER WORLD

November 3, 2015

Mr. Art Lenox
The Boeing Company
Santa Susana Field Laboratory
5800 Woolsey Canyon Road
Canoga Park, CA 91304

Mr. Pete Zorba
National Aeronautics and Space Administration
Santa Susana Field Laboratory
5800 Woolsey Canyon Road
Canoga Park, CA 91304

Subject: 2015/2016 Rainy Season Sampling and Analysis Plan (SAP) Updates, Best Management Practice (BMP) Monitoring Program

Dear Mr. Lenox and Mr. Elliott:

This letter presents the sampling and analysis plan (SAP) updates to the potential Best Management Practice (BMP) subarea and BMP performance monitoring programs within the Outfalls 008 and 009 watersheds at the Santa Susana Field Laboratory (SSFL) for the 2015/2016 rainy season, and serves as an addendum to the 2014/2015 rainy season SAP (MWH Americas, Inc. [MWH], 2014). Potential BMP subarea monitoring is conducted at locations receiving runoff from potential source areas and other infrastructure (e.g., roads, buildings, parking areas) to evaluate the potential for contribution of constituents of concern (COCs) from the potential source areas to stormwater runoff and to identify locations for new BMPs. BMP performance monitoring is conducted at BMPs (e.g., B-1 Media Filter, Lower Parking Lot BMP) to assess the effectiveness of the structural BMPs at promoting sediment settling and improving surface water quality to comply with NPDES permit limits at Outfalls 008 and 009. The Interim Source Removal Action (ISRA) performance monitoring program has been discontinued as monitoring at each ISRA area has been performed for a minimum period of two years as specified in the ISRA Work Plan (MWH, 2009) and sufficient performance monitoring data has been collected to indicate that ISRA activities have successfully reduced the contribution of ISRA COCs from ISRA areas to surface water runoff (MWH *et al.*, 2015). The results and recommendations from the 2015/2016 rainy season will be presented in the Site-wide Stormwater 2015/2016 Annual Report.

The updates to the BMP monitoring program SAP for the 2015/2016 rainy season account for field observations of monitoring locations during the 2014/2015 rainy season and an evaluation of surface water sampling data collected to date, and are described below. In addition, attached to this letter are 2015/2016 rainy season versions of the SAP tables and figures. The changes described in this letter were developed with input from and in accordance with the recommendations from the SSFL Surface Water Expert Panel (Expert Panel) and Geosyntec Consultants (Geosyntec), and were initially presented in the 2014/2015 Rainy Season Annual Report (MWH *et al.*, 2015).

BMP Monitoring Updates

Outfall 009

- Within the B-1 area, add downstream monitoring location B1BMP0008 at the B-1 storm drain outlet (Figure 2).

- Monitoring of the B1436 Detention Bioswales will be prioritized to maximize the number of samples collected at this treatment BMP (Figure 3).

- Along Area II (or Service Area) Road, add two BMP subarea monitoring locations to characterize road runoff, including monitoring location A1BMP0004 at a storm drain culvert inlet between CM-8 and CM-9 (Figure 3) and monitoring location EVBMP0010 at a storm drain culvert inlet west of CM-1 (Figure 5). Additional locations may be added during the rainy season based on field observations.

- At the Helipad, monitoring of EVBMP0002 will be prioritized and a sample of runoff will be collected during every rain event when runoff flows past the eastern Helipad berm and down Helipad Road to the ELV treatment BMP collection basin. In addition, a sample of runoff will be collected at EVBMP0002 if the plug in the sump at the bottom of the spillway from the Helipad is removed and Helipad runoff flows through the culvert under Helipad Road to the Northern Drainage (Figure 5).

- At the AP/STP area, add BMP subarea monitoring location APBMP0003 to characterize runoff within the AP/STP drainage (Figure 6).

Sincerely,
MWH

Alex Fischl, PMP
Project Manager

Allison Ruotolo-Lo, P.G. 9105
Professional Geologist

Attachments

Table 1, BMP Monitoring Inspection Locations and Analytical Plan

Figure 1, Outfalls 008 and 009, BMP Monitoring Locations
Figure 2, Outfall 009, BMP Monitoring Locations, B-1 and Lower Parking Lot Areas – Boeing
Figure 3, Outfall 009, BMP Monitoring Locations, AILF and IEL Areas – Boeing
Figure 4, Outfall 009, BMP Monitoring Locations, LOX Area – NASA
Figure 5, Outfall 009, BMP Monitoring Locations, A2LF and ELV Areas – NASA
Figure 6, Outfall 009, BMP Monitoring Locations, AP/STP Area – NASA

References

MWH, 2009. Final Interim Source Removal Action (ISRA) Work Plan, Santa Susana Field Laboratory, Ventura County, California. May.

MWH, 2014. 2014/2015 Rainy Season Sampling and Analysis Plan (SAP) Updates, Best Management Practice (BMP) Monitoring and ISRA Performance Monitoring Programs. October 29.

MWH, Santa Susana Field Laboratory Surface Water Expert Panel, and Geosyntec Consultants, 2015. ISRA Performance Monitoring and BMP Monitoring for Outfalls 008 and 009 Watersheds, 2014/2015 Rainy Season, Santa Susana Field Laboratory, Ventura County, California. August 31.

Table 1
BMP Monitoring Inspection Locations and Analytical Plan
2015/2016 Rainy Season

Object ID	Location	Areas Monitored	Purpose	Notes	Metals (Total Recoverable) (Method 200.7/200.8)	Metals (Total Dissolved) (Method 200.7/200.8)	Cd, Cu, Pb, Hg (Total Dissolved) (Method 200.7/200.8)	Cd, Cu, Pb, Hg (Total Recoverable) (Method 200.7/200.8)	Dioxins (Method 1613)	Total Suspended Solids (Method 2540)	Particle Size Distribution (Method ASTM D422)	Turbidity (Method 180.1)
Outfall 009 Watershed												
A1BMP0002	AILF	CM-9, AILF	US South, Treatment BMP Performance Monitoring	AILF tributary drainage			X	X	X	X	X	
A1BMP0003	AILF	CM-9, AILF, IEL, Area II Road	DS, Treatment BMP Performance Monitoring	CM-9 underdrain			X	X	X	X	X	
A1BMP0004	Area 2 Road	Area 2 Road Runoff	Potential BMP Location	Storm drain inlet on north side of road	X	X			X	X	X	X
A2BMP0001	A2LF	A2LF	Potential BMP Location	Tributary drainage, west	X	X			X	X	X	X
A2BMP0002	A2LF	A2LF	Potential BMP Location	Tributary drainage, east	X	X			X	X	X	X
A2BMP0006	CM-1	CM-1	US East, Treatment BMP Performance Monitoring	CM-1 eastern tributary drainage			X	X	X	X	X	
A2BMP0007	CM-1	CM-1	DS, Treatment BMP Performance Monitoring	CM-1 culvert outlet			X	X	X	X	X	
A2BMP0008	Well-13 Road	Well-13 Road Runoff	Potential BMP Location	Culvert inlet on north side of Well-13 Road	X	X			X	X	X	X
A2BMP0009	Well-13 Road	Well-13 Road Runoff	Potential BMP Location	Culvert outlet above the Northern Drainage and east of OF009 autosamplers pad	X	X			X	X	X	X
A2BMP0010	Well-13 Road	Well-13 Road Runoff	Potential BMP Location	Culvert outlet on west side of Well-13 Road, mid-point along roadway	X	X			X	X	X	X
A2BMP0011	Well-13 Road	Well-13 Road and Area 2 Road Runoff	Potential BMP Location	Culvert outlet on west side of Well-13 Road, just north of Service Area Road	X	X			X	X	X	X
APBMP0001	Ash Pile	AP/STP, ELV	Potential BMP Location	Area II Road asphalt swale	X	X			X	X	X	X
APBMP0003	Ash Pile	AP/STP	Potential BMP Location	AP/STP drainage	X	X			X	X	X	X

Table 1
BMP Monitoring Inspection Locations and Analytical Plan
2015/2016 Rainy Season

Object ID	Location	Areas Monitored	Purpose	Notes	Metals (Total Recoverable) (Method 200.7/200.8)	Metals (Total Dissolved) (Method 200.7/200.8)	Cd, Cu, Pb, Hg (Total Dissolved) (Method 200.7/200.8)	Cd, Cu, Pb, Hg (Total Recoverable) (Method 200.7/200.8)	Dioxins (Method 1613)	Total Suspended Solids (Method 2540)	Particle Size Distribution (Method ASTM D422)	Turbidity (Method 180.1)
Outfall 009 Watershed (continued)												
B1BMP0003	B-1	B-1, Upper Parking Lot	US Monitoring Location of Vegetated Area Downstream of B-1 Media Filter	Culvert inlet			X	X	X	X	X	
B1BMP0004	B-1	B-1 Media Filter	US North, Treatment BMP Performance Monitoring	Tributary drainage			X	X	X	X	X	
B1BMP0005	B-1	B-1 Media Filter	US South, Treatment BMP Performance Monitoring	Asphalt swale downstream of B-1 retention basin discharge			X	X	X	X	X	
B1BMP0006	B-1	B-1 Media Filter	DS, Treatment BMP Performance Monitoring	B-1 Media Filter underdrain			X	X	X	X	X	
B1BMP0007	B-1	Vegetated Area DS of B-1 Media Filter and Upper Parking Lot	DS Monitoring Location of Vegetated Area DS of B-1 Media Filter and Upper Parking Lot	Tributary drainage; DS of B-1 storm drain culvert outlet and US of Lower Parking Lot BMP discharge to Northern Drainage			X	X	X	X	X	
B1BMP0008	B-1	DS of B-1 Media Filter and Upper Parking Lot	DS Monitoring Location of B-1 Media Filter and Upper Parking Lot	B-1 storm drain culvert outlet			X	X	X	X	X	
EVBMP0001	ELV	ELV, Helipad	ELV Treatment BMP Overflow Monitoring	Culvert inlet; runoff will only be present when rain events exceed ELV BMP design storm	X	X			X	X	X	X
EVBMP0002	ELV, Helipad	Helipad	Helipad BMP Overflow Monitoring	Spillway inlet	X	X			X	X	X	X
EVBMP0003	CM-1	CM-1, Area II Road	US West, Treatment BMP Performance Monitoring	Sheetflow along Area II Road upstream of sandbag berm			X	X	X	X	X	
EVBMP0007	ELV	ELV Treatment BMP	US, Treatment BMP Performance Monitoring	Sample port in BMP influent pipe prior to "T" connection			X	X	X	X	X	
EVBMP0008	ELV	ELV Treatment BMP	DS, Treatment BMP Performance Monitoring	Discharge from media filter tank pipe			X	X	X	X	X	X

Table 1
BMP Monitoring Inspection Locations and Analytical Plan
2015/2016 Rainy Season

Object ID	Location	Areas Monitored	Purpose	Notes	Metals (Total Recoverable) (Method 200.7/200.8)	Metals (Total Dissolved) (Method 200.7/200.8)	Cd, Cu, Pb, Hg (Total Dissolved) (Method 200.7/200.8)	Cd, Cu, Pb, Hg (Total Recoverable) (Method 200.7/200.8)	Dioxins (Method 1613)	Total Suspended Solids (Method 2540)	Particle Size Distribution (Method ASTM D422)	Turbidity (Method 180.1)
Outfall 009 Watershed (continued)												
EVBMP0009	ELV	ELV Treatment BMP	Mid-Point Treatment BMP Performance Monitoring	Composite of samples from eastern and western sample ports between settling tanks and media filter			X	X	X	X	X	X
EVBMP0010	ELV	Area 2 Road Runoff	Potential BMP Location	Storm drain inlet on north side of road	X	X			X	X	X	X
ILBMP0001	Lower Parking Lot	IEL	Potential BMP Location	Culvert discharge under spillway chute	X	X			X	X	X	X
ILBMP0002	AILF	CM-9, IEL, Area II Road	US East, Treatment BMP Performance Monitoring	Culvert inlet off Area II Road			X	X	X	X	X	
ILBMP0004	IEL	B1436 Southern Detention Bioswale	US, Treatment BMP Performance Monitoring	Concrete swale (western) diverting sheetflow into rock crib			X	X	X	X	X	
ILBMP0005	IEL	B1436 Southern Detention Bioswale	DS, Treatment BMP Performance Monitoring	Bioswale underdrain (subsurface 12-inch drain connecting to existing culvert)			X*	X*	X*	X	X	
ILBMP0006	IEL	B1436 Northern Detention Bioswale	US, Treatment BMP Performance Monitoring	Curb cut in concrete curb along east side of bioswale			X	X	X	X	X	
ILBMP0007	IEL	B1436 Northern Detention Bioswale	DS, Treatment BMP Performance Monitoring	Bioswale underdrain (subsurface 12-inch drain connecting to existing culvert)			X*	X*	X*	X	X	
ILBMP0008	IEL	B1436 Southern Detention Bioswale	US, Treatment BMP Performance Monitoring	Concrete swale (eastern) diverting sheetflow into rock crib			X	X	X	X	X	
LPBMP0002	Lower Parking Lot	Lower Parking Lot BMP	US, Treatment BMP Performance Monitoring	Sample port in cistern discharge pipe			X	X	X	X	X	
LPBMP0003	Lower Parking Lot	Lower Parking Lot BMP	Mid-Point Treatment BMP Performance Monitoring	Sediment Basin outlet box			X	X	X	X	X	
LPBMP0004	Lower Parking Lot	Lower Parking Lot BMP	DS, Treatment BMP Performance Monitoring	Discharge from Biofilter effluent pipe			X	X	X	X	X	
LXBMP0006	LOX	LOX	Potential BMP Location	Sheetflow along dirt road	X	X			X	X	X	X

Object ID	Location	Areas Monitored	Purpose	Notes	Metals (Total Recoverable) (Method 200.7/200.8)	Metals (Total Dissolved) (Method 200.7/200.8)	Cd, Cu, Pb, Hg (Total Dissolved) (Method 200.7/200.8)	Cd, Cu, Pb, Hg (Total Recoverable) (Method 200.7/200.8)	Dioxins (Method 1613)	Total Suspended Solids (Method 2540)	Particle Size Distribution (Method ASTM D422)	Turbidity (Method 180.1)
Outfall 009 Watershed (continued)												
LXBMP0007	LOX	LOX Sandbag Berm and Slope Drains	DS, BMP Performance Monitoring	Slope drain inlet			X	X	X	X	X	
LXBMP0008	LOX	LOX Sandbag Berm and Slope Drains	DS, BMP Performance Monitoring	Slope drain inlet			X	X	X	X	X	
LXBMP0009	LOX	LOX Sandbag Berm and Slope Drains	Alternate DS, BMP Performance Monitoring	Slope drain inlet			X	X	X	X	X	

Abbreviations:

CM - Culvert Modification

DS - Downstream

US - Upstream

X = Collect and Analyze

Note:

* Collect one equipment blank per sampling day from the equipment used to sample the B1436 Detention Bioswales downstream monitoring locations (under drains) and place on hold for metals and dioxins analysis; the analyses will be performed if unusual results are reported for primary samples. The EB sample ID will be based on the ID of the primary sample collected immediately before collecting the equipment blank, and will either be ILQW0005 or ILQW0007

Outfalls 008 and 009 BMP Monitoring Locations

Base Map Legend

- Administrative Area Boundary
- RFI Site Boundary
- Subwatershed Boundaries
- NPDES Outfall
- Non Jurisdictional Surface Water Pathway
- Surface Water Divide

Figure Legend

- Discontinued ISRA Performance Monitoring Location
- Potential BMP Subarea Monitoring Location
- Downstream BMP Performance Monitoring Location
- Upstream BMP Performance Monitoring Location
- Mid-Point BMP Performance Monitoring Location
- Discontinued Potential BMP Subarea Monitoring Location
- Alternate BMP Performance Monitoring Location
- B-1 Area Stormwater Conveyance Pipelines (estimated subsurface trace)
- B-1 Area Inferred Stormwater Conveyance Pipeline
- Actual ISRA Excavation Boundary
- Former Planned ISRA Area Boundary

Note:

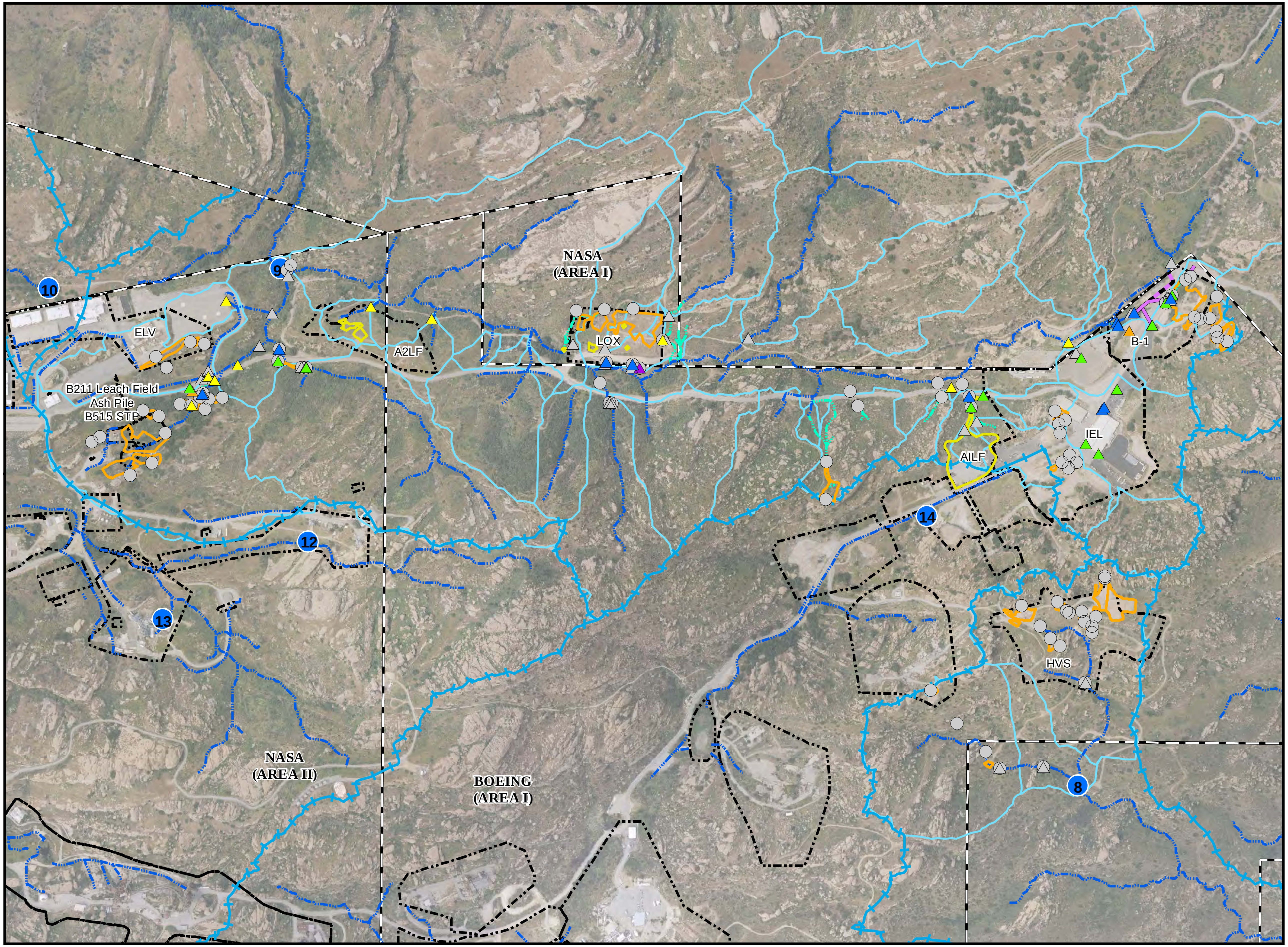
1. Aerial imagery from 2010 Sage Consulting.
2. Topographic contours from 2010 Sage Consulting.
3. Rationale for discontinuing monitoring at previous sample locations can be found in the text and/or tables of the 2010/2011, 2011/2012, 2012/2013, 2013/2014, and 2014/2015 Rainy Season Sampling and Analysis Plan.

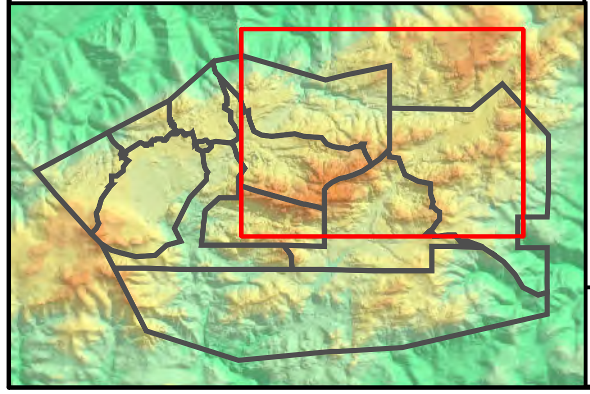
Path: \\SD-004\gist\projects\rock3\ISRA\Figures\PerfMon\2014-2015 Rainy Season\ISRA_BMPOverview_Fig1.mxd

Date: 10/26/2015

1 inch = 700 feet

0 700 1,400 Feet





MWH

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FIGURE 1

Outfall 009
BMP Monitoring Locations, B-1 and Lower Parking Lot Areas - Boeing

Base Map Legend

- Administrative Area Boundary
- Non Jurisdictional Surface Water Pathway
- RFI Site Boundary
- Surface Water Divide
- Drainage

Figure Legend

- Discontinued ISRA Performance Monitoring Location
- Potential BMP Subarea Monitoring Location
- Downstream BMP Performance Monitoring Location
- Upstream BMP Performance Monitoring Location
- Mid-Point BMP Performance Monitoring Location
- Discontinued Potential BMP Subarea Monitoring Location
- Actual ISRA Excavation Boundary
- Asphalt/Concrete Removal Area
- Media Filters
- Sedimentation Basin
- Engineered Natural Treatment System
- Storm Drain (estimated subsurface trace)
- Storm Drain inferred
- Concrete Curb
- Conveyance Pipeline
- Detention Bioswale

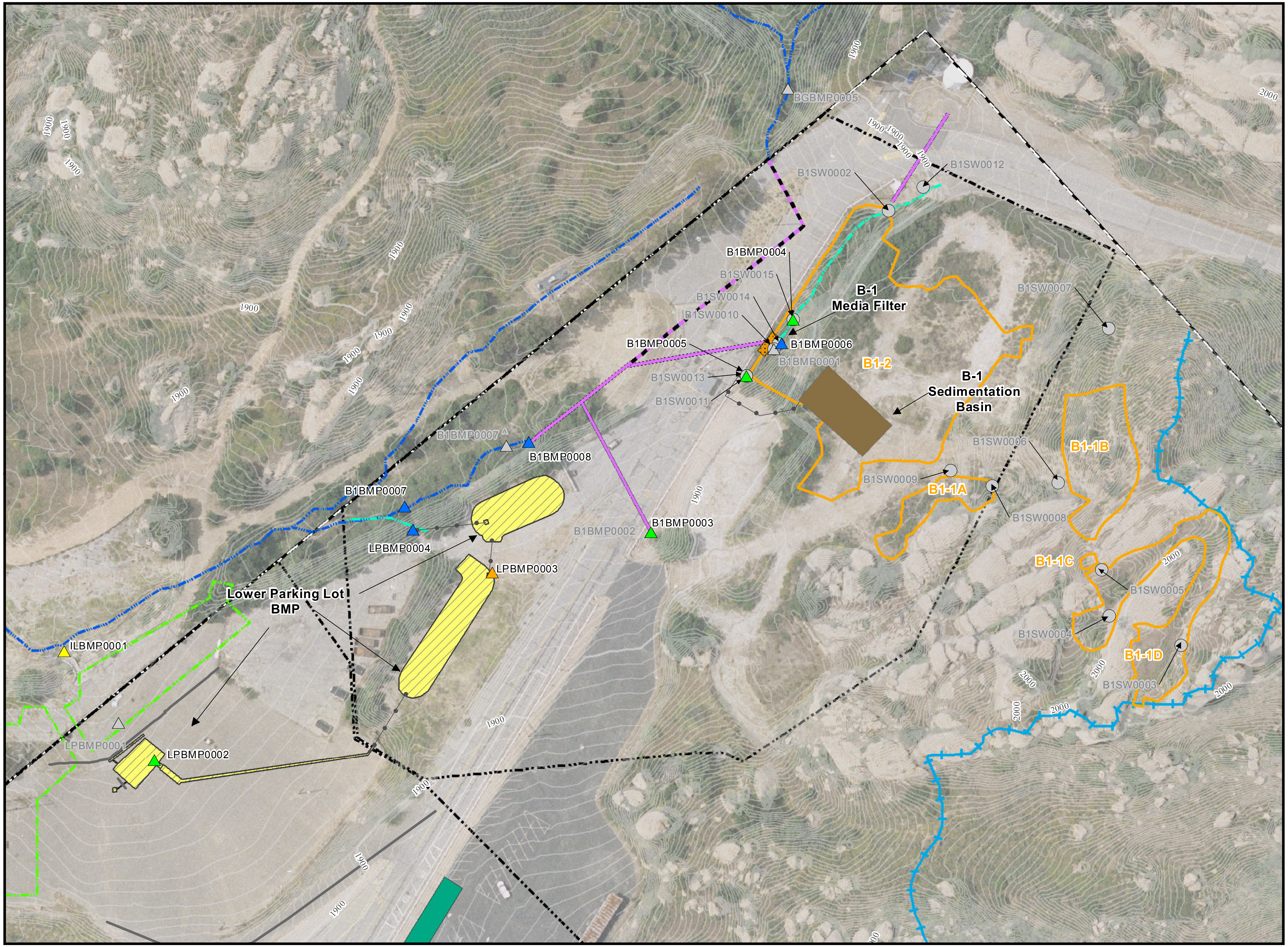
Note:

1. Aerial imagery from 2010 Sage Consulting.
2. Topographic contours from 2010 Sage Consulting.
3. Rationale for discontinuing monitoring at previous sample locations can be found in the text and/or tables of the 2010/2011, 2011/2012, 2012/2013, 2013/2014, and 2014/2015 Rainy Season Sampling and Analysis Plan.
4. Alternate location B1BMP0007A was sampled starting during the 2014/2015 rainy season due to overflow from the Biofilter which occurred upstream of the original B1BMP0007 location

Path: \\SD-004\gist\projects\rock3\ISRA\Figures\PerfMon\2014-2015 Rainy Season\ISRA_BMP\B1_Fig2.mxd
Date: 10/5/2015

1 inch = 100 feet

0 100 200 Feet



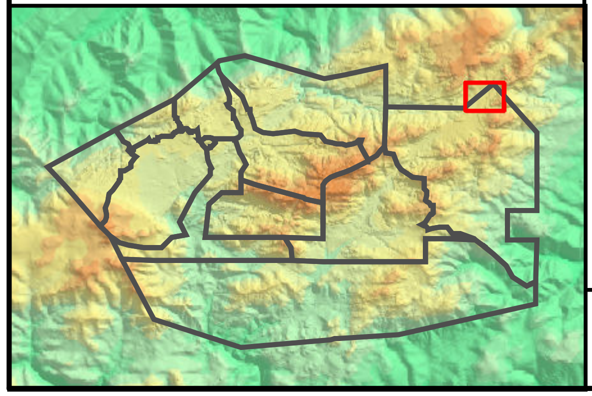


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FIGURE 2

Outfall 009
BMP Monitoring Locations
AILF and IEL Areas - Boeing

Base Map Legend

- Administrative Area Boundary
- RFI Site Boundary
- Drainage
- Non Jurisdictional Surface Water Pathway
- Surface Water Divide

Figure Legend

- Discontinued ISRA Performance Monitoring Location
- Potential BMP Subarea Monitoring Location
- Downstream BMP Performance Monitoring Location
- Upstream BMP Performance Monitoring Location
- Mid-Point BMP Performance Monitoring Location
- Discontinued Potential BMP Subarea Monitoring Location
- Actual ISRA Excavation Boundary
- Former Planned ISRA Area Boundary
- Demolition Area
- Asphalt Removal
- Rock Crib Swale
- Detention Bioswale

Note:

1. Aerial imagery from 2010 Sage Consulting.
2. Topographic contours from 2010 Sage Consulting.
3. Rationale for discontinuing monitoring at previous sample locations can be found in the text and/or tables of the 2010/2011, 2011/2012, 2012/2013, 2013/2014, and 2014/2015 Rainy Season Sampling and Analysis Plan.

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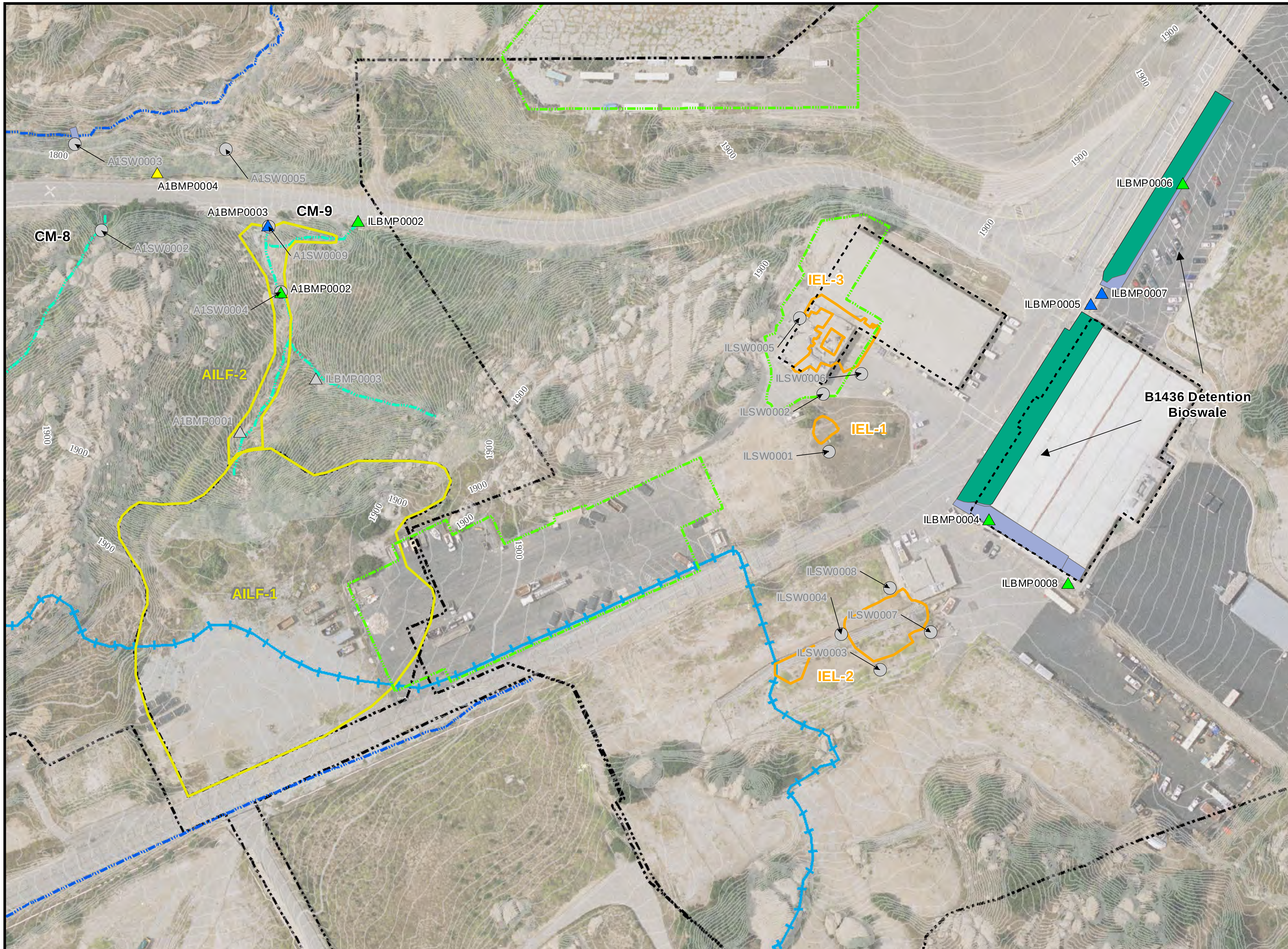
Date: 10/2/2015

1 inch = 115 feet
0 100 200 Feet



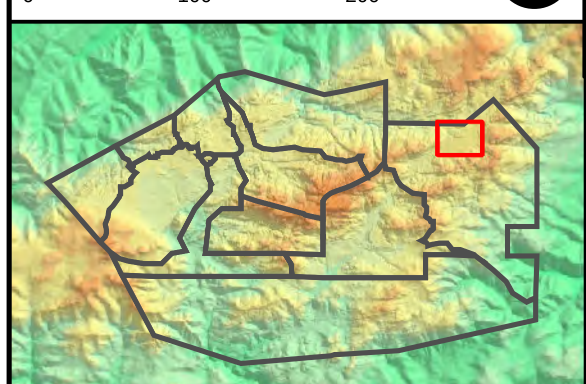


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FIGURE 3

Outfall 009
BMP Monitoring Locations
LOX Area - NASA

Base Map Legend

- Administrative Area Boundary
- RFI Site Boundary
- Non Jurisdictional Surface Water Pathway
- Surface Water Divide

Figure Legend

- Discontinued ISRA Performance Monitoring Location
- Potential BMP Subarea Monitoring Location
- Downstream BMP Performance Monitoring Location
- Discontinued Potential BMP Subarea Monitoring Location
- Alternate BMP Performance Monitoring Location
- Actual ISRA Excavation Boundary
- Former Planned ISRA Area Boundary
- Sandbags
- Slope Drain

Note:
1. Aerial imagery from 2010 Sage Consulting.
2. Topographic contours from 2010 Sage Consulting.
3. Rationale for discontinuing monitoring at previous sample locations can be found in the text and/or tables of the 2010/2011, 2011/2012, 2012/2013, 2013/2014, and 2014/2015 Rainy Season Sampling and Analysis Plan.

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Date: 10/2/2015

1 inch = 80 feet

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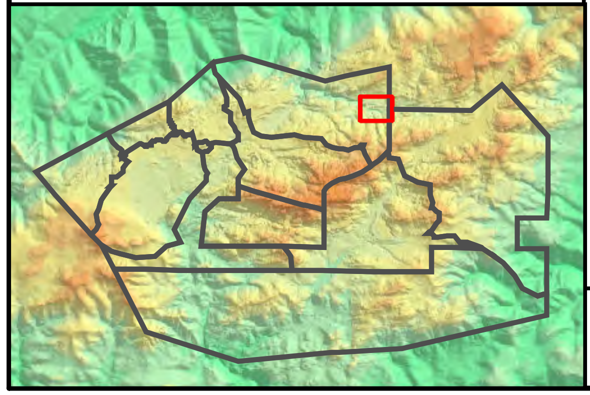

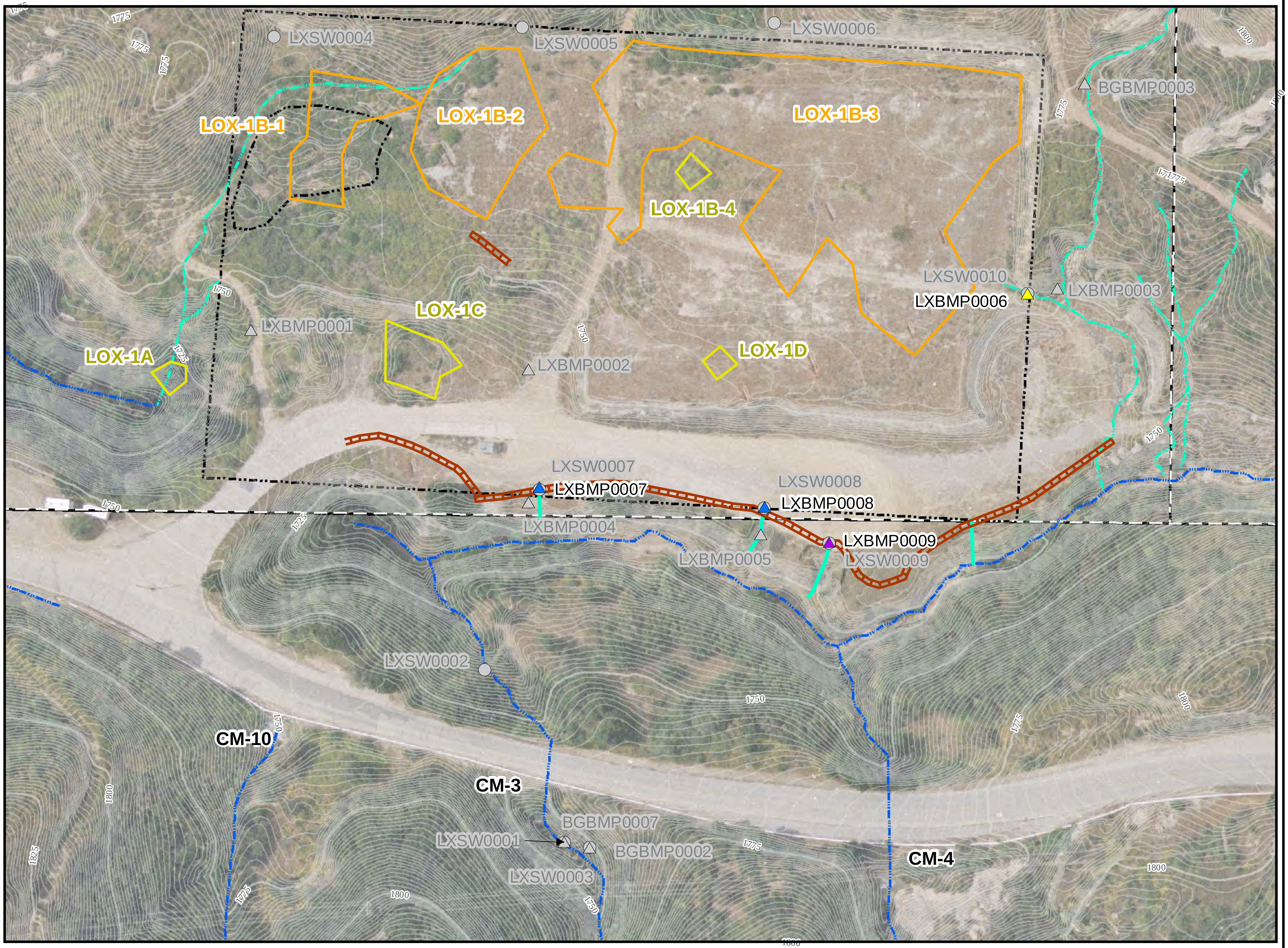

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FIGURE 4

Outfall 009
BMP Monitoring Locations
A2LF and ELV Areas - NASA

Base Map Legend

- Administrative Area Boundary
- RFI Site Boundary
- Non Jurisdictional Surface Water Pathway
- Surface Water Divide
- NPDES Outfall

Figure Legend

- Discontinued ISRA Performance Monitoring Location
- Potential BMP Subarea Monitoring Location
- Downstream BMP Performance Monitoring Location
- Upstream BMP Performance Monitoring Location
- Mid-Point BMP Performance Monitoring Location
- Discontinued Potential BMP Subarea Monitoring Location
- Actual ISRA Excavation Boundary
- Former Planned ISRA Area Boundary
- Sandbags
- Treatment BMP Feature
- Treatment BMP Conveyance Pipeline

Note:

1. Aerial imagery from 2010 Sage Consulting.
2. Topographic contours from 2010 Sage Consulting.
3. Rationale for discontinuing monitoring at previous sample locations can be found in the text and/or tables of the 2010/2011, 2011/2012, 2012/2013, and 2013/2014 Rainy Season Sampling and Analysis Plan.

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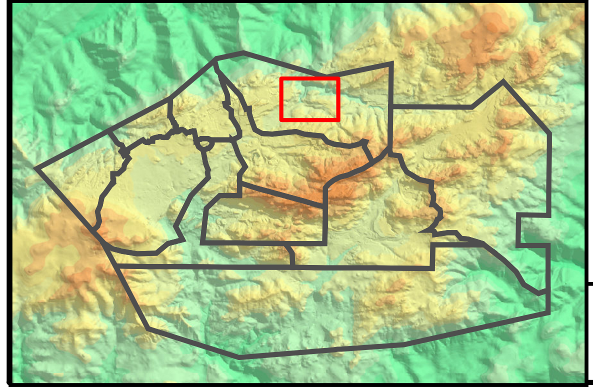
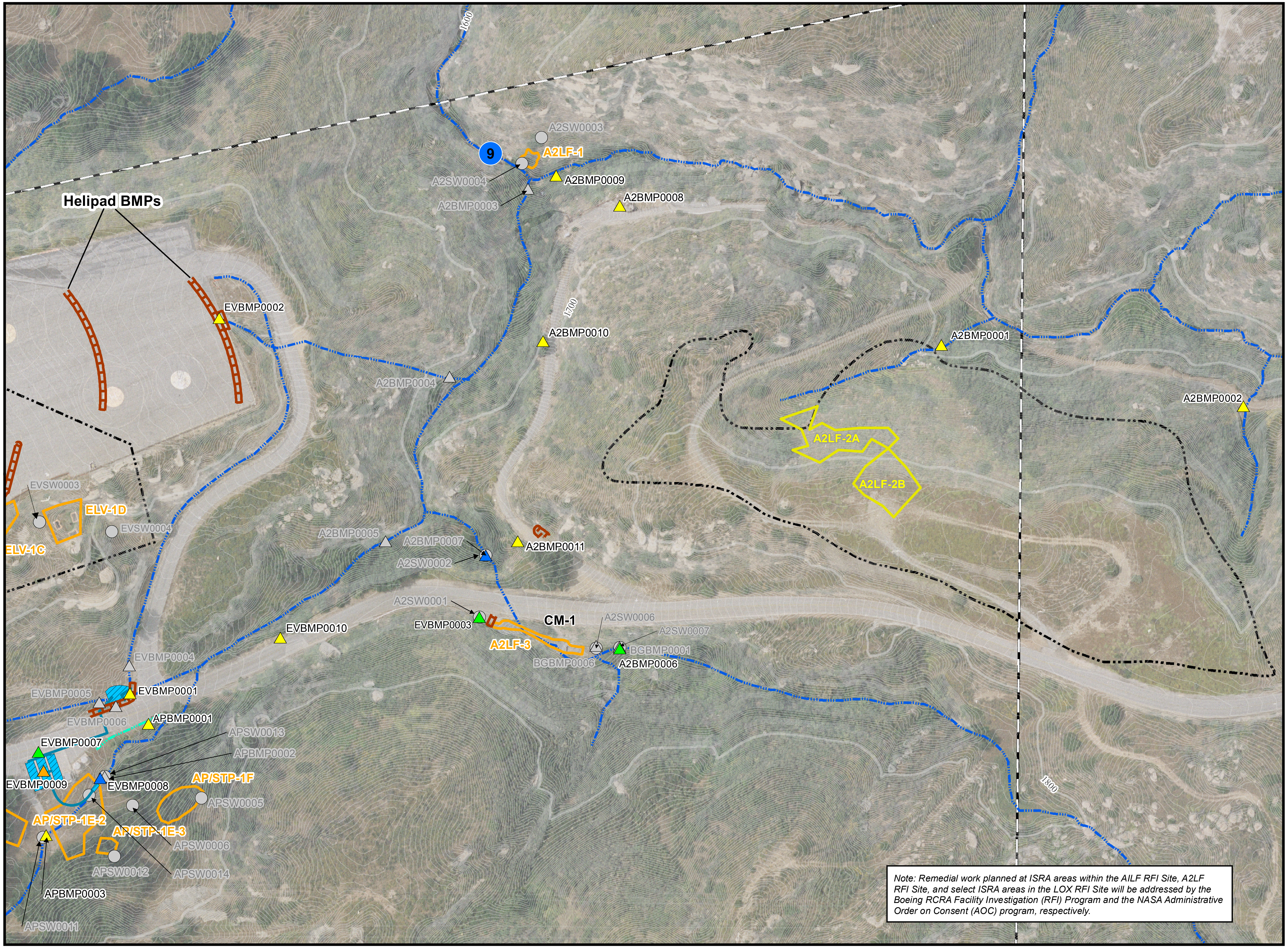
Date: 3/8/2016

1 inch = 140 feet

0 140 280 Feet





Note: Remedial work planned at ISRA areas within the AILF RFI Site, A2LF RFI Site, and select ISRA areas in the LOX RFI Site will be addressed by the Boeing RCRA Facility Investigation (RFI) Program and the NASA Administrative Order on Consent (AOC) program, respectively.

MWH

S A N T A S U S A N A F I E L D L A B O R A T O R Y

FIGURE 5

Outfall 009
BMP Monitoring Locations
AP/STP Area - NASA

Base Map Legend

- Administrative Area Boundary
- RFI Site Boundary
- Drainage
- Non Jurisdictional Surface Water Pathway
- Surface Water Divide

Figure Legend

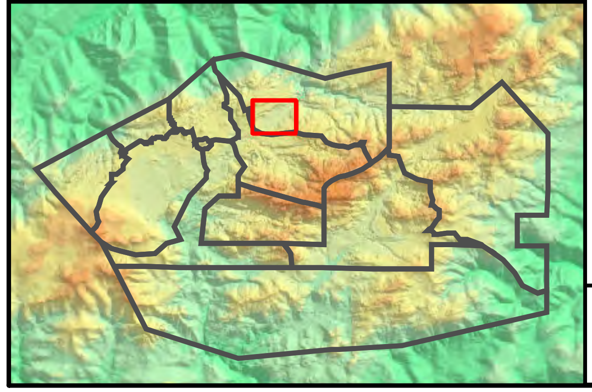
- Discontinued ISRA Performance Monitoring Location
- Potential BMP Subarea Monitoring Location
- Downstream BMP Performance Monitoring Location
- Upstream BMP Performance Monitoring Location
- Mid-Point BMP Performance Monitoring Location
- Discontinued Potential BMP Subarea Monitoring Location
- Actual ISRA Excavation Boundary
- Asphalt/Concrete Removal Area
- Treatment BMP Feature
- Treatment BMP Conveyance - Pipeline

Note:
1. Aerial imagery from 2010 Sage Consulting.
2. Topographic contours from 2010 Sage Consulting.
3. Rationale for discontinuing monitoring at previous sample locations can be found in the text and/or tables of the 2010/2011, 2011/2012, 2012/2013, 2013/2014, and 2014/2015 Rainy Season Sampling and Analysis Plan.

Path: \\SD-004\gist\projects\rock3\ISRA\Figures\PerfMon\2014-2015 Rainy Season\ISRA_BMP\APSTP_Fig6.mxd
Date: 10/26/2015

1 inch = 110 feet

0 110 220 Feet



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S A N T A   S U S A N A   F I E L D   L A B O R A T O R Y

FIGURE 6

Appendix B: Laboratory and Validation Reports

Appendix C: Non-Industrial Sources Special Study Work Plan

Geosyntec consultants

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Memorandum

Date: Originally submitted November 02, 2015

Revised version submitted January 20, 2016

Updated September 09, 2016

To: The Boeing Company

From: Santa Susana Surface Water Expert Panel and Geosyntec Consultants

Subject: Special Monitoring Studies for the 009 Watershed

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1.0 INTRODUCTION

Based on data evaluations performed for the August 2015 Outfall 008 and 009 Annual Rainy Season Report, and in response to continued National Pollutant Discharge Elimination System (NPDES) exceedances for lead and dioxins at Outfall 009, the Expert Panel has recommended new special monitoring studies to further investigate stormwater pollutant sources in the Outfall 009 watershed. Recent Outfall 009 subarea monitoring results indicate that concentrations of lead and dioxins may be elevated in stormwater generated from paved areas (Figures 1 & 2). The proposed studies herein are designed to further investigate these potential source areas. Results will be used to further inform the placement and design of future Best Management Practices (BMPs) in the Outfall 009 watershed and to determine whether the suspected sources of these pollutants of concern are the predominant contributors to the concentrations found in stormwater discharges at Outfall 009. These data will be useful for future communications with the public and Regional Water Quality Control Board regarding why lead and dioxin exceedances persist at Outfall 009 and to help explain their pervasiveness in runoff from urban paved surfaces in metropolitan Los Angeles, California.

The results generated in this study will be novel due to the number and types of potential pollutant sources that are being evaluated at this site. Results will be analyzed with appropriate laboratory methods to be eligible for publication in a peer-reviewed journal[1]. Therefore, data quality is of the utmost importance. Results must be repeatable and defensible and statistically significant differences must be demonstrated to make conclusions about source pollutant contributions. To accomplish this, specific hypotheses have been defined, based on the Expert Panel's questions, which will be tested through the sampling and analysis procedure described herein. Special attention has been paid to sample numbers and background sites have been included, where appropriate. The purpose of this robust sampling and analysis plan is to generate high quality data that will allow for analysis resulting in defensible conclusions.

A Health and Safety Plan has been developed by Geosyntec Consultants and was reviewed by Boeing safety personnel prior to the commencement of the monitoring studies described herein. The Health and Safety Plan is to be followed by all personnel performing on-site activities related to the monitoring studies. Local university student interns are being used to the extent

[1] Geosyntec staff will perform a literature review to identify potential knowledge gaps in current literature that could be bolstered by this study.

feasible on study tasks including field work. Student interns have been properly trained and are escorted throughout the Santa Susana Field Laboratory as necessary.

Figure 1. Dioxin TEQ concentrations measured in stormwater samples collected from 2004 to 2016[2].

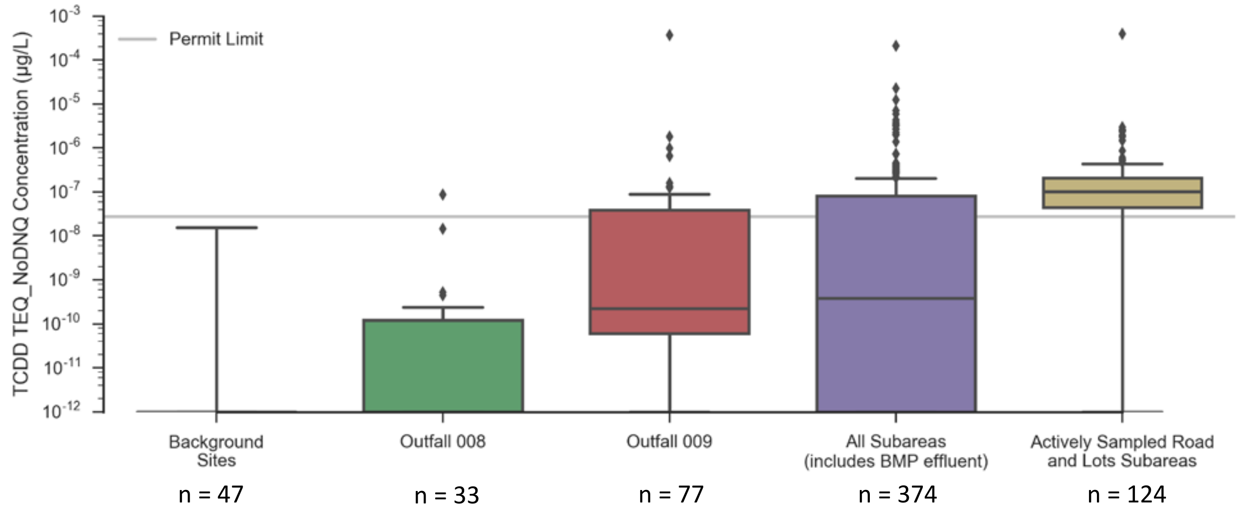
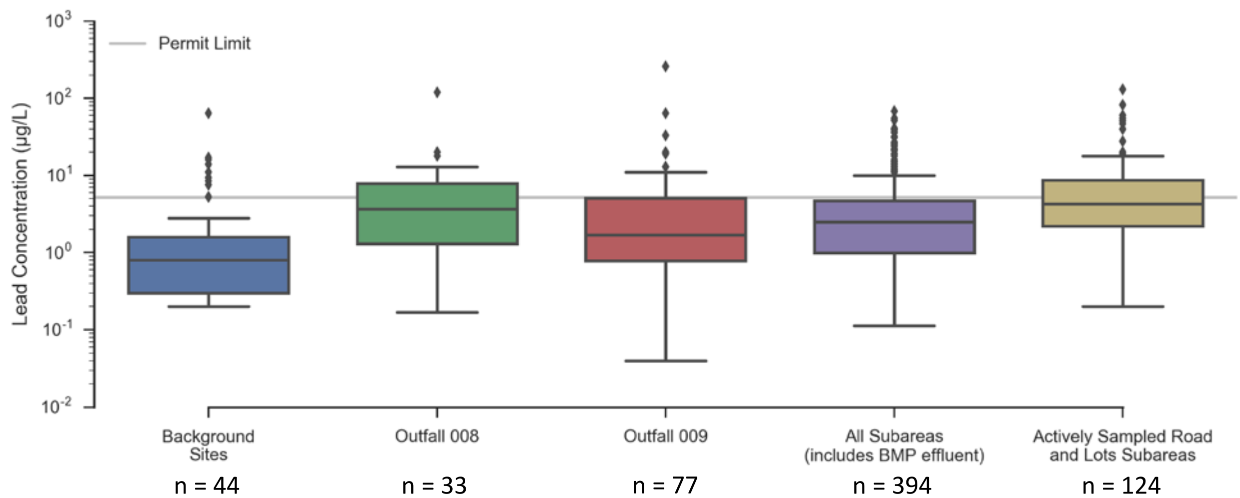


Figure 2. Total lead concentrations measured in stormwater samples collected from 2004 to 2016[2].



[2] Boxes show the median value and the upper (75th percentile) and lower (25th percentile) quartiles. Whiskers represent 1.5 times the interquartile range and data points outside this are shown individually. Actively sampled road and lots subareas include samples collected from APBMP0001-A (n=5), BIBMP0002 (n=6), BIBMP0003 (n=17), B1BMP0004 (n=15), BIBMP0004-5 (n=10), BISW0015 (n=1), EVBMP0002-B (n=7), EVBMP0003-A (n=6), ILBMP0001 (n=26), ILMBP0002 (n=16) and LPBMP0002 (n=15).

2.0 SPECIAL STUDIES

The Expert Panel identified the following two study questions as the design basis for the new sampling studies that are currently being implemented.

2.1.1 Question 1

From where (spatially) within the Outfall 009 watershed are dioxins and lead in stormwater predominantly coming?

- **Hypothesis 1.1**: Dioxin and lead concentrations in stormwater are higher downstream of where developed area runoff enters the Northern Drainage compared with upstream/headwater background sites.
- **Hypothesis 1.2**: Dioxin and lead concentrations in bed sediments are higher downstream of where developed area runoff enters the Northern Drainage compared with upstream/headwater background sites.
- **Hypothesis 1.3**: The total dioxin and lead mass in bed sediments is greater on intermediate sized sediments than on less abundant sediment sizes.

Approach: Grab samples will be collected from stormwater along the Northern Drainage at seven key locations (Table 1). These locations were selected based on accessibility and bracketing key areas of stormwater discharge (e.g., Area II subareas, the Area II Landfill, LOX, the IEL and B-1 areas, and upstream background locations). Stream sediment samples will be collected at the same seven locations once during dry weather, and sieved into three particle sizes (<75 μm, 75 μm to 1 mm, and >1 mm) prior to analysis. Stormwater and bed sediment samples will be analyzed for lead and dioxin TEQ (Table 2). Results from stream bed sediment samples will indicate the gradient of particulate-bound pollutant concentrations along the main channel to further identify sources of these contaminants.

2.1.2 Question 2

What are the predominant sources of dioxin and lead to paved subareas—e.g., pavement material itself (weathered or newly resurfaced), vehicles, treated wood poles, and/or atmospheric deposition?

- **Hypothesis 2.1**: Dioxin and lead concentrations in stormwater runoff from paved surfaces are higher in areas with recently resurfaced asphalt and high traffic compared to runoff from areas containing older/weathered asphalt and less traffic.
- **Hypothesis 2.2**: Dioxin and lead concentrations in pavement solids collected from paved surfaces are higher in areas with recently resurfaced asphalt and high traffic compared to solids from areas with older/weathered asphalt and less traffic.
- **Hypothesis 2.3**: Dioxin and lead concentrations are higher in soils near treated wood utility poles than in soils not near treated wood poles.
- **Hypothesis 2.4**: Dioxin and lead are present in atmospheric deposition solids at concentrations that would contribute to NPDES exceedances when suspended in stormwater.

Approach: Stormwater sampling will be conducted from areas representative of runoff from paved surfaces including: recently resurfaced asphalt, older/weathered asphalt, medium traffic, and high traffic[3]. Samples of pavement solids will also be collected from these areas via hand vacuum sampling. Samples of soils near treated wood will be collected to be representative of treated wood utility poles including: old versus new, burned versus non-burned, and areas where poles have recently been demolished. Soil samples will also be collected from soils near other treated wood (not utility poles) and background areas upgradient from treated woods. Atmospheric deposition solids will be collected from two locations via dry atmospheric deposition collection (see Table 1 for all sample locations). All samples will be analyzed for lead and dioxin TEQ (with stream sediment and pavement solids samples also analyzed by particle sizes and with particle size distribution analyses) (see Table 2 for full list of analytes). Results from these samples will enable the comparison of lead and dioxin concentration differences in solids from areas representing different pavement solids, soils near treated wood utility poles, and atmospheric deposition.

[3] These stormwater samples will be collected and analyzed using existing, active subarea monitoring efforts; therefore, no new subarea monitoring is required.

Table 1. Special Studies sampling locations.

Task	Location IDs*	Site Description	Attachment
1/2	EPNDSW01 / EPNDBS01	Stormwater and stream sediment site, Northern Drainage above confluence with Area II drainage	A-1
	EPNDSW02 / EPNDBS02	Stormwater and stream sediment site, Area II drainage above confluence with Northern Drainage	A-1
	EPNDSW03 / EPNDBS03	Stormwater and stream sediment site, Dirt access road adjacent to Northern Drainage	A-1
	EPNDSW04 / EPNDBS04	Stormwater and stream sediment site, Dirt road crossing downstream of box culvert	A-2
	EPNDSW05 / EPNDBS05	Stormwater and stream sediment site, ND special studies background site at BGBMP0004 sampling location (Sage Ranch near CM-5)	A-2
	EPNDSW06 / EPNDBS06	Stormwater and stream sediment site, Downstream of 24" stormdrain outlet discharge	A-3
	EPNDSW07 / EPNDBS07	Stormwater and stream sediment site, ND special studies background site at BGBMP0005 sampling location (Sage Ranch near entrance)	A-3
3	EPADSO01	Atmospheric deposition site, Baker tank	A-1
	EPADSO02	Atmospheric deposition site, Fire station	A-3
4	EPHVSO01	Hand vacuuming site, Service area road near LOX, Old asphalt	A-1
	EPHVSO02	Hand vacuuming site, High truck traffic near CM-9	A-3
	EPHVSO03	Hand vacuuming site, Lower parking lot, Old asphalt	A-3
	EPHVSO04	Hand vacuuming site, Upper parking lot, High traffic	A-3
	EPHVSO05	Hand vacuuming site, Upper parking lot, Recently resurfaced	A-3
	EPHVSO06	Hand vacuuming site, Inside entrance gate, High traffic	A-3
5	EPTWBS01/02/03	Treated wood soil site, New utility poles, 3 locations	A-3
	EPTWBS04/05/06	Treated wood soil site, Old/weathered utility poles , 3 locations	A-3
	EPTWBS07/08/09	Treated wood soil site, Burned utility poles, 3 locations	A-3
	EPTWBS10/11/12	Treated wood soil site, Demolished utility pole areas, 3 locations	A-3
	EPTWBS13/14/15	Treated wood soil site, Other treated wood areas, 3 locations	A-3[4]
	EPTWBS16/17/18	Treated wood soil site, Upgradient background sites, 3 locations, co-located with EPTWBS04, EPTWBS06, and EPTWBS07	A-3

*EP = Expert Panel, ND = Northern Drainage, SW = Stormwater, BS = Soils/Sediments, AD = Atmospheric Deposition, SO = Solids, HV = Hand Vacuuming, TW = Treated Wood.

[4] Locations include soils near wood retaining walls (EPTWBS13 and EPTWBS15) and a wood fence (EPTWBS14).

Table 2. Special Studies sampling and analysis summary.

Task	Sample Type	Analytes	# of Locations	# of Events	# of Particle Sizes Analyzed	Total # of Samples	Assumptions
1	ND Stormwater	TSS	7	8	1	56	Up to eight storm events will be sampled at seven locations.
		Total Lead	7	8	1	56	
		Dioxin TEQ	7	8	1	56	
2	ND Stream Sediments	Total Lead	7	1	3	21	Samples will be collected from seven locations during one dry weather event. Samples will be dried and sieved into three particle sizes[5]. Each sample will be a composite of five subsamples.
		Dioxin TEQ	7	1	3	21	
		PSD	7	1	3	21	
		TOC	7	1	3	21	
3	Atmospheric Deposition	PSD	2	12	1	24	Sampling will be conducted at two locations monthly for one year during dry weather (sampling pans will be covered during rainfall).
		TSS	2	12	1	24	
		Total Lead	2	12	1	24	
		Dioxin TEQ	2	12	1	24	
4	Pavement Solids	PSD	6	5	2	60	Samples will be collected from six locations. Each sample will be a composite of at least ten subsamples. Each sample will be sieved into three particle sizes[5] with the >1mm size archived, but not analyzed. Sampling will be performed seasonally for one year with one additional event to capture the impact of ash deposition from a nearby fire.
		Total Lead	6	5	2	60	
		Dioxin TEQ	6	5	2	60	
		TOC	6	5	2	60	
5	Soils near Treated Woods	PSD	18	1	1	18	Each sample will be a composite of three soil subsamples from each location. Three samples will be collected from each of the five treated wood categories and the background site. Wood chips collected from treated woods may also be analyzed.
		Total Lead	18	1	1	18	
		Dioxin TEQ	18	1	1	18	
		TOC	18	1	1	18	

[5] Particle sizes: <75 µm, 75 µm to 1 mm, and >1 mm.

3.0 SAMPLING AND ANALYSIS APPROACH

3.1 ND Stormwater Sampling

Grab samples will be collected at seven stream locations during wet weather (Table 1; Attachments A-1 through A-3), consistent with mobilization and collection procedures from the 2010 BMP Sampling and Analysis Plan. Samples will be collected during as many storms as possible (up to eight storms) during 2016/2017 and will be analyzed for TSS, total lead, and dioxin TEQ consistent with NPDES analysis procedures (Table 2). Samples will be collected as close to the start of the storm as possible, while accommodating safety needs.

Stormwater runoff is also being collected from paved surfaces as part of ongoing BMP monitoring. As described in the 2015-2016 BMP Sampling and Analysis Plan, runoff is collected from areas including the helipad, the road near CM-9, and the lower and upper parking lots. Paved areas will also be sampled for solids as described in Section 3.4.

3.2 ND Stream Sediment Sampling

Stream bed sediment samples will be collected at the same seven stream locations as ND stormwater sampling once during dry weather[6]. Sediment samples will be collected by measuring a 4 ft by 4 ft grid on the channel bottom, sampling surface sediments (top inch) from five randomly selected 1 ft by 1 ft grid cells, and then compositing the samples for PSD, TOC, total lead and dioxin TEQ analysis (Table 2)[7]. For each sampling event, a composite sediment sample will be created at each of the seven locations. Samples will be dried and sieved into three particle size categories (<75 µm, 75 µm to 1 mm, and >1 mm), and each particle size will be analyzed separately for TOC, total lead and dioxin TEQ.

Collection of stormwater and sediment samples from multiple locations along the channel is necessary to assess the delivery of source materials to Outfall 009. Sediment contamination may differ by location and by particle size indicating different sources of contamination. Sediment accumulation in the upstream channel may also be a source of contamination only during highly erosive flows, which may not be captured by sampling downstream during lower flow conditions. Stormwater and sediment samples collected from background locations (EPNDSW05

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[6] Minimum one week of antecedent dry weather.
[7] Additional cells may be sampled if a greater sample volume is required for analysis.

and EPNDSW07) will be critical for determining water and sediment contaminant concentrations prior to any potential inputs at the site.

3.3 Atmospheric Deposition Sampling

Atmospheric deposition samples will be collected monthly at two locations; one located on the Baker tank near the helipad paved area (EPADSO01) and a second located at Fire Station 31-319 near the site entrance (EPADSO02) (Table 1; Attachments A-1 and A-3). These locations will capture deposition that may be originating from offsite. Additional background sites were not included for atmospheric deposition, as any nearby site would also be expected to be impacted by surrounding urbanization. Pan samplers (e.g., large, deep, metal pans) were recommended by the Expert Panel to be placed on the aforementioned building/tank roofs and left exposed for several weeks at a time during dry weather before being sampled. To collect samples, pans will be rinsed with high purity water into sample containers and delivered to the laboratory for analyses. Samples will be analyzed for PSD[8], TSS, lead, and dioxin TEQ (Table 2). Sampling will be conducted at both locations monthly for one year to represent seasons and varying conditions. Pans will be covered during rain events with a probability of precipitation of 50% or greater and a predicted rainfall depth of 0.25" or greater. Precipitation forecasts will be monitored using the National Weather Service[9]. In the event that an unpredicted rain event of greater than 0.25" occurs while sampling pans are not covered, pans will be cleaned and the one-month sampling period will be restarted.

3.4 Sampling of Pavement Solids

Pavement solids will be collected from six different paved areas including roads and parking lots (Table 1; Attachments A-1 and A-3). Four representative categories of areas will be sampled: 1) two areas with recently resurfaced asphalt (EPHVSO04 and EPHVSO05), 2) two older/weathered areas with medium traffic (EPHVSO01 and EPHVSO03), 3) two high traffic paved areas (EPHVSO04[10], EPHVSO06), and 4) a high truck traffic area (trucks carrying soil) (EPHVSO02). Samples will be collected using a portable commercial vacuum powered with a portable generator (2hp Mastercraft 2012-SSW- Wet/Dry Stainless Steel Vacuum equipped with a narrow aluminum attachment head). A pre-filter cloth bag (Mastercraft 16" Dacron filter bag)

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[8] PSD will be analyzed for fine sediments in this solution using water PSD methods.

[9] http://www.wrh.noaa.gov/forecast/wxtables/index.php?lat=34.23553701614161&lon=-118.69390296788874&table=custom&duration=7&interval=6

[10] EPHVSO04 represents both newly resurfaced and high traffic areas.

will be used to line the vacuum main filter. Detailed sample collection and processing steps are described on pp. 301-306 of Burton and Pitt (2002). For each sample, a minimum of ten 1 m by 1 m subareas will be vacuumed and composited within the paved area (a total of at least 10 m^2 for each paved area)[11]. Collected pavement solids will be removed from the vacuum after the subsamples are obtained. Samples will be dried, weighed, and sieved into three particle sizes (<75 µm, 75 µm to 1 mm, and >1 mm)[12]. The <75 µm and 75 µm to 1 mm particle sizes will be analyzed for lead and dioxin TEQ (Table 2). The >1 mm particle size will be archived for potential future analysis (to be determined based on results of smaller particle sizes). Pavement solids sampling will be repeated quarterly for one year to represent seasonal differences[13].

3.5 Sampling of Soils Near Treated Woods

Surface soil sampling near treated woods will be performed consistent with ISRA program surface soil sample collection procedures. Each surface soil sample will be a composite of three subsamples, collected from the top inch of soil and within one foot of the treated wood. Three sampling locations were selected from each of the following treated wood categories: 1) new utility poles, 2) older/weathered utility poles, 3) burned utility poles, 4) areas where utility poles have recently been demolished, 5) other treated wood areas such as landscaping timbers, retaining walls, or barricade/fence posts (Table 1; Attachments A-1 and A-3). Three background sites will also be sampled, approximately ten feet upgradient from the treated wood poles in areas that are not in the flow path of treated wood but have similar soils and other characteristics. A small piece cut directly from each pole or treated wood will also be saved for possible future analysis. An example of a wood pole to be sampled is shown in Figure 3. Soil samples will be dried, weighed and analyzed for lead, dioxin TEQ and PSD[14] (Table 2). Samples will be collected from these 18 locations once during dry weather.

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[11] Additional subareas will be sampled if needed to generate the required sample mass for laboratory analysis.
[12] Left over sieved fractions will be archived in wide-mouth glass bottles with Teflon lined lids.
[13] An additional sampling event was performed to capture ash accumulation from a nearby fire.
[14] Sieved soil fractions will not be analyzed individually, but will be archived in wide-mouth glass bottles with Teflon lined lids for possible future analysis.

Figure 3. Example of new treated wood pole, EPTWBS03.

4.0 DATA ANALYSIS

To test the hypotheses developed based on Question 1, stormwater and stream bed sediments will be collected from seven locations in the Outfall 009 drainage area. By compiling stormwater data at these sites from up to eight rain events, dioxin and lead concentrations will be compared using statistical tests, such as the nonparametric Kruskal-Wallis one-way analysis of variance on ranks to determine if concentrations change from upstream background sites to downstream sites near Outfall 009 (Hypothesis 1.1). These analyses will be supplemented with graphical analyses and standard summary statistics to show the concentrations at each site. Other statistical analyses, such as the Mann-Whitney rank sum test, will also be used to compare concentrations between sites. Sediment sample concentrations are expected to remain relatively consistent over the course of this study. However, replicated sampling may be required in the future to determine if sediment concentrations significantly increase from upstream to downstream (Hypothesis 1.2). Results from samples analyzed by particle size will be used to compare concentrations of dioxin and lead to determine if higher levels are associated with fine particles (Hypothesis 1.3) using appropriate statistical tests to measure the confidences of observed differences for the concentrations between the different sites and particle sizes (such as two-way ANOVA if the data are normally distributed).

To test the hypotheses developed based on Question 2, pavement solids, soils near treated woods, and atmospheric deposition solids will be collected and analyzed at representative locations in the Outfall 009 drainage area. Data collected as part of the BMP monitoring program for runoff from paved surface areas in addition to data from pavement solids samples will be used to test the hypothesis that concentrations of dioxin and lead in recently resurfaced asphalt and high traffic areas are higher than older/weathered asphalt and areas with less traffic (Hypotheses 2.1 & 2.2). Data from soil samples collected near five categories of treated wood will be used to test the hypothesis that contaminant concentrations are higher in these soils compared to background areas (Hypothesis 2.3). These results will also be used to test the hypothesis that certain types of treated would are more significant pollutant sources. Data from ongoing soil sampling in areas not near treated wood and site concentration goals will also be used for comparison. Results from atmospheric deposition sampling will be used to test the hypothesis that this is contributing to exceedances of these contaminants at Outfall 009 (Hypothesis 2.4). Multivariate analyses of the observed concentrations (such as Cluster analyses and Principal Component analyses along with two-way ANOVA evaluations) will be used to identify any significant groupings and differences for these sample type groups, compared to runoff samples collected at source areas and in the Northern Drainage. Results from TSS analysis of stormwater collected from stream and paved area runoff will be used to calculate solids concentrations and loadings of dioxin and lead from these areas and will be compared to the expected surface loadings on the paved surfaces. This will allow for the contaminant levels in stormwater samples to be compared to the potential sources addressed by Question 2.

Results from these special studies will be used to inform the selection and placement of BMPs in the Outfall 009 drainage. Based on results from stormwater sampling, if lead or dioxin sources in stormwater are found to be predominantly from high traffic paved areas, then treatment efforts will continue to be focused on runoff from paved areas with an emphasis on high traffic areas. BMP designs will be based on the particulate sizes measured in the stream bed sediment and downstream stormwater samples. Based on pavement solids sampling, if lead and dioxin sources are found to be predominantly from paved road materials such as newly resurfaced pavement, then treatment efforts will be focused on runoff from these paved areas. If results indicate vehicle or truck traffic is a significant factor in buildup of lead and dioxins on pavement solids, then these areas will be prioritized for stormwater treatment and/or solids removal. BMPs will be designed in consideration of the particulate sizes showing the highest concentrations and load contributions of these contaminants. Based on results from soil sampling near treated wood, if lead or dioxin sources are found to be predominantly from soils near treated wood utility poles, then areas around these poles will be targeted for soil removal and/or placement and design of stormwater BMPs (such as simple barriers). If lead or dioxin sources are found to be predominantly from atmospheric deposition, treatment efforts will continue to be focused on runoff from all paved areas due to their efficiency in transporting atmospheric deposition solids.

5.0 ROLES AND RESPONSIBILITIES

Table 3 outlines the roles and responsibilities of those involved with the Special Studies program.

Table 3. Special Studies staffing and responsibilities.

Affiliation	Name	Responsibility	Contact
Geosyntec Consultants	Brandon Steets	Special studies Project Manager	(805) 979-9122 BSteets@Geosyntec.com
	Stacy Luell	Study design, sampling support, data analysis, and report preparation	(310) 957-6118 SLuell@Geosyntec.com
	Jared Ervin		(805) 979-9129 JErvin@Geosyntec.com
Haley & Aldrich	Katherine Miller	Northern Drainage stormwater sampling	KMiller@haleyaldrich.com
MWH	Alex Fischl	Treated wood soil sampling and Northern Drainage sediment sampling	(925) 627-4627 alexander.fischl@mwhglobal.com
Local Universities	Student Interns	Hand vacuum and atmospheric deposition sampling	Jose Avina, Wayne Tran and Christine Zheng

6.0 SCHEDULE

Table 4 provides an updated schedule, as of August 2016, for the Special Studies sampling. Regularly scheduled bi-weekly conference calls with the expert panel will be used to update study progress and discuss any potential changes to the sampling and analysis plans.

Table 4. Special Studies sampling and analysis schedule.

Task	Dates	Completed
Conference Calls	Bi-weekly	Ongoing
Study Design	October 2015 to January 2016	Updated August 2016
1. Stormwater Sampling	March 2016 to 2017	1 of 8 events
2. Stream Sediment Sampling	March 2016	Complete (1 event)
3. Atmospheric Deposition Sampling	June 2016 to May 2017	4 of 12 events
4. Pavement Solids Sampling (Hand Vacuuming)	June 2016 to May 2017	2 of 5 events
5. Treated Wood Soil Sampling	May 2016	Complete (1 event)
Data Analysis and Reporting	July 2016 to 2017	Ongoing

7.0 REFERENCES

Anderson, K. and J. Downing. "Dry and Wet Weather Atmospheric Deposition of Nitrogen, Phosphorous, and Silicon In an Agricultural Region." *Water, Air, and Soil Pollution* 176 (2006): 351-54.

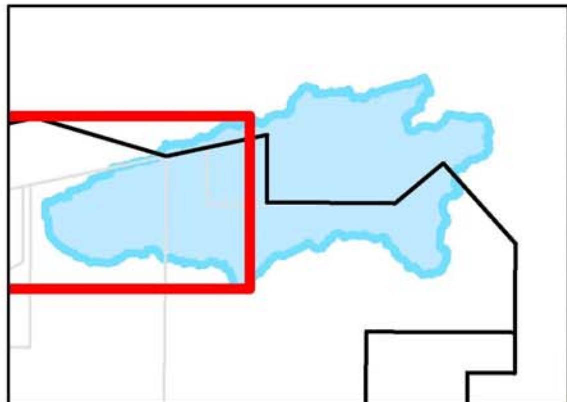
Burton, G. and R. Pitt. Stormwater Effects Handbook—A Toolbox for Watershed Managers, Scientists, and Engineers. CRC Press, 2002.

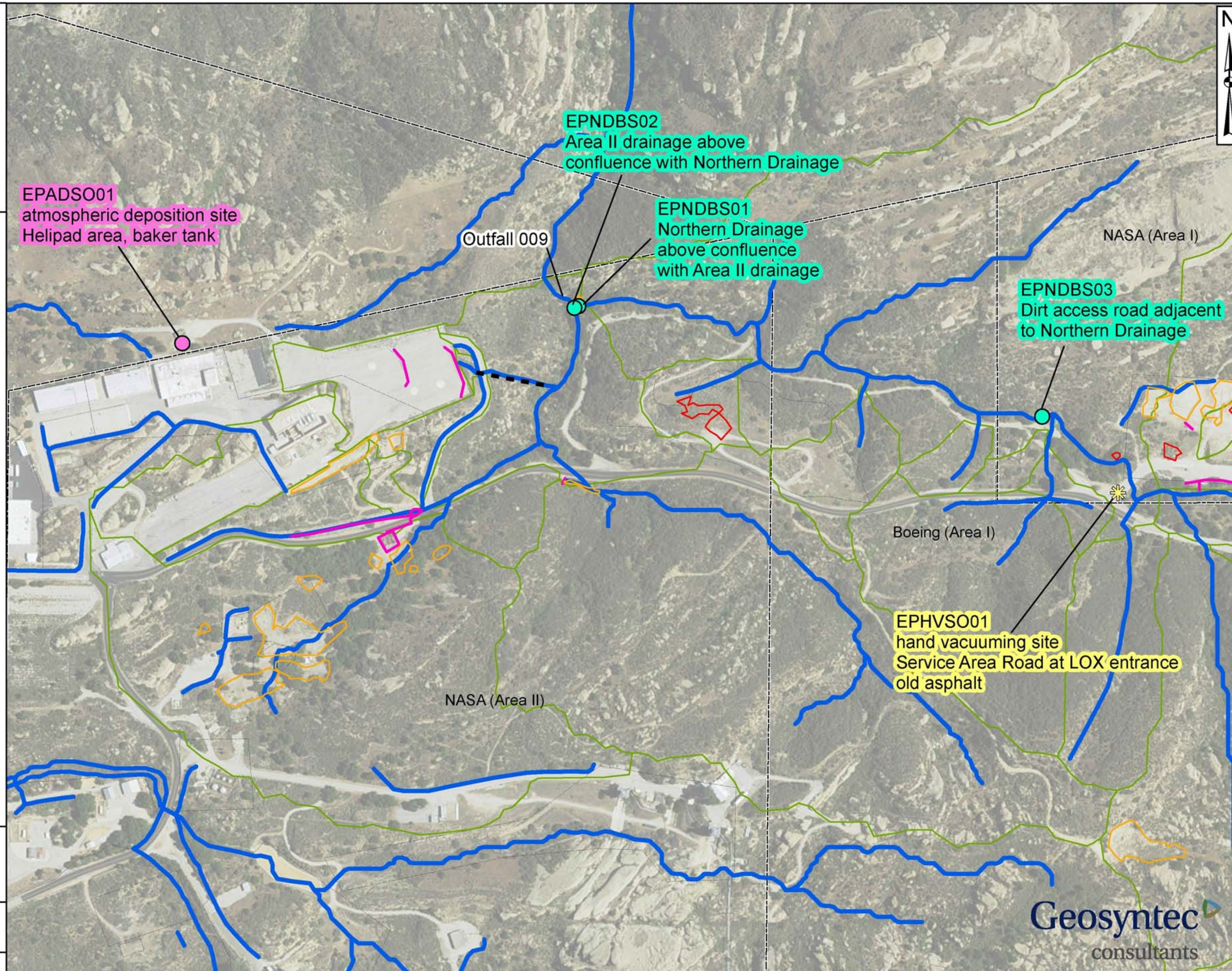
Wetherbee, G. and M. Rhodes. “Effects of Equipment Performance on Data Quality from the National Atmospheric Deposition Program/ National Trends Network and the Mercury Deposition Network.” U.S. Geological Survey (USGS), 2013.

* * * * *

ATTACHMENT A

Northern Drainage Special Studies Sampling Locations





Legend

- Completed ISRA Areas
- Former Planned ISRA Areas
- Drainage Area (Approx.)
- Administrative Boundary
- RFI Site Boundary
- BMPs
- Drainage
- Culvert

Northern Drainage Special Study Sample Locations

- Atmospheric Deposition
- Hand Vacuuming
- Stormwater/Stream Sediment Sampling

0 200 400 800 Feet

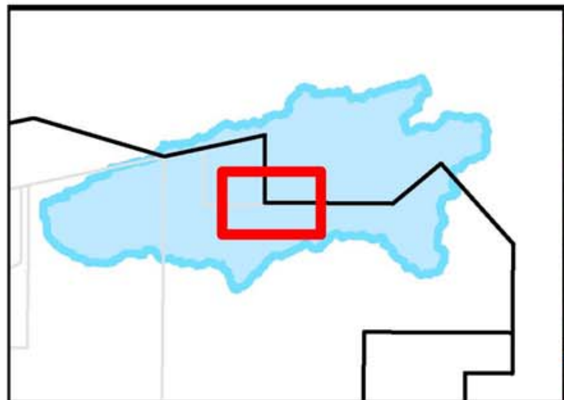
Attachment A-1
Outfall 009 and Area II Landfill Area Northern Drainage Special Study Sampling Locations

Santa Susana Field Laboratory
Ventura County, CA

March 2016

Geosyntec consultants

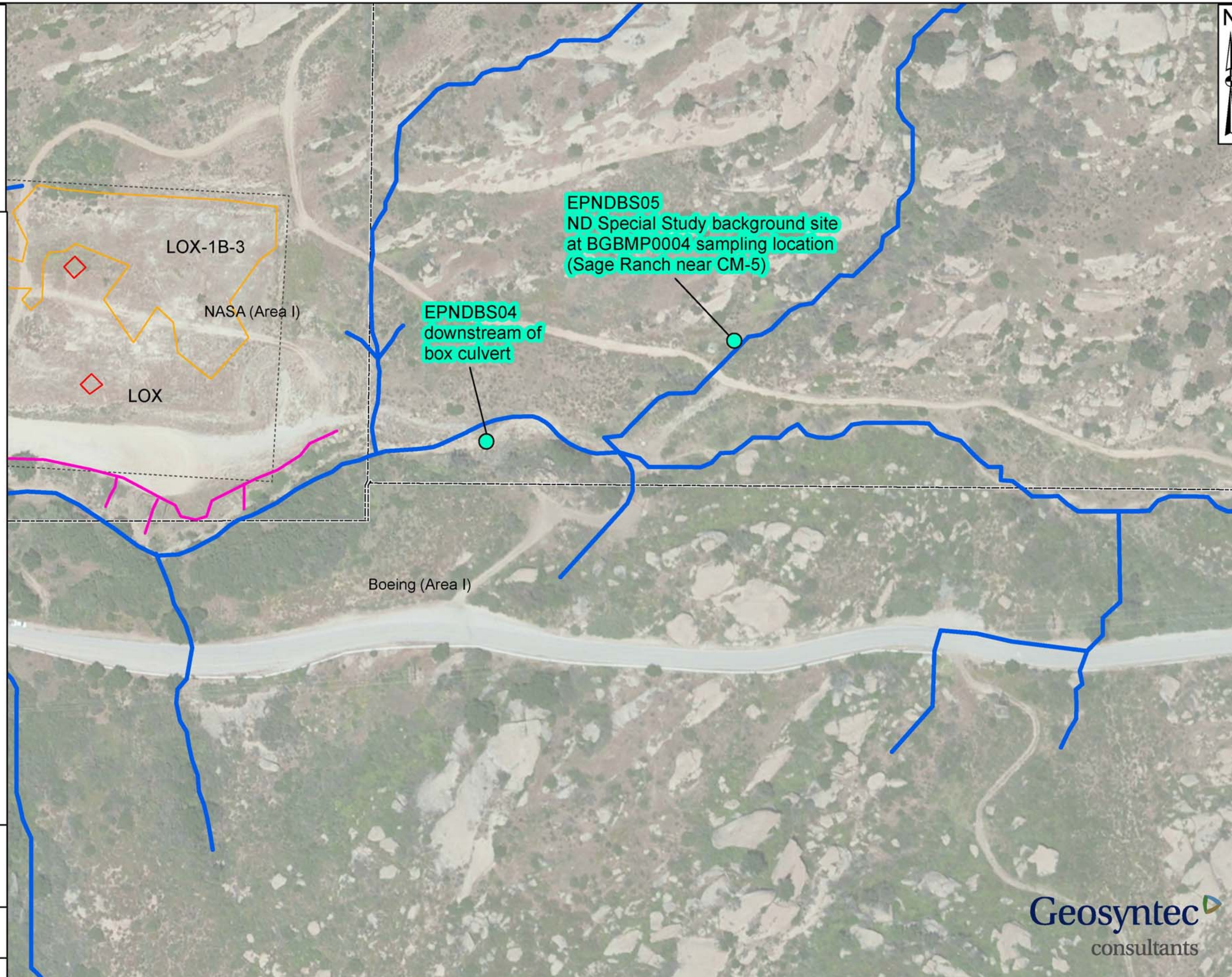
Date: 3/9/2016, Path: P:\GIS\Projects\Boeing\SSFL\2015 SB0363V\Special_Studies_Aug2015\2015SpecialStudySites-ELVArea_Color.mxd, User: SLuell



Legend

- Completed ISRA
- RFI Site Boundary
- Administrative Boundary
- BMPs
- Drainage
- Stormwater/Stream Sediment Sampling

0 65 130 260
Feet

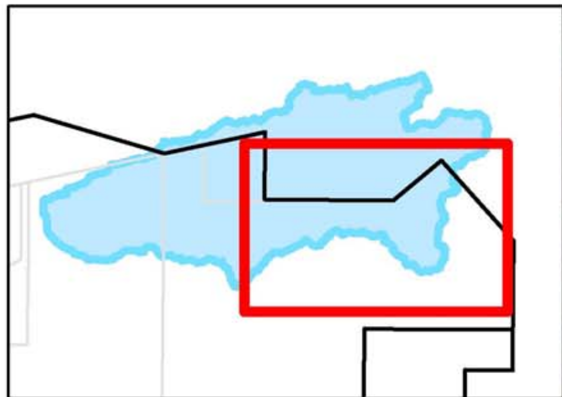


Attachment A-2
LOX Area
Northern Drainage Special Study
Stormwater Sampling Locations

Santa Susana Field Laboratory
Ventura County, CA

March 2016

Date: 3/14/2016, Path: P:\GIS\Projects\Boeing\SSFL\2015 SB0363V\Special_Studies_Aug2015\2015SpecialStudySites-LOX_Color.mxd, User: SLuell



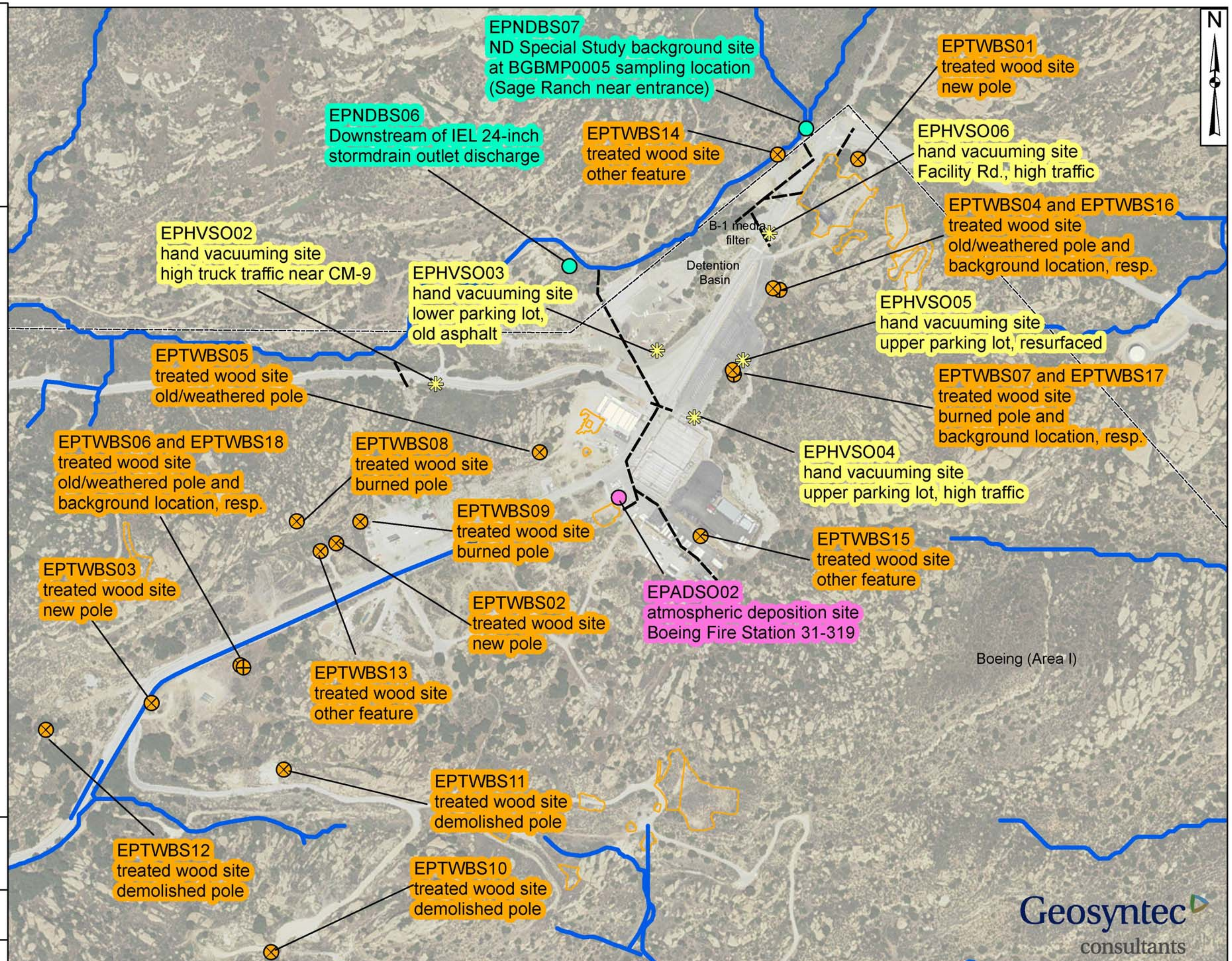
Legend

- Completed ISRA Areas
- Administrative Boundary
- BMPs
- Drainage
- Culvert
- Conveyance Pipeline

Northern Drainage Special Study Sample Locations

- Atmospheric Deposition
- Hand Vacuuming
- Stormwater/Stream Sediment Sampling
- Treated Wood Sediment Sampling Background Location
- Treated Wood Sediment Sampling

0 200 400 800 Feet



Attachment A-3
IEL and B-1 Area
Northern Drainage Special Study
Sampling Locations

Santa Susana Field Laboratory
Ventura County, CA

July 2016

Geosyntec consultants

Date: 7/15/2016, Path: \\Westla-01\gis\Projects\Boeing\SSFL\2015 SB0363V\Special_Studies_Aug2015\2015SpecialStudySites-B1_Color_updated_JE.mxd, User: JErvin

Appendix D: Watershed 001 and 002 Road Erosion Assessment

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WATERSHED ROAD EROSION ASSESSMENT
OUTFALLS 001 AND 002
SANTA SUSANA FIELD LABORATORY
5800 WOOLSEY CANYON ROAD
CANOGA PARK, CALIFORNIA

by Haley & Aldrich, Inc.
San Diego, California

for The Boeing Company
Ventura County, California

File No. 40458-096
October 2016

HALEY & ALDRICH, INC.
5333 Mission Center Road
Suite 300
San Diego, CA 92108
619.280.9210

19 October 2016
File No. 40458-096

The Boeing Company
Santa Susana Field Laboratory
5800 Woolsey Canyon Road
Canoga Park, California 93063

Attention: Mr. Paul Costa

Subject: Watershed Road Erosion Assessment
Outfalls 001 and 002
Santa Susana Field Laboratory
5800 Woolsey Canyon Road
Canoga Park, California

Dear Mr. Costa,

This Report addresses the findings and recommendations from the Watershed Road Erosion Assessment for Outfalls 001 and 002 performed on 3 August and 4 August 2016.

Background

In the Site-Wide Stormwater Work Plan and 2014/15 Annual Report, the Expert Panel recommended an erosion assessment of all roads in the watersheds for Outfalls 001 and 002 in response to monitoring results with concentrations measured above the 2015 Permit benchmarks at Outfalls 001 and 002.

On August 3 and 4, 2016, Nancy Gardiner, Certified Professional in Erosion and Sediment Control (CPESC) and Qualified Stormwater Pollution Prevention Plan Developer (QSD) and Danielle Kerper (QSD) from Haley & Aldrich, Inc. assessed current conditions of roads in the watersheds for Outfalls 001 and 002 per the Expert Panel's recommendation and per industry best practices. The assessment included all paved, unpaved, gravel-coated, maintained, and non-maintained roads in the watersheds for Outfalls 001 and 002. Not included were roads in the watersheds upstream of Outfalls 011 and 018. Basic methodology for this assessment included figure preparation for all roads in the watersheds (Figure 1), driving approximately 10 miles per hour along each road, and making observations on both sides of the road. If an area of erosion was noticed, photos were taken of the feature and conditions noted. The assessment included observations of minor areas of erosion as well as more robust erosional features based on best professional judgement.

Findings

The following sections present our findings from the road erosion assessment. Corresponding locations are noted on Figure 1. Please note that the photos on Figure 1 are geotagged by GPS coordinates and may vary slightly from photos in this memo.

OUTFALL 001 WATERSHED

Location A

Approximate Coordinates: 34°13’00.74” N; 118°41’23.34” W
General Area Description: On the south side of the spur road to OF001 at the “T” intersection with the main road to OF001, downgradient from the locked gate #575.

Observations:

There was evidence of prior erosion due to concentrated flow from a 2014 potable water release from a municipality-owned water main, per discussion with JHA Environmental. Erosion features observed at this location include a rill measuring approximately 8 inches deep by 1-foot wide (see pictures #1 and #2). JHA noted that they add rip-rap periodically to dissipate water velocity within this rill and down the access road to Outfall 001.

Observations (continued):

Erosion has occurred underneath portions of the HDPE pipe (from the GETS to Outfall 019) due to the concentrated flow. Another rill measuring approximately 2 feet deep by 4 inches wide was observed about 200 feet further down the spur road at a culvert running beneath the road (see picture #3). Here, concentrated flows have moved gravel from the road into the natural drainage (see picture #4).

Picture #1: Looking southeast at rill near locked gate #575.

Picture #2: Looking southeast at rill near culvert.

Picture #3: Looking southwest at rill underneath HDPE pipe near culvert.

Picture #4: Looking northwest at northern side of culvert where gravel from the road has been deposited in the drainage.

Recommendations:

Add rip rap along entire length of rill and consider adding shoring where the HDPE pipe is being undermined.

Location B

Approximate Coordinates: 34°13’00.30” N; 118°41’38.29” W
General area description: On the south side of the spur road to OF001 approximately 800 feet east of the outfall.

Observations:

Observed erosion on the south side of the road underneath the HDPE pipe (from the GETS to Outfall 019) and cutting back the banks on the side of the road (see picture #5 and #6).

Picture #5: Looking southwest at erosion underneath HDPE pipe.

Picture #6: Looking southwest at erosion underneath HDPE pipe

Recommendations:

Erosion is minor; no recommendations but continue to observe location.

Location C

Approximate Coordinates: 34°13'06.51" N; 118°41'22.24" W
General area description: On the west side of the main road to OF001 approximately 600 feet north of the "T" intersection with the spur road to OF001.

<u>Observations:</u>

Rip-rap has been placed along the main discharge point (low point), but some active erosion with minor rill development was observed approximately 20 feet to the south along the main road to OF001 (see pictures #7-9).

Picture #7: Looking southwest at rip rap placed at discharge point.

Picture #8: Looking southwest at minor rill development.

Observations (continued):

Picture #9: Looking west at minor rill development.

Recommendations:

Erosion is minor; no recommendations but continue to observe location.

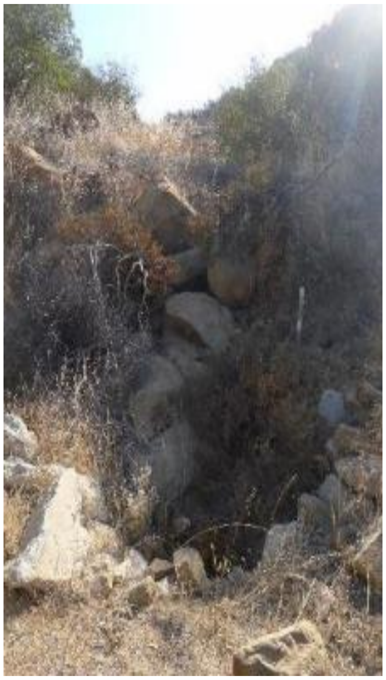
Location D

Approximate Coordinates: 34°13’07.72” N; 118°41’22.52” W
General Area Description: On the west side of the main road to OF001 approximately 700 feet north of the “T” intersection with the spur road to OF001.

Observations:

Active erosion was observed along the main road to OF001 immediately north of a 3-foot diameter corrugated metal pipe (CMP) culvert running under the road. Discharges from the road appear to be transporting gravel into the drainage (see picture #11). Erosion features observed at this location include erosion within the channel, which appears to be cutting the bank. Flow to this area comes from the steep rocky hillside on upslope (eastern) side of road which then enters the culvert (see pictures #10 and #12). The culvert was observed to be stable and not conveying gravel with no discernible erosion beneath the HDPE pipe.

Observations (continued):



Picture #10: Looking east at rocky hillside upslope of erosion.

Picture #11: Looking north at gravel in drainage and culvert pipe.

Picture #12: Looking east at erosion upgradient of culvert pipe.

Recommendations:

Add a fiber roll along the top of the slope at the point of erosion upgradient of culvert pipe. Continue observations at this location. If erosion worsens, reevaluate need for more substantial BMPs.

Location E

Approximate Coordinates: 34°13’17.13” N; 118°41’21.52” W
General Area Description: On the eastern spur road approximately 350 feet east of the “T” intersection with the main road to OF001.

Observations:

Minor erosion was observed on the road surface at this location (see picture #13).

Picture #13: Looking east at minor erosion on road surface.

Recommendations:

Erosion is minor; no recommendations but continue to observe location.

Location F

Approximate Coordinates: 34°13'18.49" N; 118°41'29.17" W
General Area Description: On the main road to OF001 about halfway between the western spur road and where the main road to OF001 splits from the Albertson Fire Road.

Observations:

Previous erosion and sediment controls (old fiber roll check dams and rip-rap) were observed at the K-rail that has been placed along the east side of the road where the HDPE pipe crosses the culvert (see pictures #14 and #16). Jute netting was also observed on the slope of the culvert. Loose sandy sediment was observed on the road surface with some minor slope failure along the west bank of road (see picture #15). The bottom of the drainage appeared clear with no notable sediment accumulation (see picture #17).

Picture #14: Looking south at HDPE pipe crossing culvert.

Picture #15: Looking west at minor slope failure along west bank of road

Observations (continued):

Picture #16: Looking south at old fiber roll check dams and rip rap.

Picture #17: Looking east at culvert discharge location.

Recommendations:

Add additional rip rap along east side of road and maintain fiber roll check dams.

Location G

Approximate Coordinates: 34°13’31.90” N; 118°41’29.95” W
General Area Description: Western side of the gravel-coated spur road adjacent to CTL-IV road.

Observations:

Silt fence and gravel water bars are installed along the road. Observed fine silt accumulating along the south side of the road against the silt fence (see pictures #18 and #19).

Picture #18: Looking south at silt fence and gravel water bar.

Picture #19: Looking south at loose silt accumulating along silt fence.

Recommendations:

Consider installing gravel bag check dams (two wide) along the edge of the silt fence where loose sediment is observed.

Location H

Approximate Coordinates: 34°13’23.24” N; 118°41’30.24” W
General Area Description: On both sides of the Albertson Fire Road approximately 100 feet west of the split with the main road to OF001.

Observations:

Observed erosion along both sides of the road. Rip-rap has been placed along the south side of road (see picture #22). An escarpment is present along the north side of the road (see picture #20). Slope failure was observed along the south side of the road approximately halfway down the hill (see picture #21).

Picture #20: Looking west at escarpment on north side of road.

Picture #21: Looking southwest at slope failure along south side of road.

Observations (continued):

Picture #22: Looking southwest at rip rap and erosion on south side of road.

Recommendations:

Continue to observe location and add rip rap as needed.

OUTFALL 002 WATERSHED

Location I

Approximate Coordinates: 34°13’17.92” N; 118°41’57.96” W
General Area Description: On the northeastern side of the Albertson Fire Road approximately halfway between the split with the main road to OF001 and the “T” intersection with the main road to OF002.

Observations:

Erosion was observed on the north side of the road. The erosion pattern shows that flow begins to channelize along the north side of the road (see pictures #23 and #24). This channel becomes larger toward the west. Rip-rap has been placed in this area and some gravel from the road was observed in vegetation along the drainage (see picture #25).

Observations (continued):

Picture #23: Looking northwest at erosion along north side of road.

Picture #24: Looking southeast at erosion along north side of road.

Picture #25: Looking north at gravel in vegetation within drainage.

Recommendations:

Add rip rap along entire length of erosional feature.

Location J

Approximate Coordinates: 34°13’25.41” N; 118°42’25.18” W
General Area Description: On both sides of the Albertson Fire Road at the “T” intersection with the spur road to OF002.

Observations:

There is a double culvert CMP crossing under the road in this area. Active erosion is occurring on the southeastern corner of the culvert crossing with a rill forming (see picture #26). The smaller of the two culverts is partially blocked (see picture #27). This is also erosion occurring along the road on the other side of the “T” intersection (see picture #28) which leads to the drainage with minor erosion at the northwest end of the culvert crossing (see picture #29).

Observations (continued):

Picture #26: Looking west at erosion on southeast corner of culvert crossing.

Picture #27: Looking south at culverts under road. Culvert on the left is partially blocked.

Picture #28: Looking southeast at erosion along northeast side of road.

Picture #29: Looking east at erosion at northwest corner of culvert crossing.

Recommendations:

Install fiber roll along the top of the slope at the point of erosion on the southeast corner of the culvert crossing, clean out the partially-blocked culvert, and add rip rap along northeast side of the road.

Location K

Approximate Coordinates: 34°13’17.81” N; 118°42’26.23” W
General Area Description: On the south side of the OF002 western spur road at the “T” intersection with the main road to OF002, and very close to the main OF002 drainage.

Observations:

There is a substantial amount of very fine, loose sediment on the road surface and on both sides of the road due to recent blading by the County of Ventura (see picture #30 and #31). This sediment could be mobilized directly into the OF002 drainage by wind erosion or stormwater runoff.

Picture #30: Looking west at fine sediment on road surface.

Picture #31: Looking east at fine sediment on road surface.

Recommendations:

Install two water bars across the steep portion of the western spur road at the “T” intersection with the main road to OF002 (see photo below). Also, consider spraying a calcium magnesium chloride-based soil stabilization product along the flat part and sides of the steep portion of the road. If a calcium magnesium chloride-based soil stabilization product will be used at this location, the product will need to be reviewed and approved for use at SSFL.

Location L

Approximate Coordinates: 34°13'31.26" N; 118°43'02.83" W
General Area Description: On the OF002 pine tree spur road.

Observations:

The surface of this steep road is rutted out and has rill development of several inches deep along the east/southeast side of road (see pictures #33 and 34). The rill crosses the road along the lower slope (see picture #32). This is a potential source of sediment in the watershed as the rill leads into the drainage.

Picture #32: Looking east at rill on south/southeast side of road.

Picture #33: Looking northeast at rutting across road.

Observations (continued):

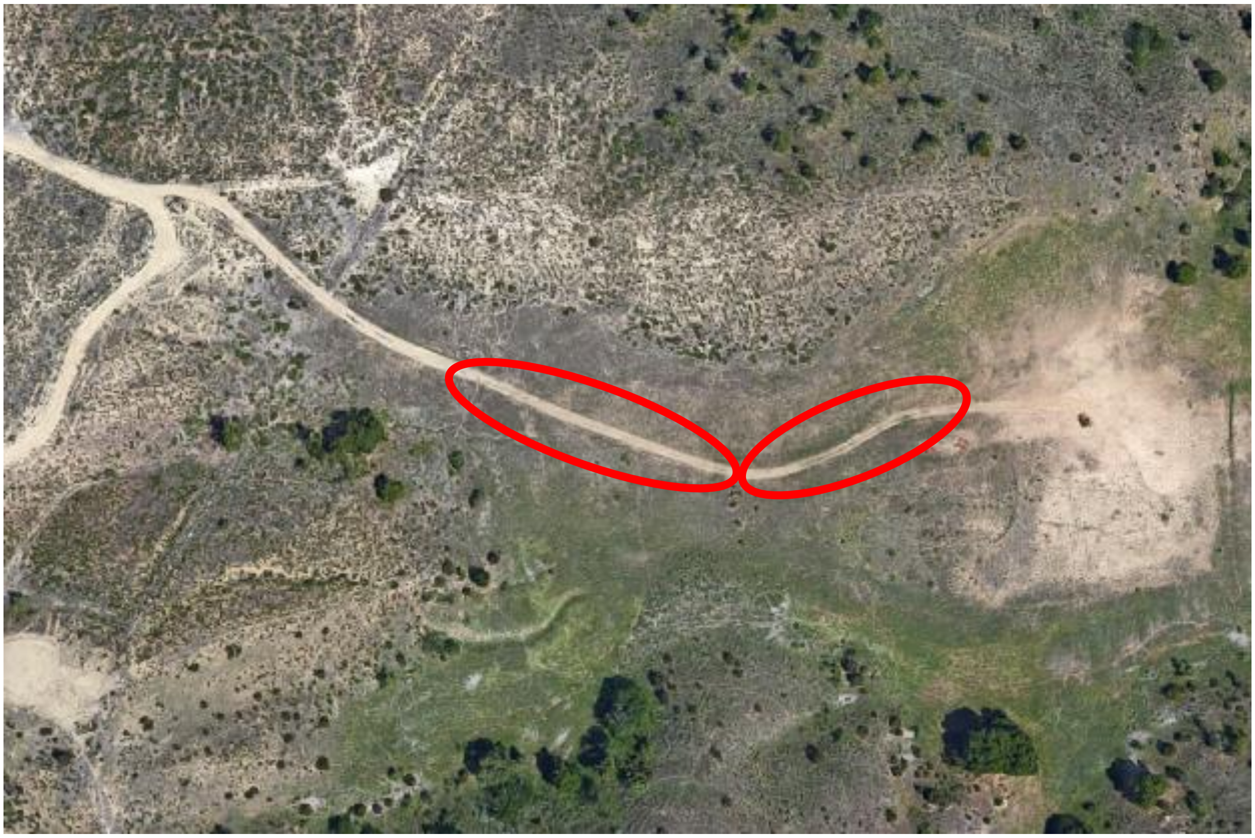
Picture #34: Looking northeast at rutting along southwestern side of road

Recommendations:

Install gravel bag check dams at regular intervals along entire length of the rill. Consider installing water bars if rilling increases.

Location M

Approximate Coordinates: 34°13’31.12” N; 118°42’51.50” W
General Area Description: On the OF002 northern spur road near where the road ends.



Observations:

Observed rutting and rill development along the majority of the road that may be a source of sediment in the drainage (see picture #35 and #36).

Observations (continued):

Picture #35: Looking southeast at rill development along south side of road.

Picture #36: Looking east at rill development across road.

Recommendations:

Erosion is minor; no recommendations but continue to observe location.

Closing

If you have any questions concerning this report, please do not hesitate to call us at 619.280.9210 or via email at dkerper@haleyaldrich.com or ngardiner@haleyaldrich.com.

Sincerely yours,
HALEY & ALDRICH, INC.

Danielle Kerper, PG, QSD/QSP
Senior Technical Specialist

Nancy Gardiner, CPESC, QSD/QSP, QISP
Stormwater Program Manager

C: Geosyntec; Attn: Brandon Steets, PE

Attachments:
Figure 1 – Watershed Road Erosion Assessment – Outfalls 001 and 002

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LEGEND

PHOTO LOCATION	NATURAL DRAINAGE	SSFL PROPERTY BOUNDARY
ACTIVE OUTFALL	ADMINISTRATIVE AREA	OUTFALL 001 WATERSHED AREA
FUTURE OUTFALL	SURFACE WATER DIVIDE	OUTFALL 002 WATERSHED AREA
FORMER OUTFALL	STUDY AREA	

NOTES

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
2. MAP COORDINATES IN STATE PLANE NAD 27, CALIFORNIA ZONE V.
3. SOME ROAD NAMES ARE UNOFFICIAL AND REFERENCED IN HALEY & ALDRICH, INC. AUGUST 22, 2016 REPORT ENTITLED "WATERSHED ROAD EROSION ASSESSMENT, OUTFALLS 001 AND 002, SANTA SUSANA FIELD LABORATORY, 5800 WOOLSEY CANYON ROAD, CANOGA PARK, CALIFORNIA"

N

0 540 1,080 1,620 2,160
SCALE IN FEET

HALEY ALDRICH

SANTA SUSANA FIELD LABORATORY
VENTURA COUNTY, CALIFORNIA

WATERSHED ROAD EROSION ASSESSMENT
OUTFALLS 001 AND 002

SEPTEMBER 2016

FIGURE 1

GIS FILE PATH: \\sdg\common\40458_SSFL\Global\GIS\MapProjects\2016-08\WATERSHED_ROAD_EROSION\40458_091_0001_WATERSHED_ROAD_EROSION_D.mxd — USER: gbowen — LAST SAVED: 8/23/2016 4:07:59 PM

Appendix E: Watershed 001 and 002 Drainage Stabilization Assessment

MEMORANDUM

Date:	August 30, 2016
To:	Paul Costa, The Boeing Company
Copies to:	SSFL Surface Water Expert Panel
From:	Judd Goodman, Chris Wessel, and Elise Wall, Geosyntec Consultants
Subject:	OF001 and OF002 Drainage Stabilization Assessment Memorandum Geosyntec Project Number: SB0363W

PURPOSE

A part of its 2015 Work Plan, the Expert Panel proposed a drainage stabilization assessment along the drainages above Outfall 001 (OF001) and Outfall 002 (OF002) by a qualified fluvial geomorphologist (Geosyntec, 2016). The purpose of this geomorphic reconnaissance is to assess the need for instream geomorphic control features to control instream sources of sediment to OF001 and OF002 (Geosyntec, 2016). This technical memorandum summarizes the methods and findings of the field assessment performed on August 19, 2016, and provides recommendations.

INTRODUCTION AND BACKGROUND

OF001 and OF002 are fed by large, natural watersheds located in the SSFL buffer area. As shown in Figure 1, OF001's tributary area is 597 acres and OF002's tributary area is 899 acres. OF001 is approximately one mile downstream of OF011, with an elevation change of approximately 160 ft; OF002 is approximately one mile downstream of OF018, with an elevation change of approximately 140 ft. The two drainages, which are largely unenhanced, run mostly in a north-south direction. Although small ponds are present at the upstream end of each reach,[1] discharges from these ponds are infrequent[2]. The extent of both reaches of interest are shown in the watershed map on Figure 1. Attachment 1 includes plan and profiles for Reach 1 (between OF011 and OF001) and Reach 2 (between OF018 and OF002), including detailed profiles by subreach (1A to 1D and 2A to 2D).

[1] "Perimeter Pond" is immediately upstream of OF011 and "R-2A Pond" is immediately upstream of OF018.
[2] Matthew Birney stated in email correspondence that no discharge event from Perimter Pond has been measured since recording began in November 2012, and that only two discharge events have been measured from R-2A since early 2012.

In 2009, a technical memorandum recommending interim sediment control measures for the reaches upstream of OF001 and OF002 was drafted by Geosyntec (Geosyntec, 2009). The memorandum recommended stabilization measures upstream of OF001 and OF002 in response to heightened TSS concentrations found at each outfall. As a follow up to this previous work, assessments of the drainages upstream of OF001 and OF002 were recommended by the 2015 Expert Panel Workplan. This memorandum briefly summarizes the findings from these assessments.

METHODOLOGY

Geosyntec performed a field investigation on August 19, 2016 at the Santa Susana Field Laboratory (SSFL) to conduct a geomorphic assessment of the ephemeral drainages between OF001 and OF011 and between OF002 and OF018. A stream walk covering each study reach was conducted to identify geomorphic changes in locations that are not otherwise monitored.

Stream walks were conducted from upstream to downstream. Unless prevented by steep terrain, boulders, or dense vegetation (e.g., poison oak), the entirety of each study reach was observed from the middle of the channel.

The general structure and composition of each reach was observed, with particular attention given to areas exhibiting signs of erosion or deposition. Where applicable, surrounding development (e.g., roads, platforms, channel modifications) was noted and observed in order to help differentiate between natural erosion processes and accelerated processes. Photographs were taken throughout the reaches, correlated with approximate station IDs. A selection of field photographs is provided in Attachment 2.

FINDINGS

Geosyntec observed that both stream reaches appear to be relatively stable in that they have not experienced any major morphologic change since 2009. Localized observations of past bank erosion were observed, particularly on the outside bank of some channel bends, but this erosion appeared to be caused by natural processes and not by specific actions or development at the site.

Additional observations of the reach upstream of OF001 included the following:

- Significant portions of the reach were lined by bedrock. Where soft soil banks were present downstream of these segments, minor undercutting of the banks was often present, as expected. In general, vertical walls at the toe of each bank were 0.5 - 1 ft in height, where present.
- The portions of the reach between OF001 and Sta 23+00 and Sta 28+00 and OF011 have a gentle slope, with no drastic topographic variations. Moderate vegetation is present along these segments of the reach, providing some bank stabilization. The soil in these portions is generally soft.
- The portion of the reach between Sta 23+00 and 28+00 is steep and inaccessible. Large boulders fill this portion of the reach, so erosion here is not a concern.

- Two riprap check structures and a portion of stone lined channel were observed upstream of OF001. A single corrugated metal pipe (CMP) culvert is present under Roca Ave, approximately 3,700 ft upstream of OF001.
- Signs of erosion from adjacent roads was not observed.

Additional observations of the reach upstream of OF002 included the following:

- The segment of the reach between Sta 12+00 and 50+00 had significant vegetation, with large trees covering the majority of the channel. The vegetation appeared to provide significant bank stabilization along the majority of this segment of the reach.
- The segment of the reach between OF002 and 10+00 had banks that were more gently sloped than the upstream portion of the reach. The channel bottom for this segment was mostly composed of cobbles.
- A weir spanning the channel was observed approximately 3,800 ft upstream of OF002. A CMP culvert is present under Roca Ave, approximately 3,300 ft upstream of OF002.
- Signs of erosion from adjacent roads was not observed.

RECOMMENDATIONS

Based on the field assessment, no additional stabilization measures within these reaches are suggested at this time. Rather, it is recommended that TSS levels at OF001 and OF002 be consistently monitored to determine if channel stabilization measures are necessary. Specifically, in-stream measures should be considered if either of the following occurs:

1. There are clearly elevated TSS levels in the downstream outfalls (OF001 and OF002) relative to the associated upgradient outfalls (OF011 and OF018); or

2. The TSS levels at OF001 and OF002 are at a level that compromises compliance with stormwater discharge requirements.

If there is a clear TSS concern at either of the outfalls, one suggestion is to install an in-stream check structure immediately upstream of the outfall of concern, such that no earthen bed or bank material is exposed between the check structure and outfall. This would allow some settling of solids prior to sampling at the outfall.

REFERENCES

Geosyntec Consultants, 2009. Interim Sediment Control Measures for Outfalls 001 and 002. October 9.

Geosyntec Consultants, 2016. Santa Susana Field Laboratory Site-Wide Stormwater Annual Report. 2015/2016 Rainy Season. August.

* * * * *

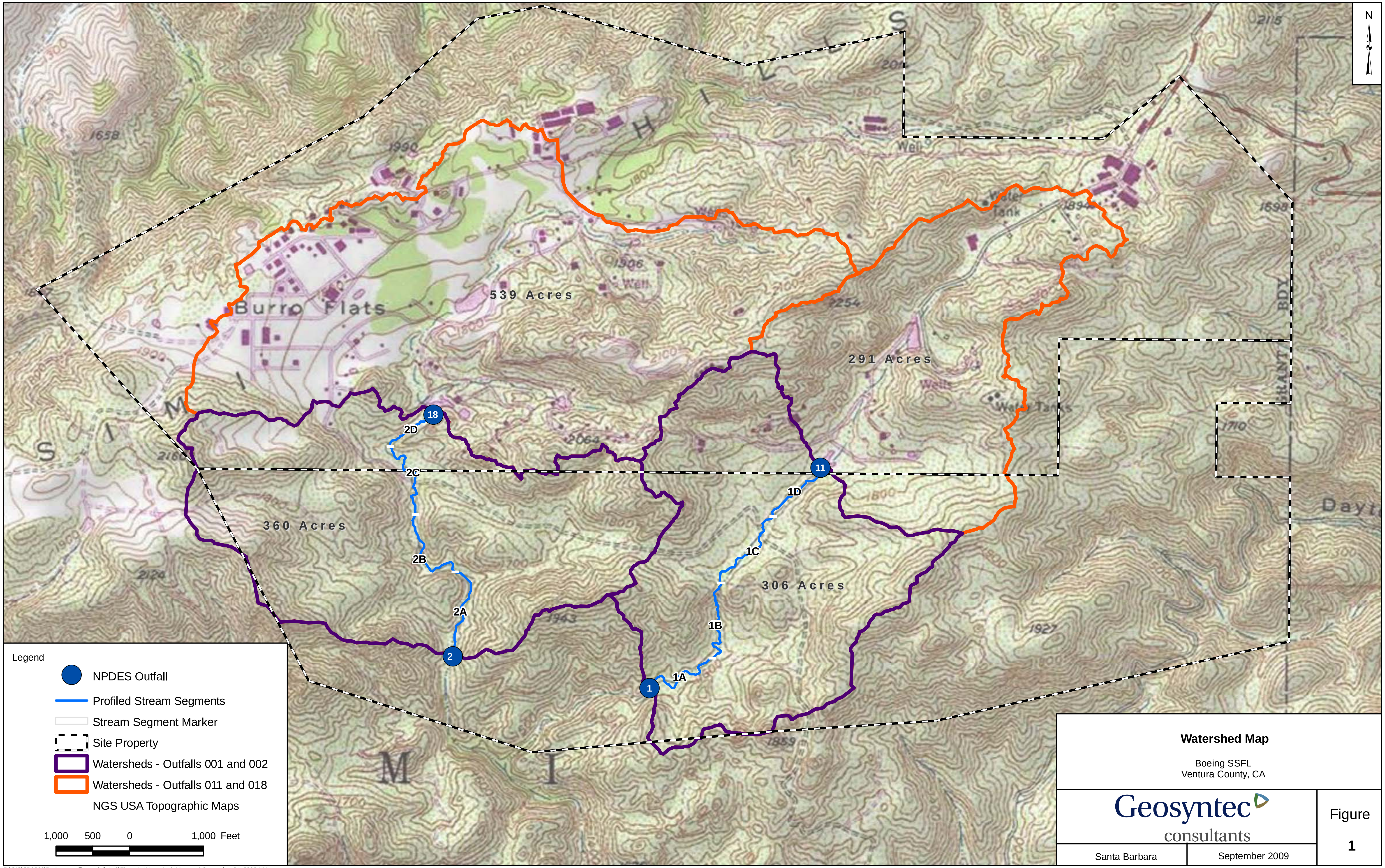
ENCLOSURES

Figure 1 – Watershed Map

Attachment 1 – Plan and Profiles

Attachment 2 – Representative Field Photographs

FIGURES



Watershed Map

Boeing SSFL
Ventura County, CA

Figure 1

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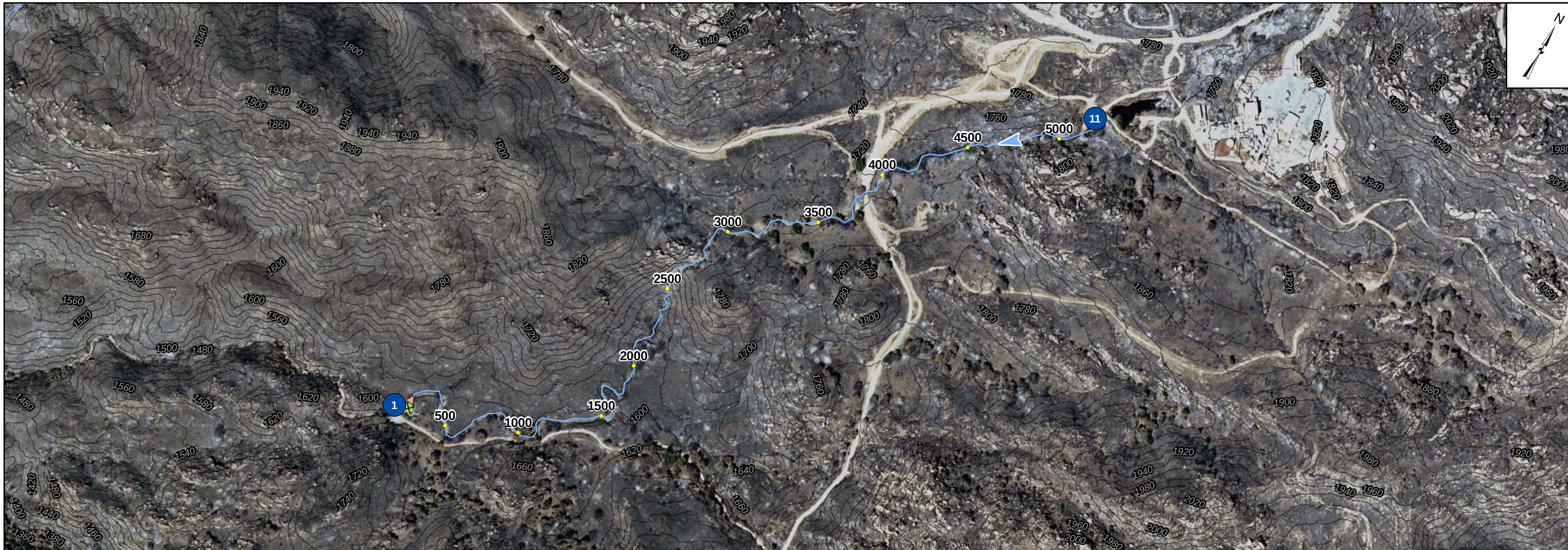
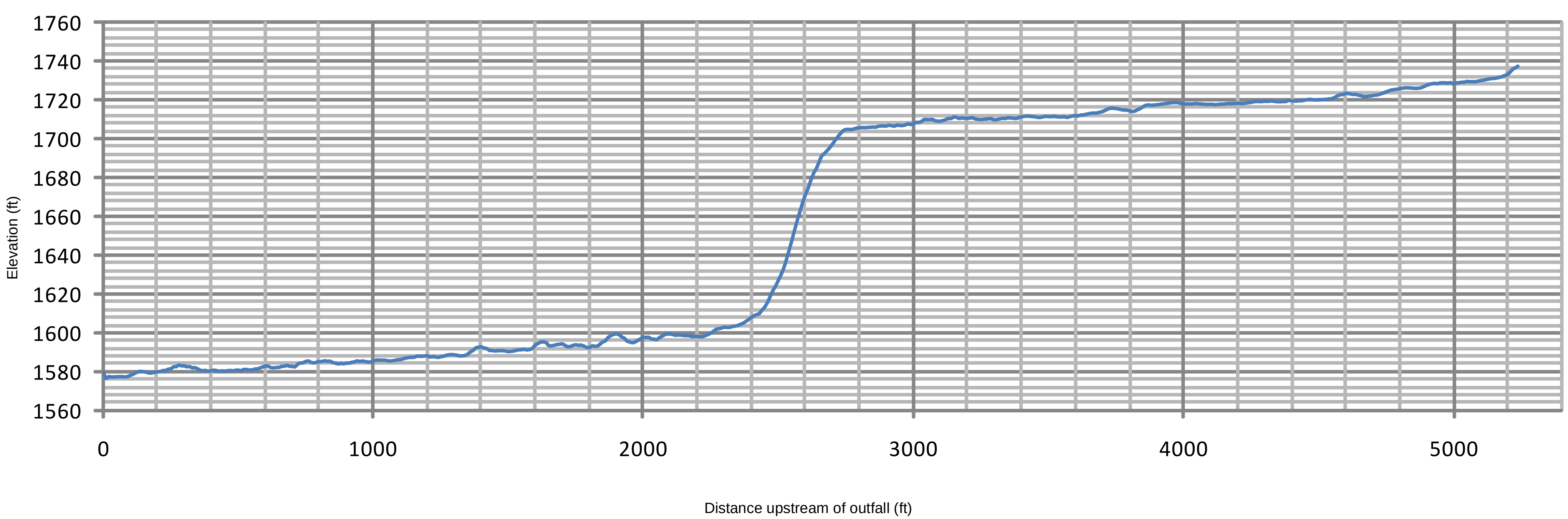
ATTACHMENT 1

Plan and Profiles





Legend

- NPDES Outfall
- Distance Marker (ft)
- Stream
- Contours (20 ft)
- Cross-section Location
- Sample Location

500 250 0 500 Feet

Outfall 001 to 011
Plan and Profile

Boeing SSFL
Ventura County, CA

Geosyntec consultants

Reach
1

Santa Barbara | September 2009

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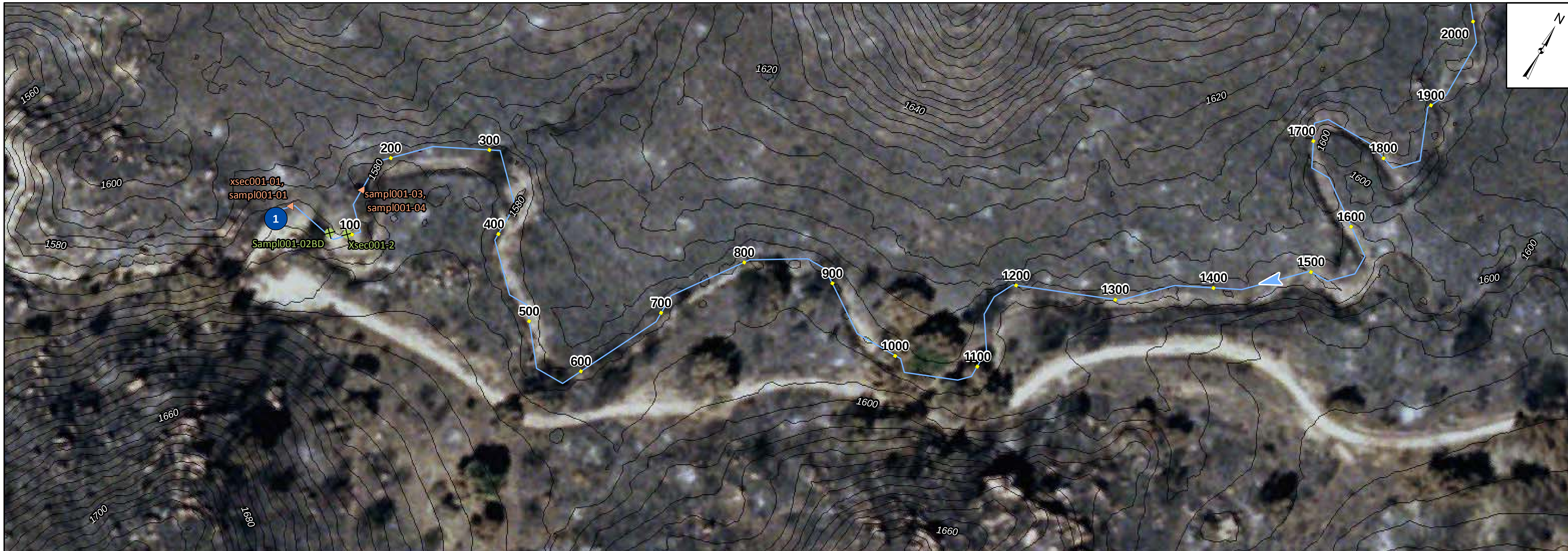

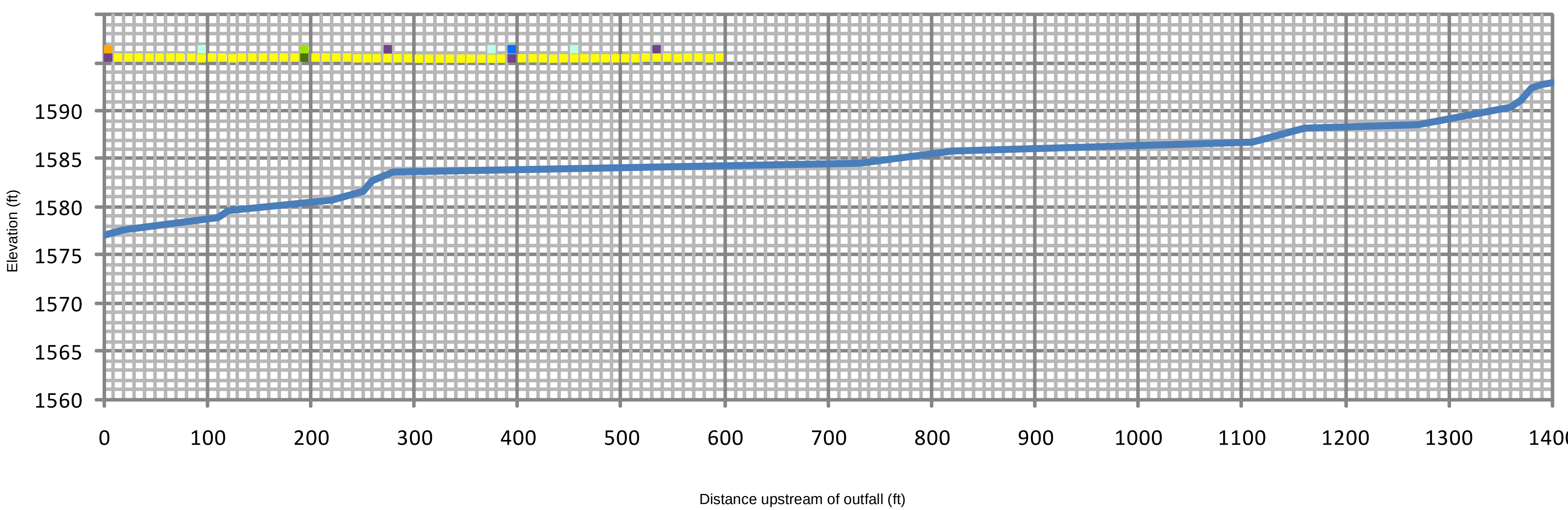

Legend

- NPDES Outfall
- 100-foot Distance Marker
- Stream
- Contours (5 ft)
- Cross-section Location
- Sample Location
- Scoured in channel
- Deposition in channel
- Hard knick point
- Soft knick point
- Pinch point
- Natural dam
- Bank cutting
- Vegetation in channel

100 50 0 100 Feet

Outfall 001 to 011
Detailed Plan and Profile

Boeing SSFL
Ventura County, CA

Geosyntec consultants

Santa Barbara | September 2009

Sub Reach
1A

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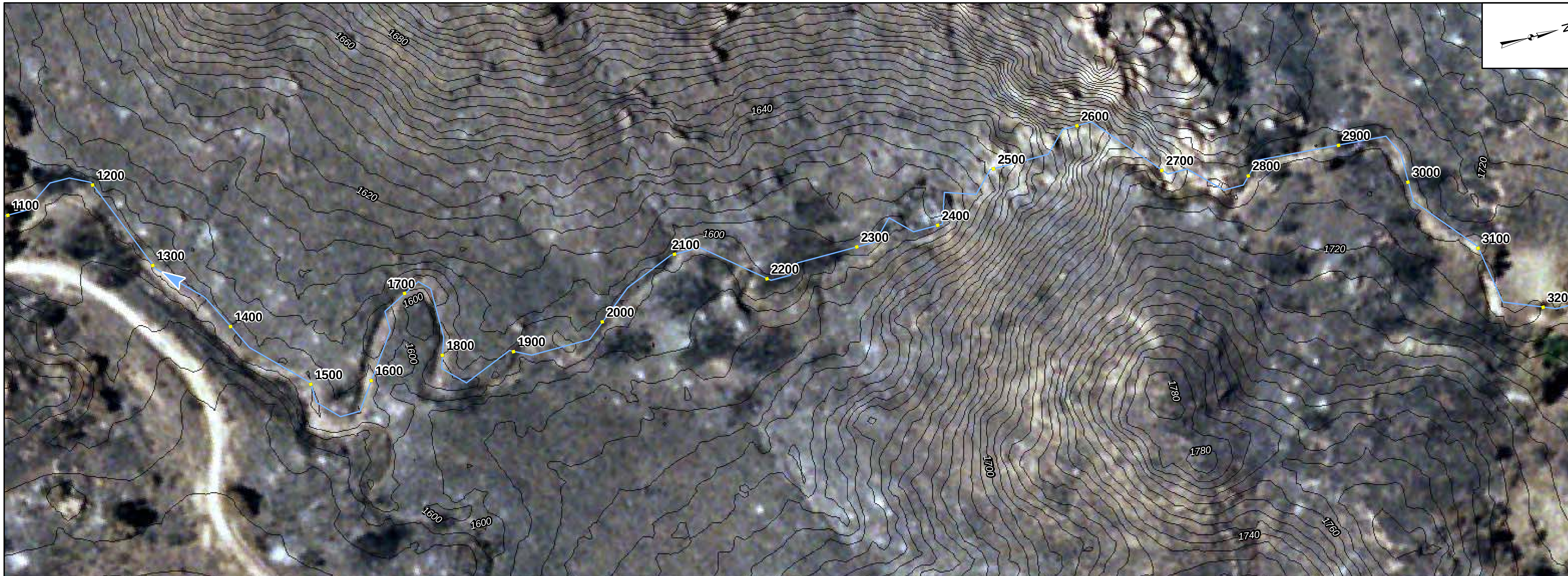

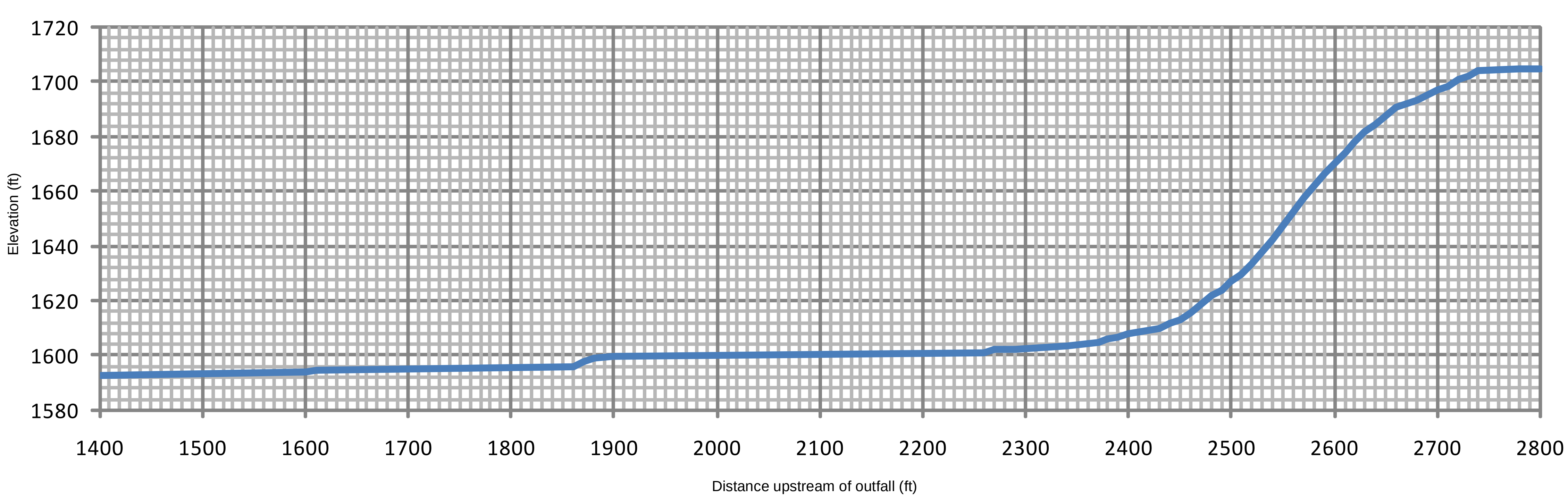

Legend

- NPDES Outfall
- 100-foot Distance Marker
- Stream
- Contours (5 ft)
- Cross-section Location
- Sample Location

100 50 0 100 Feet

Outfall 001 to 011
Detailed Plan and Profile

Boeing SSFL
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Santa Barbara | September 2009

Sub Reach
1B

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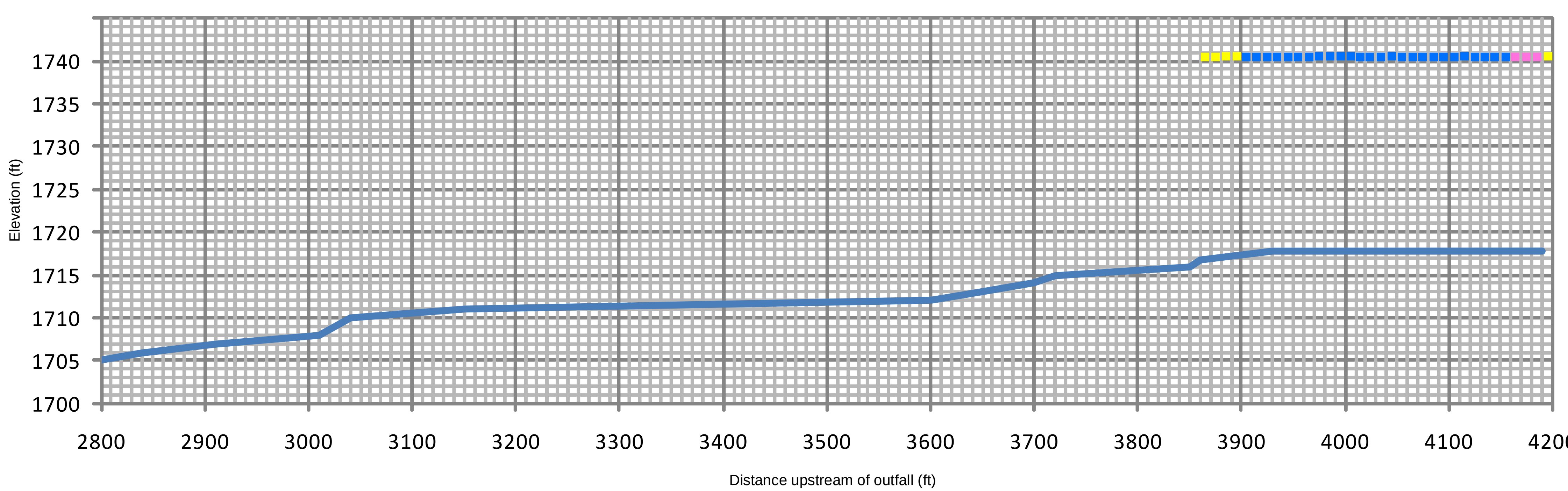


Legend

- NPDES Outfall
- 100-foot Distance Marker
- Stream
- Contours (5 ft)
- Cross-section Location
- Sample Location
- Scoured in channel
- Deposition in channel
- Hard knick point
- Soft knick point
- Pinch point
- Natural dam
- Bank cutting
- Vegetation in channel

100 50 0 100 Feet

Outfall 001to 011
Detailed Plan and Profile

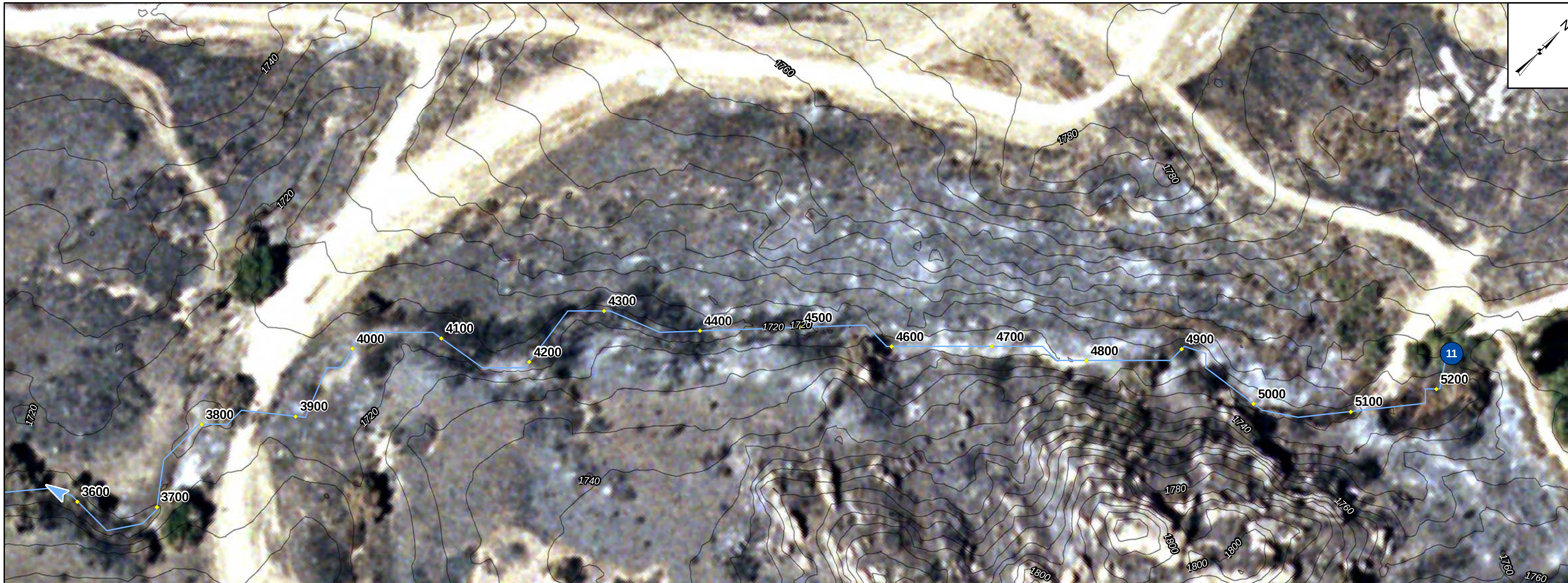
Boeing SSFL
Storm Water Treatment Facilities

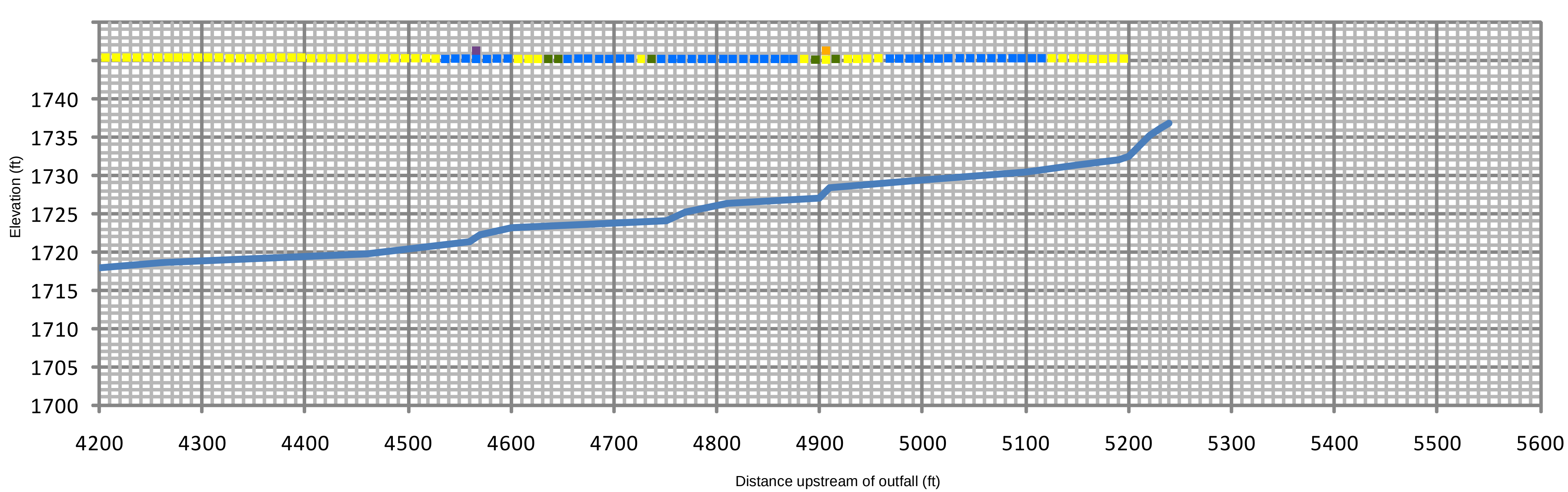
Geosyntec consultants

Santa Barbara | September 2009

Sub Reach

1C





Legend

- NPDES Outfall
- 100-foot Distance Marker
- Stream
- Contours (5 ft)
- Cross-section Location
- Sample Location
- Scoured in channel
- Deposition in channel
- Hard knick point
- Soft knick point
- Pinch point
- Natural dam
- Bank cutting
- Vegetation in channel

100 50 0 100 Feet

Outfall 001 to 011
Detailed Plan and Profile

Boeing SSFL
Storm Water Treatment Facilities

Geosyntec consultants

Santa Barbara | September 2009

Sub Reach **1D**

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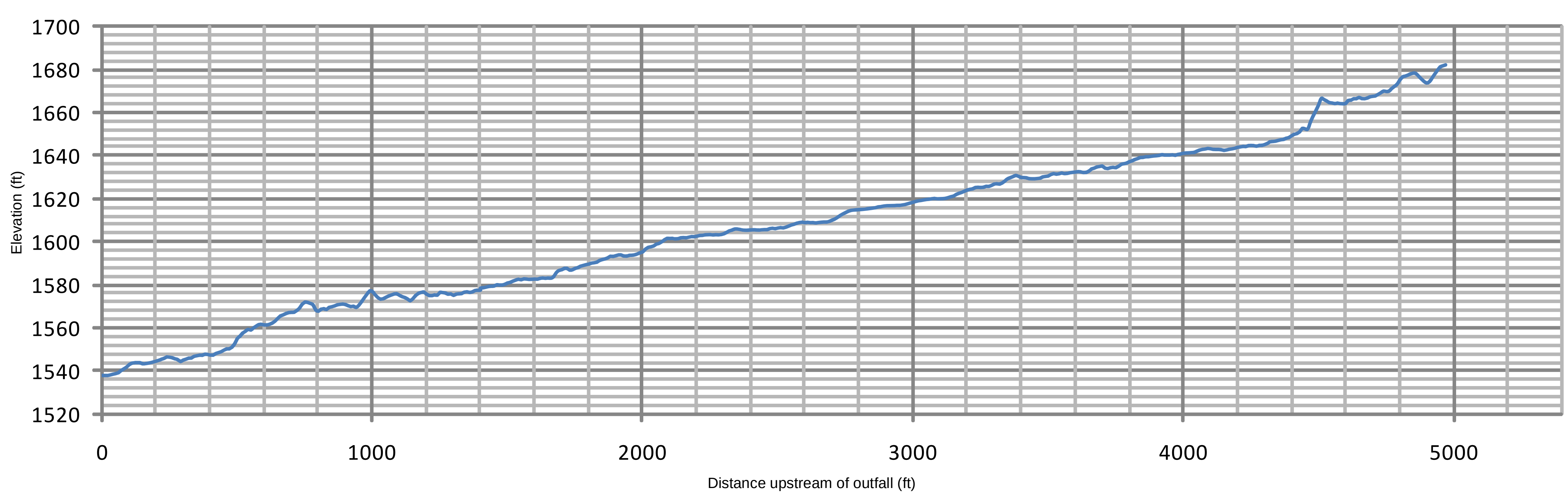


Legend

- NPDES Outfall
- Distance Marker (ft)
- Stream
- Contours (20 ft)
- Cross-section Location
- Sample Location

490 245 0 490 Feet

Outfall 002 to 018
Plan and Profile

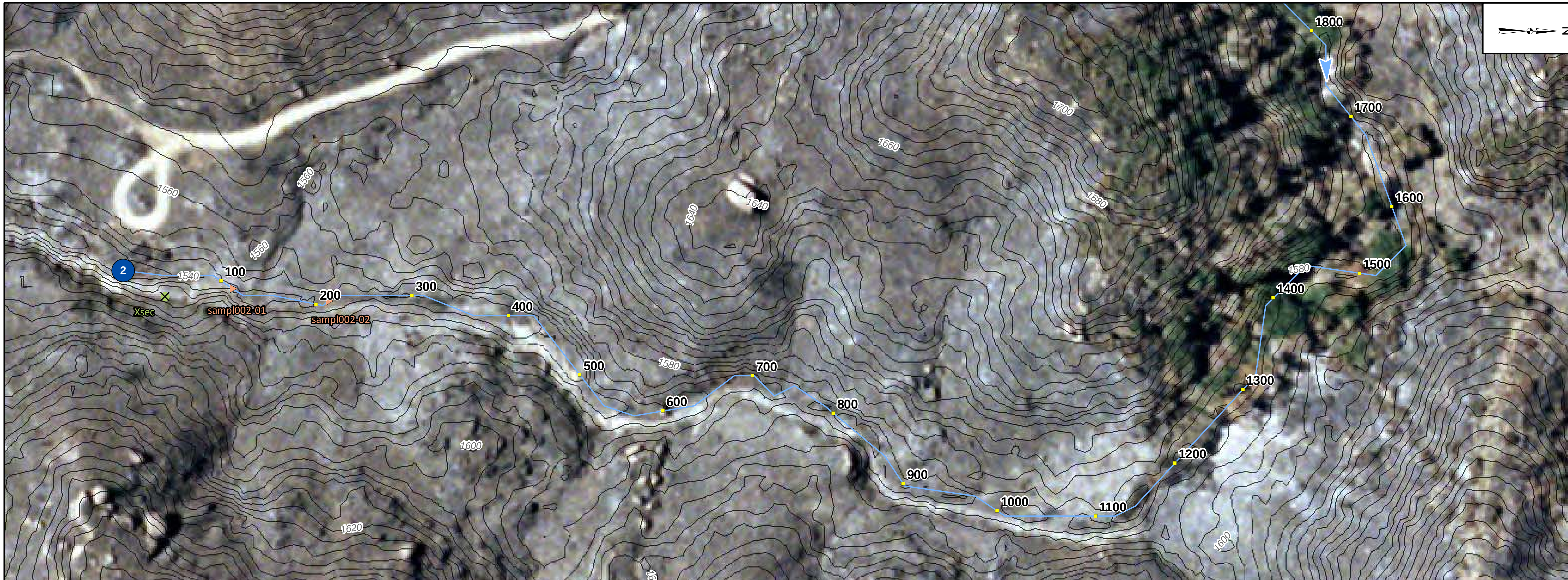
Boeing SSFL
Storm Water Treatment Facilities

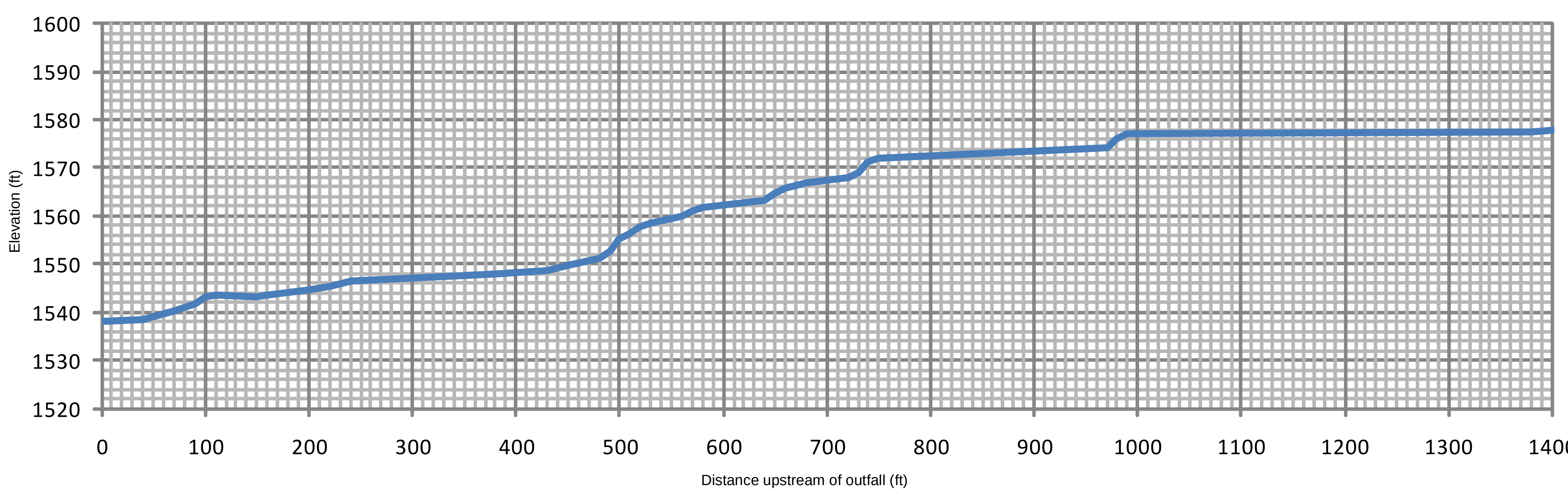
Geosyntec consultants

Santa Barbara | September 2009

Reach 2

P:\GIS\SB0363\Projects\profile_outfalls1+2\Figure8_Outfall_002_018_Plan_Profile.mxd September 24, 2009 NM





Legend

- NPDES Outfall
- 100-foot Distance Marker
- Stream
- Contours (5 ft)
- Cross-section Location
- Sample Location

100 50 0 100 Feet

Outfall 002 to 018
Detailed Plan and Profile

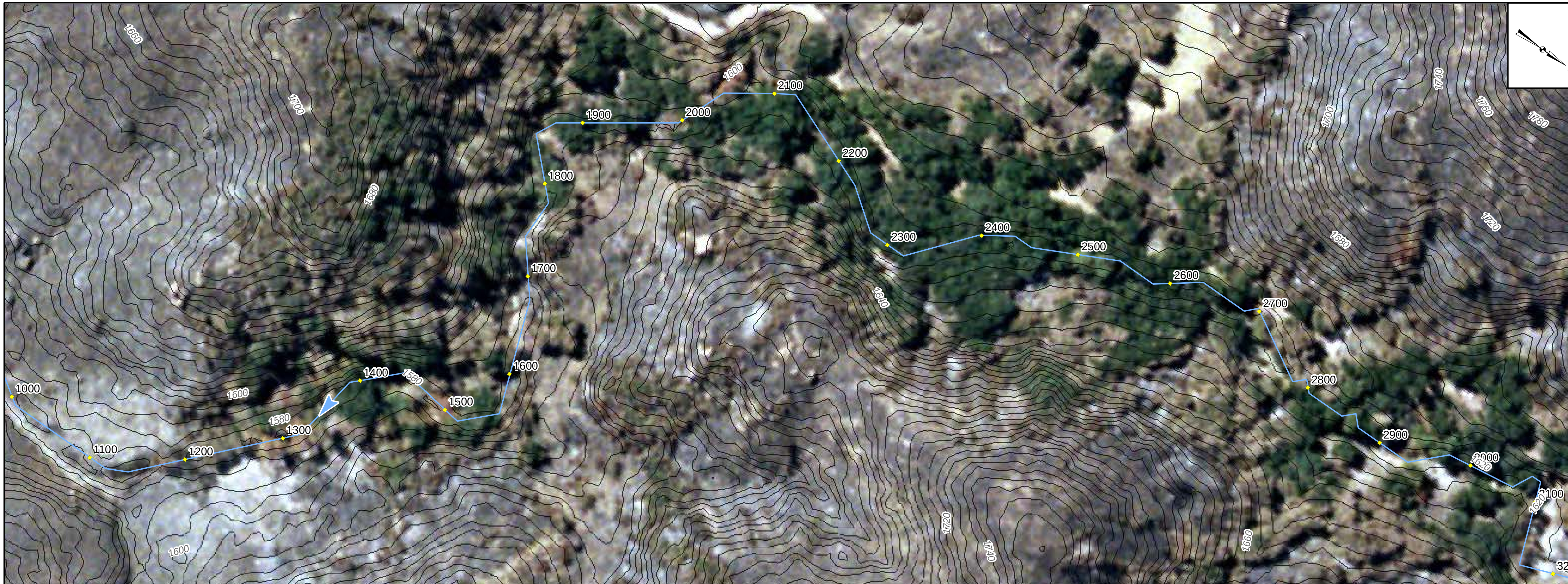
Boeing SSFL
Storm Water Treatment Facilities

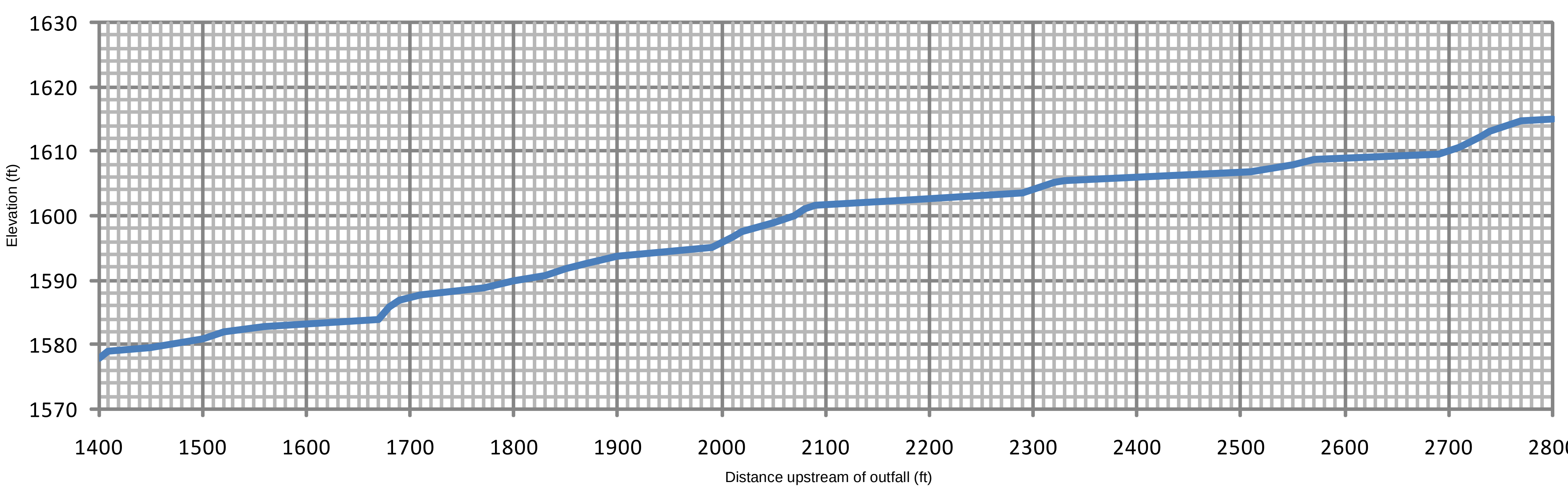
Geosyntec consultants

Sub Reach **2A**

Santa Barbara | September 2009

P:\GIS\SB0363\Projects\profile_outfalls1+2\Figure9A_Outfall_002_018_Detailed.mxd September 28, 2009 NM





Legend

- NPDES Outfall
- 100-foot Distance Marker
- Stream
- Contours (5 ft)
- Cross-section Location
- Sample Location

100 50 0 100 Feet

Outfall 002 to 018
Detailed Plan and Profile

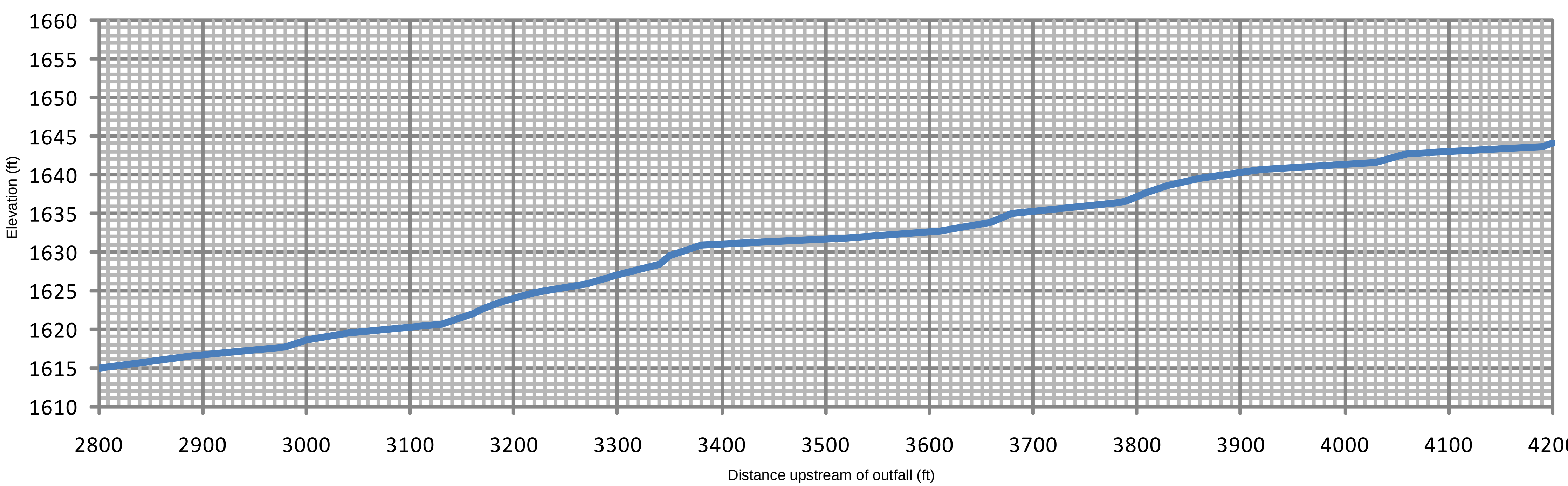
Boeing SSFL
Storm Water Treatment Facilities

Geosyntec consultants

Santa Barbara | September 2009

Sub Reach **2B**

P:\GIS\SB0363\Projects\profile_outfalls1+2\Figure9B_Outfall_002_018_Detailed.mxd September 28, 2009 NM



Legend

- NPDES Outfall
- 100-foot Distance Marker
- Stream
- Contours (5 ft)
- Cross-section Location
- Sample Location

100 50 0 100 Feet

Outfall 002 to 018
Detailed Plan and Profile

Boeing SSFL
Storm Water Treatment Facilities

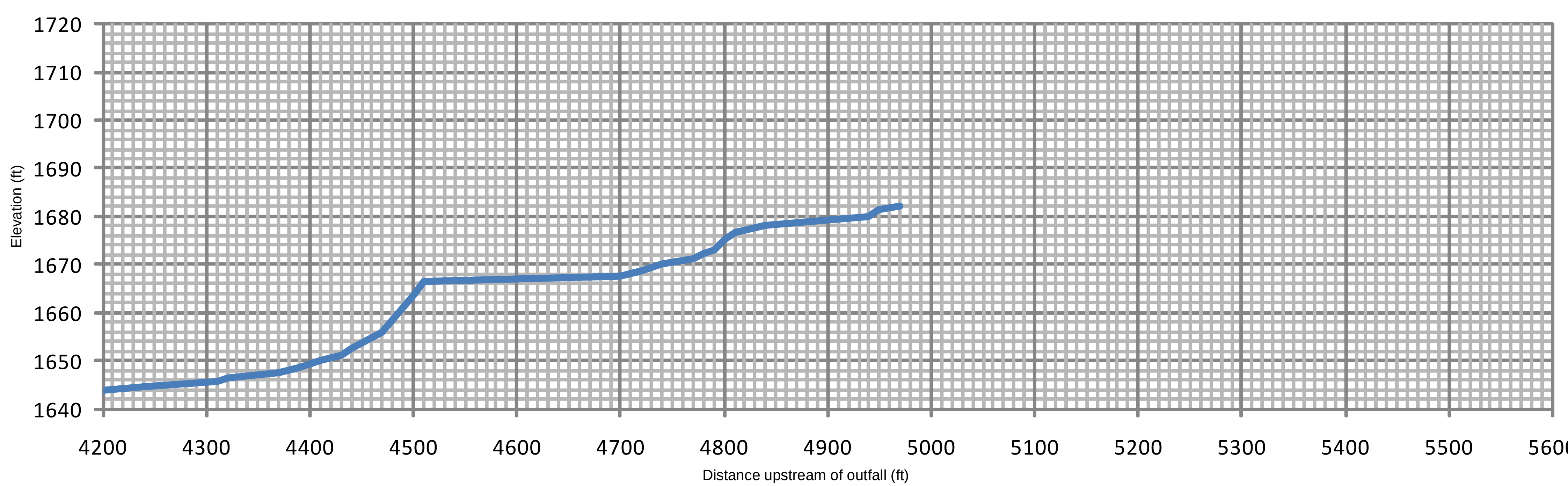
Geosyntec consultants

Sub Reach

2C

Santa Barbara | September 2009

P:\GIS\SB0363\Projects\profile_outfalls1+2\Figure9C_Outfall_002_018_Detailed.mxd September 28, 2009 NM



Legend

- NPDES Outfall
- 100-foot Distance Marker
- Stream
- Contours (5 ft)
- Cross-section Location
- Sample Location

100 50 0 100 Feet

Outfall 002 to 018
Detailed Plan and Profile

Boeing SSFL
Storm Water Treatment Facilities

Geosyntec consultants

Santa Barbara | September 2009

Sub Reach **2D**

ATTACHMENT 2

Representative Field Photographs

GEOSYNTEC CONSULTANTS
Photographic Record

Client: Boeing	**Project Number: SB0363W**
Site Name: Santa Susana Field Laboratory	**Site Location: Santa Susana Field Laboratory**

OF001Insp_08192016_03	
Date: 08/19/2016	
Station ID: OF001 52+00	
Comments: Vertical soft bank, 1 ft vertical height. Immediately downstream of OF011. This is a fairly common feature between OF011 and the road crossing of Sta 38+00.	

OF001Insp_08192016_18	
Date: 08/19/2016	
Station ID: OF001 43+00	
Comments: Vertical soft bank, 1 – 1.5 ft vertical height. This is a fairly common feature between OF011 and the road crossing (Sta 38+00).	

GEOSYNTEC CONSULTANTS **Photographic Record**	
Client: Boeing	**Project Number: SB0363W**
Site Name: Santa Susana Field Laboratory	**Site Location: Santa Susana Field Laboratory**

OF001Insp_08192016_25	
Date: 08/19/2016	
Station ID: OF001 37+00	
Comments: Typical channel bank and bed between Sta 28+00 and the road crossing (Sta 38+00). Grass covering a majority of the slopes, with minor undercutting of the tow of the bank. Channel bottom is soft.	

OF001Insp_08192016_33	
Date: 08/19/2016	
Station ID: OF001 33+00	
Comments: Major bank scarring along the left bank at this bend**.** Vertical height approximately 4 – 5 ft. Appears to be naturally occurring.	

GEOSYNTEC CONSULTANTS
Photographic Record

Client: Boeing	**Project Number: SB0363W**
Site Name: Santa Susana Field Laboratory	**Site Location: Santa Susana Field Laboratory**

OF001Insp_08192016_39

Date: 08/19/2016

Station ID: OF001 29+00

Comments:
Major bank scarring along left bank at this sharp turn. Vertical height approx. 4 ft.

OF001Insp_08192016_42

Date: 08/19/2016

Station ID: OF001 22+00

Comments:
Near the bottom of the steep portion of the drainage, at approximately Sta 22+00. Channel filled with boulders and large cobbles.

GEOSYNTEC CONSULTANTS
Photographic Record

Client: Boeing	**Project Number: SB0363W**
Site Name: Santa Susana Field Laboratory	**Site Location: Santa Susana Field Laboratory**

OF001Insp_08192016_03	
Date: 08/19/2016	
Station ID: OF001 20+00	
Comments: Typical stream section between OF001 and Sta 22+00. Soft bottom with shrubs on the banks.	

OF001Insp_08192016_63	
Date: 08/19/2016	
Station ID: OF001 05+00	
Comments: Installed check-structure, facing downstream. No sediment buildup present on upstream side of the structure. Found to be in good shape.	

GEOSYNTEC CONSULTANTS
Photographic Record

Geosyntec consultants

Client: Boeing	Project Number: SB0363W
Site Name: Santa Susana Field Laboratory	Site Location: Santa Susana Field Laboratory

Photograph 5, 2009 Sed Control Report

Date: 09/10/2009

Station ID: OF001 03+00

Comments: Comparison photographs.

Boulder Pinch-Point in 2009.

OF001Insp_08192016_64

Date: 08/19/2016

Station ID: OF001 03+00

Comments: Comparison photographs.

Boulder Pinch-Point in 2016, with rock check structure. View downstream.

GEOSYNTEC CONSULTANTS **Photographic Record**	
Client: Boeing	**Project Number: SB0363W**
Site Name: Santa Susana Field Laboratory	**Site Location: Santa Susana Field Laboratory**

OF001Insp_08192016_65	
Date: 08/19/2016	
Station ID: **OF001 00+25**	
Comments: View facing upstream from OF001.	

OF001Insp_08192016_67	
Date: 08/19/2016	
Station ID: **OF001 100**	
Comments: View facing downstream from OF001.	

GEOSYNTEC CONSULTANTS
Photographic Record

Client: Boeing	**Project Number: SB0363W**
Site Name: Santa Susana Field Laboratory	**Site Location: Santa Susana Field Laboratory**

OF002Insp_08192016_03	
Date: 08/19/2016	
Station ID: OF002 39+00	
Comments: Steep right bank approx. 30 ft from road, approx. 6 ft vertical height. Toe erosion is approximately 1-1.5 ft in height.	

OF002Insp_08192016_05	
Date: 08/19/2016	
Station ID: OF002 38+00	
Comments: In-channel weir structure.	

Client: Boeing	**Project Number: SB0363W**
Site Name: Santa Susana Field Laboratory	**Site Location: Santa Susana Field Laboratory**

OF002Insp_08192016_11	
Date: 08/19/2016	
Station ID: OF002 34+50	
Comments: CMP culvert at Roca Ave, facing downstream.	

OF002Insp_08192016_12	
Date: 08/19/2016	
Station ID: OF002 34+00	
Comments: From Roca Ave crossing, facing upstream, above the CMP culvert. Steep vertical right bank, with a more gently sloped left bank.	

GEOSYNTEC CONSULTANTS **Photographic Record**	Geosyntec consultants
Client: Boeing	**Project Number: SB0363W**
Site Name: Santa Susana Field Laboratory	**Site Location: Santa Susana Field Laboratory**

OF002Insp_08192016_15	
Date: 08/19/2016	
Station ID: OF002 30+00	
Comments: Bank held by oaks. Approx. 4 - 5 ft vertical height. This is a fairly common occurrence in this portion of the reach – steep banks, heavy vegetation, and cobbles throughout the bottom of the channel.	

OF002Insp_08192016_31	
Date: 08/19/2016	
Station ID: OF002 12+00	
Comments: Facing downstream at the point where the reach transitions from dense tree canopy to shrubs. Bedrock is exposed here for a significant portion of the stretch from OF002 to Sta 12+00.	

GEOSYNTEC CONSULTANTS
Photographic Record

Client: Boeing	**Project Number: SB0363W**
Site Name: Santa Susana Field Laboratory	**Site Location: Santa Susana Field Laboratory**

Photograph 9, 2009 Sed Control Report

Date: 09/10/2009

Station ID: OF002 00+25

Comments:
Comparison photographs.

Channel bottom with significant cobble. View facing upstream.

OF002Insp_08192016_35

Date: 08/19/2016

Station ID: OF002 00+25

Comments:
Comparison photographs.

Channel bottom with significant cobble upstream of OF002. View facing upstream.

Client: Boeing	**Project Number: SB0363W**
Site Name: Santa Susana Field Laboratory	**Site Location: Santa Susana Field Laboratory**

OF002Insp_08192016_36 **Date: 08/19/2016** **Station ID: OF002 00+20** **Comments:** View of OF002, from upstream.	
OF002Insp_08192016_37 **Date: 08/19/2016** **Station ID: OF002 00+25** **Comments:** View from OF002, facing downstream.	

Appendix F: 2015/2016 BMP Subarea Prioritization Analysis

Prepared for

The Boeing Company
Santa Susana Site
5800 Woolsey Canyon Road
Canoga Park, California, 91304-1148

Appendix F: Watershed 008 and 009 BMP Subarea Prioritization Analysis

2015/2016 Reporting Year

Prepared by

The Surface Water Expert Panel

and

Geosyntec consultants

engineers | scientists | innovators

924 Anacapa Street, Suite 4A,
Santa Barbara, CA, 93101

SB0363W
October 2016

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Attachments

Attachment 1: Summary Flowchart for BMP Subarea Ranking Analysis Approach

Attachment 2: Map of Locations used in Subarea Ranking Analysis

Attachment 3: Outfall 008 and 009 Watershed Subarea Monitoring Locations

Attachment 4: Treatment Drainage Areas

Attachment 5: Ranking Analysis Approach Methodology

Attachment 6: Summary of Results by Subarea

Acronyms

BEF	Bioaccumulation Equivalency Factors
BMP	Best Management Practice
CASQA	California Stormwater Quality Association
Cd	Cadmium
CM	Culvert Modification
COC	Constituent of Concern
CV	Coefficient of Variation
Cu	Copper
Det	Detected
DNQ	Detected not Quantified
ENTS	Engineered Natural Treatment Systems
ISRA	Interim Source Removal Action
LOX	Liquid Oxygen Plant
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
mg/L	milligram per liter
NASA	National Aeronautics and Space Administration
ND	Not Detected
NPDES	National Pollutant Discharge Elimination System
Pb	Lead
PL	Permit Limit
PS	Particulate Strength
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigations
RWQCB	Regional Water Quality Control Board
SSFL	Santa Susana Field Laboratory
SW	Stormwater
TCDD	Tetrachlorodibenzo-*p*-dioxin
TEQ	Toxic Equivalence
TSS	Total Suspended Solids
USEPA	U.S. Environmental Protection Agency

Executive Summary

The 2010 Engineered Natural Treatment Systems (ENTS) and Expert Panel Work Plan for SSFL Outfalls 008 and 009 (Outfall 008/009 BMP Work Plan) identified an annual process for the Surface Water Expert Panel (Panel) to evaluate subareas within the Outfall 008 and 009 watersheds for potential implementation of new Best Management Practices (BMPs). These BMPs may include source controls (such as removal of impacted surface soils), erosion and sediment controls (such as straw wattles and hydromulch), instream measures (such as bank stabilization and grade control structures), and/or structural treatment controls (such as sediment basins, media filters, and biofilters). The purpose of any newly proposed BMPs would be to improve National Pollutant Discharge Elimination System (NPDES) permit compliance at Outfalls 008 and 009 (Order No. R4-2010-0090)[1]. A new NPDES Permit became effective on April 1, 2015 (Order No. R4-2015-033), continuing to regulate stormwater discharges at the SSFL NPDES outfalls. The 2015 Permit also included a requirement to develop a Site-Wide Expert Panel Work Plan to replace the Outfall 008/009 BMP Work Plan. The Site-Wide Stormwater Work Plan and 2014/15 Annual Report ("2015 Work Plan") (Expert Panel, 2015) was developed to meet this requirement. The 2015 Work Plan included the continuation of the Outfall 008 and 009 annual subarea ranking process (Geosyntec Consultants and Expert Panel, 2011).

The purpose of this subarea ranking analysis is to rank subareas within Boeing's and NASA's 008 and 009 watersheds for potential implementation of new or enhanced stormwater controls and to evaluate existing measures, based on the most current available data and subarea specific considerations. The Expert Panel's recommended approach to this task is to rank potential BMP subarea monitoring locations based on the results of water quality sample comparisons between (a) stormwater concentrations and permit limits, and (b) subarea stormwater particulate strengths[2] and background stormwater particulate strengths. A statistical methodology was developed to rank the subareas based on these comparison results, while accounting for the number of useable data available at each subarea as well as number of data observations that fall above these thresholds (i.e., reflecting statistical confidence in how frequently each subarea will exceed the comparison thresholds). This methodology relied on "weighting factors" that are calculated for each COC for each subarea. In the end, the pollutant-specific weighting factors were summed to produce a multi-constituent score to allow for relative ranking amongst the potential BMP subareas. This approach was submitted to the RWQCB on June 22, 2011, presented at a public meeting on August 25, 2011, the California Stormwater Quality Association (CASQA) conference in 2011, published in Stormwater Magazine in 2013, and published in Water Resources Impact in March 2016 (Costa, et al., 2016).

---

[1] Outfall 009 had two NPDES exceedances in two of three NPDES-sampled events this year; however, total rainfall was only 11.97 inches in the 2015/2016 reporting year, which is 65 percent of the average annual rainfall (16.8 inches). January 5-10, 2016 produced 3.87 inches, and March 5-7, 2016 produced 1.57 inches, which were the two largest events of the reporting year. No daily rain totals exceeded the 1-year, 24-hour design storm depth (2.5 inches). Outfall 008 did not flow during the 2015/2016 reporting year.

[2] Particulate strength is determined by taking the total concentrations of the compound minus its dissolved concentrations and dividing by the total suspended solids, which provides a measure of the mass of particulate form of the compound per mass of suspended sediment. These values are useful in evaluating the relative strength of sediment-based pollutant sources in stormwater samples.

The data included in this analysis fell into the following categories and periods of record:

1) Interim Source Removal Action (ISRA) and culvert modification (CM) performance monitoring data (2009-2015),

2) NPDES outfall monitoring data (2004-2016), and

3) Potential BMP subarea monitoring data (2010-2016).

Where available, data from co-located ISRA subareas were combined with data from BMP subareas in order to provide a more robust dataset at potential BMP locations. The exact periods of record vary by dataset and by sample subarea but are all-inclusive since the beginning of the monitoring program. This ranking evaluation was originally intended to occur annually through the term of the 008/009 BMP Work Plan (i.e., through 2015); the first was submitted to RWQCB by the Expert Panel and Geosyntec in July 2011. However, this process has been extended under the 2015 Work Plan and will continue to verify effectiveness of newly implemented controls and to compute water quality conditions across various subareas.

This year, as in previous years, the Expert Panel has overseen and reviewed the BMP ranking analysis and evaluated the results to make new BMP recommendations. Initial analysis results were presented to the Expert Panel in a meeting held July 19-20, 2016. The Panel received the draft ranking memo in August 2016 and the revised draft in September 2016.

Results Summary

The monitoring locations in Table ES-1 are identified as the highest ranked subareas, with multi-constituent scores ranging from 0.44 to 0.97 out of a maximum score of 1.0. Scores closer to 1.0 indicate the monitoring locations with poorer historical water quality. Table ES-1 is limited to the top-ranked subareas discussed below; a complete summary table is provided in the main report as Table 10. Besides the multi-constituent scores, information within Table ES-1 is also of significance because:

- Only four of the top twenty monitoring locations (A2BMP0011, B1BMP0003, ILBMP0001, and APBMP0001-A) are both active (i.e., not discontinued[3]) and not upstream of an existing BMP (i.e., without downstream stormwater treatment);
- All of the above four monitoring locations are targeted for a new control recommendation (as described in the 2016 Annual Report);
- It contains two (ILBMP0002 and EVBMP0003) of the three subareas (ILBMP0002, EVBMP0003, B1BMP0005) where 2,3,7,8-TCDD[4] was detected (but not quantified) in the 2012/2013 reporting year and three (ILBMP0001, LPBMP0002, ILBMP0004) of the four subareas (B1BMP0005, ILBMP0001, LPBMP0002, ILBMP0004) where 2,3,7,8-TCDD was detected (but not quantified) in the 2015/2016 reporting year. 2,3,7,8-TCDD was not detected in any samples collected during the 2013/2014 or 2014/2015 reporting years;

[3] No site was discontinued if it had known water quality issues. Sites were typically discontinued due to reclassification due to upstream BMP implementation, redundancy, or termination of the required ISRA monitoring period.

[4] 2,3,7,8-TCDD is a congener that potentially indicates unweathered anthropogenic dioxin contamination.

- The top ten highest ranked monitoring locations for dioxins; and
- The top four highest ranked monitoring locations for metals.

In some cases, these results reflect conditions prior to or following implementation of temporary measures or corrective actions; this is indicated in the “description” column of the table. It should be noted that all top 20 monitoring locations described below are located in the Outfall 009 watershed, with none in the Outfall 008 watershed. No events produced observable runoff sufficient to be sampled at Outfall 008 during the current reporting year, indicating that retention occurred within the watershed during the small storms that occurred. Water quality at stormwater background locations was generally good with no location ranked above 38, although there were several instances of concentrations greater than NPDES permit limits at those locations. A detailed discussion of each of the top 20 ranked monitoring locations is provided in Section 5 of this report.

Figure ES-1 summarizes the key subarea monitoring locations that have both an influent and effluent paired location, focusing on the locations ranked in the top 20 from the multi-constituent ranking analysis. This comparison demonstrates that treatment through the BMPs resulted in improved water quality, as demonstrated by a decrease between the influent and effluent rank. For example, two influent streams within the B1 area (ranked 14 and 42) are both more highly ranked than the associated B1 effluent, which is ranked 43. A similar occurrence is observed for the influent/effluent ranks for CM-1, CM-9, the ELV treatment BMP, and the lower parking lot sedimentation basin and biofilter.

Figure ES-2 summarizes a select subset of subarea monitoring locations ranked in the top 20 that are associated with BMP modification and/or improvement. In most cases, there was a decrease in location rank based on the multi-constituent score after the BMP was implemented, demonstrating that BMP implementation has generally resulted in improved water quality. The lower lot sheetflow shows an increase in rank but was technically discontinued when the lower lot biofilter was constructed.

Figures ES-3 through ES-8 show the locations of the top 20 ranked subarea monitoring locations, with approximate drainage areas and site-specific ranking results.

Table ES- 1. Subareas Ranked by Multi-Constituent Score

Rank			Multi-Constituent Score	BMP Subarea (Co-locations)	Watershed	Description	Approximate Upgradient Drainage Area (ac)	Number of Events Sampled		Both the NPDES permit limit and 95th percentile background particulate strength threshold exceeded for at least one COC	Site Status		
Overall	From Maximum Metal Weighting	From Maximum Dioxin Weighting						2009-2016	2015-2016		Currently Upstream of Treatment BMP[1]	Targeted for Current Control	Unaddressed at This Time
1	1	7	0.97	ILBMP0002	Outfall 009	Road runoff to CM-9, before treatment	2.2	16	3	YES	CM-9		
2	3	1	0.9	EVBMP0003 (A2SW0001)	Outfall 009	CM-1 upstream west, pre-ELV improvements, before treatment - OLD	4.9	18	0	YES	CM-1		
3.5	4	25	0.63	A1SW0009-A	Outfall 009	CM-9 downstream-underdrain outlet (post-A1LF asphalt removal, pre-filter fabric over weir boards) - OLD	10.2	1	0	YES			(2)
3.5	10.5	13	0.63	A2BMP0011	Outfall 009	Well 13 and Area 2 Road Runoff	0.30	1	1	YES			(3)
5	2	40	0.62	EVBMP0004	Outfall 009	2012-2013 Lower Helipad Road	2.5	3	0	YES	ELV Treatment BMP		
6	21	8	0.6	EVBMP0002	Outfall 009	Helipad (pre-sandbag berms) - OLD	4.1	6	0	YES	Sandbag berm		
7	6	25	0.6	APBMP0001	Outfall 009	Road runoff to ashpile culvert inlet, pre-ELV improvements - OLD	3.6	2	0	YES		X	
8	23	4	0.58	LPBMP0001-A	Outfall 009	Lower lot sheetflow (post-gravel bag berms)	2.7	6	0	YES	Lower Lot Biofilter		
9	30	6	0.53	ILBMP0008	Outfall 009	Upstream 2 (B1436 Southern Detention Bioswale influent)	13.3	8	8	YES	B1436 Southern Detention Bioswale		
10	15	17	0.51	A1SW0009-B	Outfall 009	CM-9 downstream-underdrain outlet (post-filter fabric over weir boards, post-A1LF asphalt removal) - OLD	10.2	6	0	YES			(2)
12	10.5	25	0.5	B1SW0014-A	Outfall 009	B1 media filter effluent (pre-media filter reconstruction) - OLD	8.6	1	0	NO			(2)
12	10.5	25	0.5	B1SW0002	Outfall 009	Woolsey Canyon Road Runoff, before treatment	3.8	2	0	YES	B1 Media Filter		
12	10.5	25	0.5	EVBMP0006	Outfall 009	2012-2013 Area II Road near ELV ditch	8.2	1	0	NO	ELV Treatment BMP		
14	70.5	2	0.5	B1BMP0004 (B1BMP0004-5, B1SW0015)	Outfall 009	B1 media filter inlet north, before treatment	6.7	21	5	YES	B1 Media Filter		
15	70.5	3	0.49	B1BMP0003 (B1BMP0002)	Outfall 009	Upper parking lot / road runoff to B1 area culvert inlet	4.8	23	2	YES		X	
16	70.5	5	0.49	LPBMP0002	Outfall 009	Lower parking lot influent to cistern, before treatment	29.9	15	8	YES	Lower Lot Biofilter		
17	36	9	0.47	ILBMP0004	Outfall 009	Upstream 1 (B1436 Southern Detention Bioswale)	0.40	7	7	YES	B1436 Southern Detention Bioswale		
18	70.5	10	0.45	LPBMP0003	Outfall 009	Lower parking lot sediment basin outlet, before treatment	29.9	15	8	YES	Lower Lot Biofilter		
19	70.5	11	0.45	ILBMP0001	Outfall 009	Lower parking lot 24" storm drain bypass	30.2	26	3	YES		X	
20	10.5	37	0.44	APBMP0001-A	Outfall 009	Area II road runoff, post-ELV stormwater improvements	0.32	5	3	YES		X	

Notes

(1) For those sites indicated as currently upstream of a treatment BMP, no further treatment or pretreatment are needed; downstream controls are functioning well, as demonstrated in Table 12.
(2) Replaced with updated sample ID post-improvements
(3) Only 1 sample; more data needed

- The rounding of weights may account for similar weights being ranked differently.
- Approximate drainage areas based on the cumulative drainage area of the SWMM catchment in which the monitoring location is located.
- Gray text indicates historical subarea monitoring locations that are discontinued.
- "OLD" in the location description means that the location is now sampled under a new suffix (-A, -B, etc.) due to a change in the upstream watershed, typically BMP implementation.

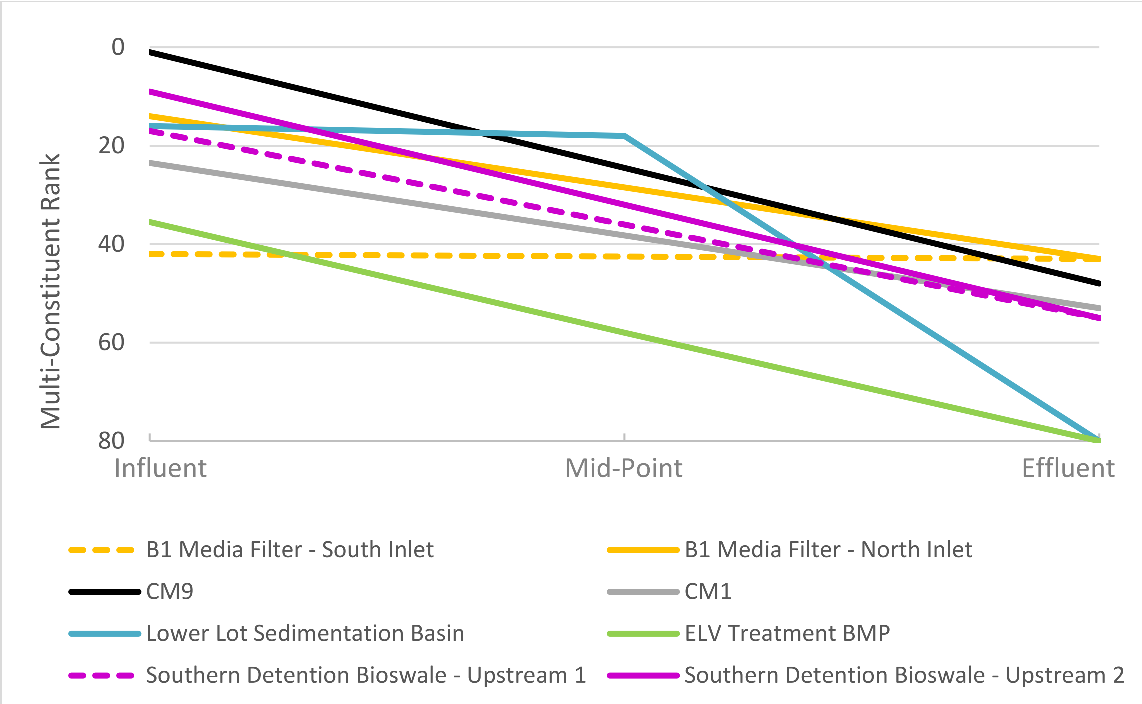


Figure ES- 1. Graphical Comparison of BMP Influent/Effluent Monitoring Location Ranks

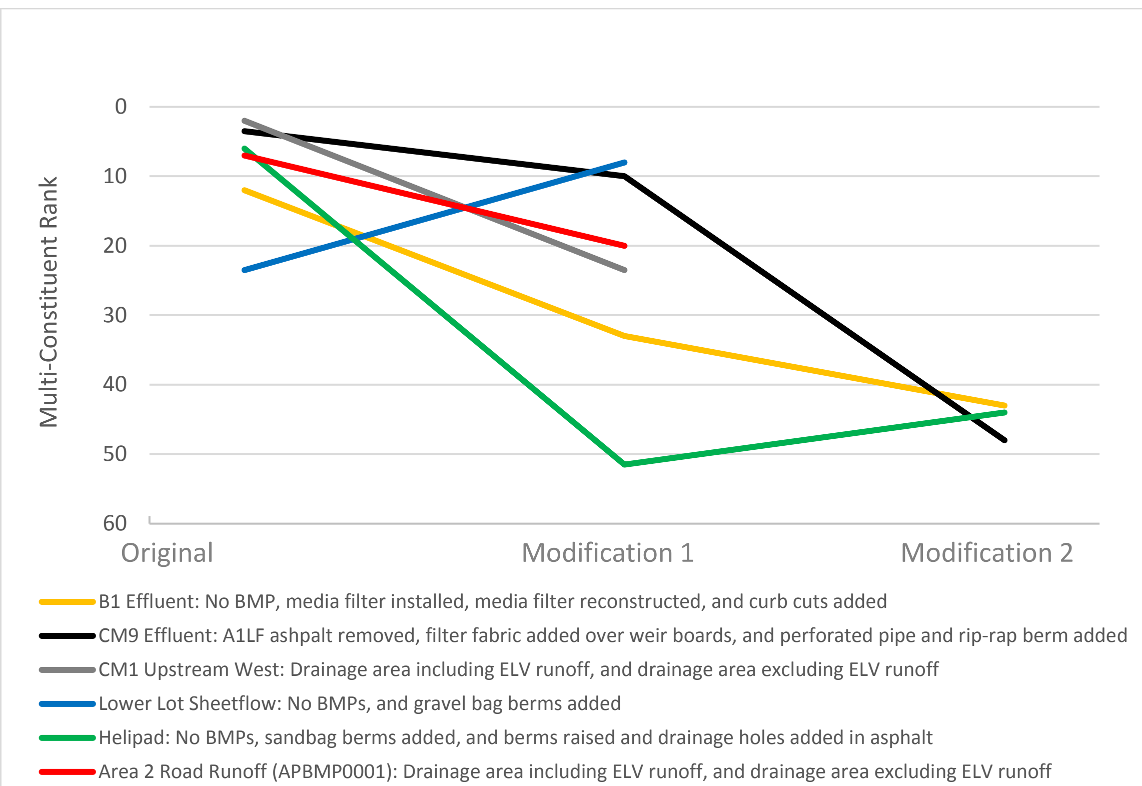
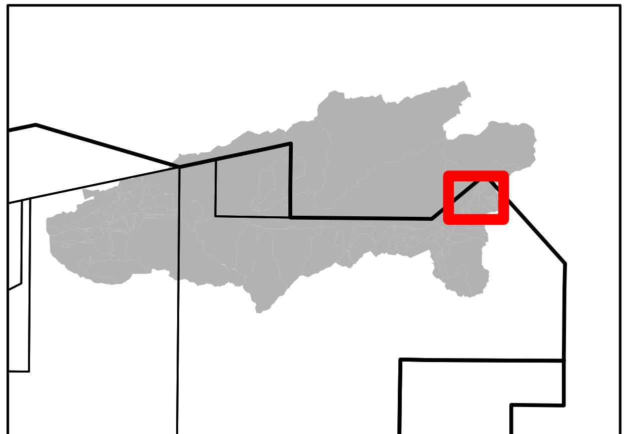
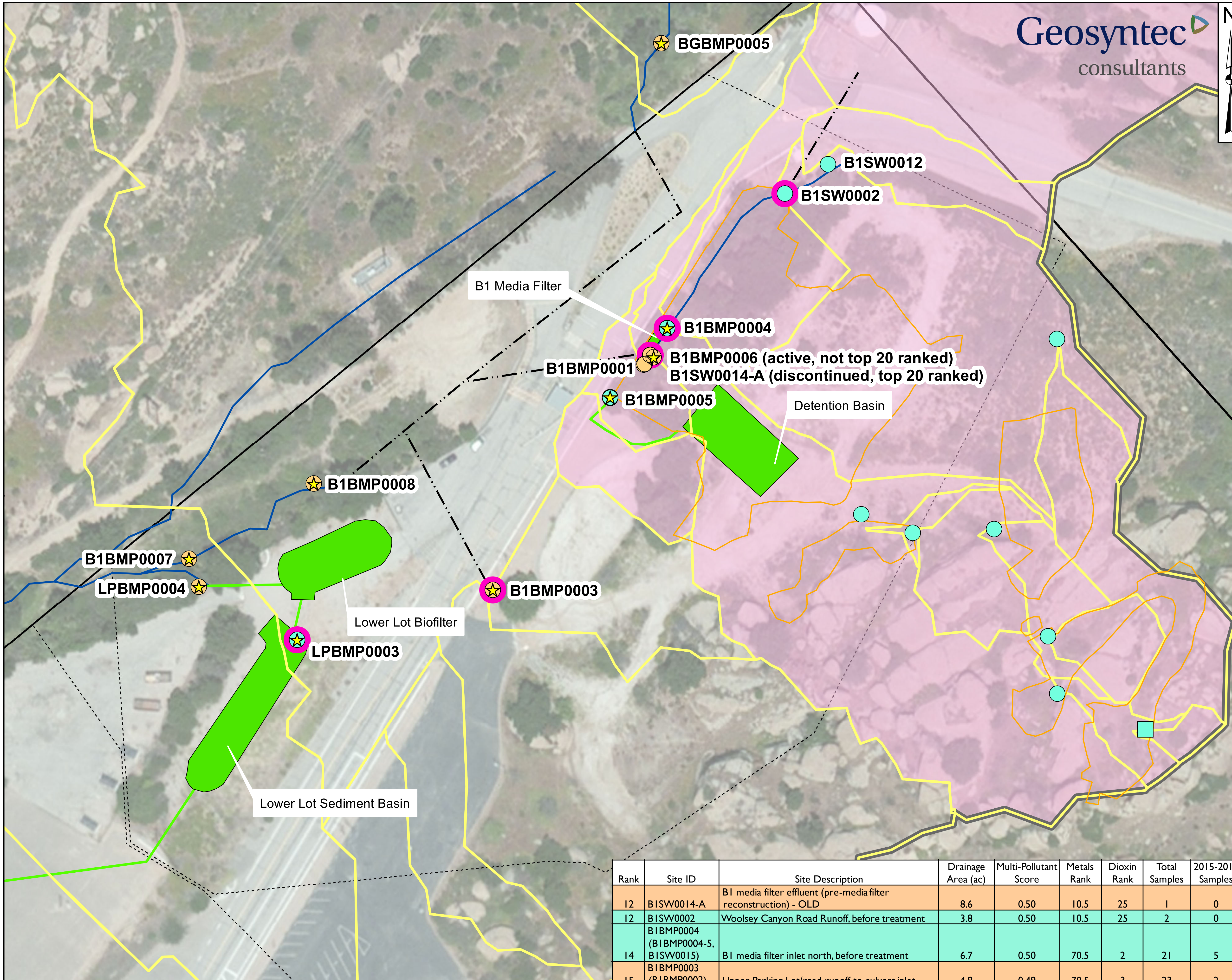


Figure ES- 2. Graphical Comparison of BMP Improvement Ranks





Rank	Site ID	Site Description	Drainage Area (ac)	Multi-Pollutant Score	Metals Rank	Dioxin Rank	Total Samples	2015-2016 Samples
12	B1SW0014-A	B1 media filter effluent (pre-media filter reconstruction) - OLD	8.6	0.50	10.5	25	1	0
12	B1SW0002	Woolsey Canyon Road Runoff, before treatment	3.8	0.50	10.5	25	2	0
14	B1BMP0004 (B1BMP0004-5, B1SW0015)	B1 media filter inlet north, before treatment	6.7	0.50	70.5	2	21	5
15	B1BMP0003 (B1BMP0002)	Upper Parking Lot/road runoff to culvert inlet	4.8	0.49	70.5	3	23	2

Legend

- With Downstream Treatment
- Without Downstream Treatment
- Active Site
- Stormwater Background Monitoring Location
- BMP Subarea Monitoring Location
- Top 20 Ranked Site
- Drainage
- Storm Drain
- Treatment BMPs
- Asphalt Removal
- Completed ISRA Area
- Untreated Drainage Area
- Drainage Area Treated by B1 Media Filter

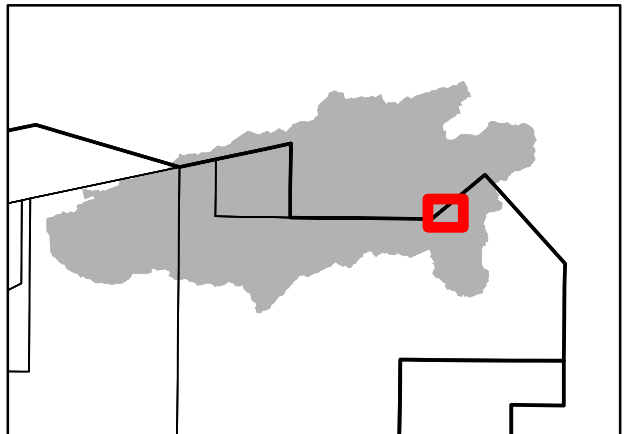
0 40 80 160 Feet

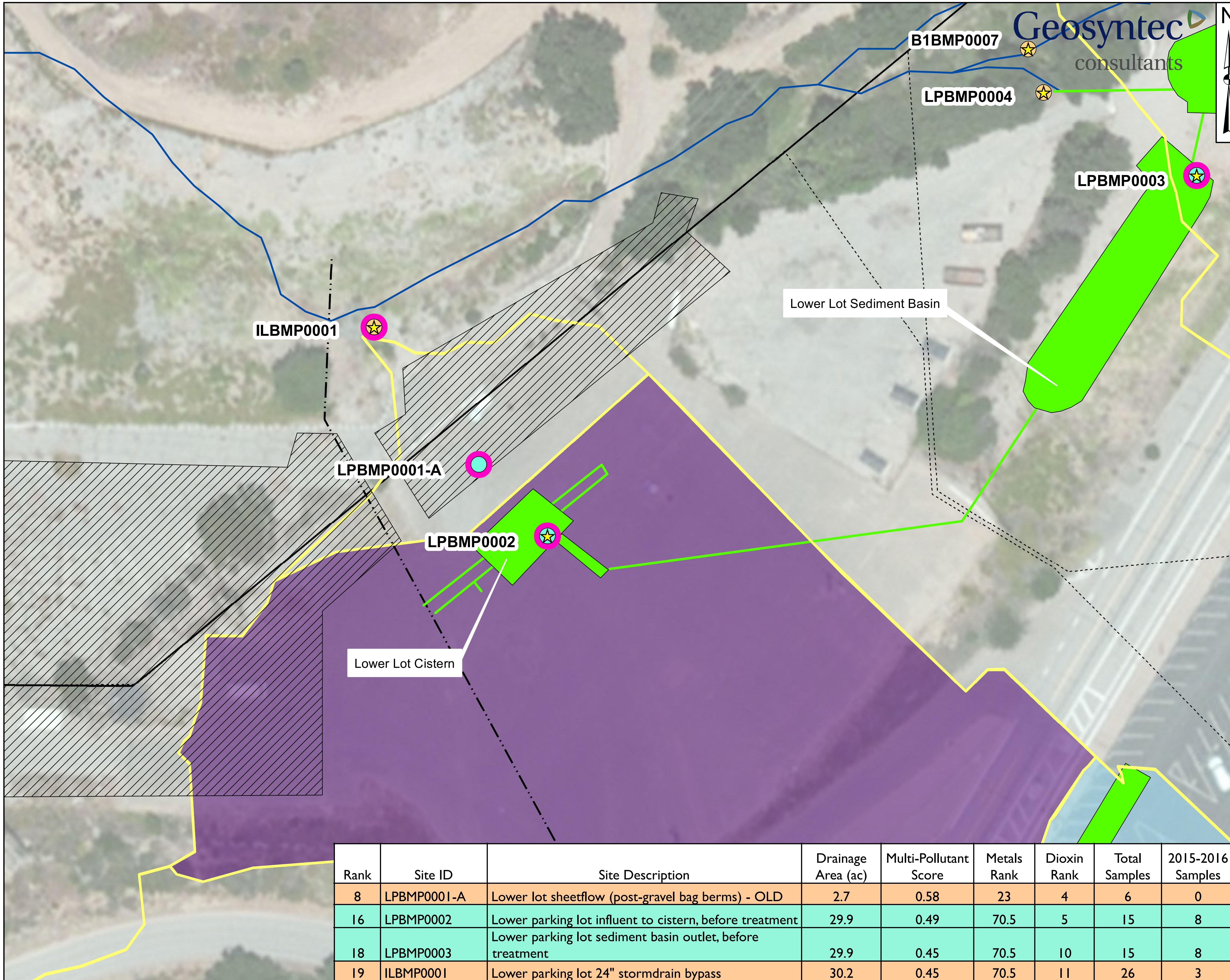
Figures ES-3
Top 20 Ranked: B1 Area

Santa Susana Field Laboratory
Ventura County, CA

October 2016

Date: 9/16/2016, Path: Z:\GIS\Projects\Boeing\SSFL\2016 SB0363W\Ranking Memo\2016 Priority Sites-B1_v4.mxd, User: OLincoln





Legend

- With Downstream Treatment
- Without Downstream Treatment
- ☆ Active Site
- Top 20 Ranked Site
- Stormwater Background Monitoring Location
- BMP Subarea Monitoring Location
- Drainage
- Storm Drain
- Treatment BMPs
- Asphalt Removal
- Completed ISRA Area
- Untreated Drainage Area
- Drainage Area Treated by Biofilter
- Drainage Area Treated by Detention Bioswales

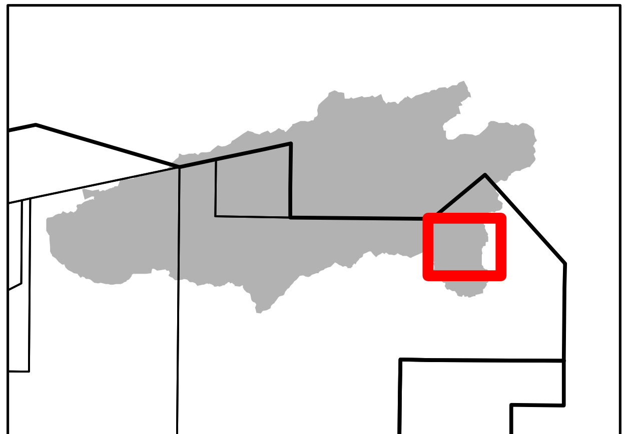
0 25 50 100 Feet

Rank	Site ID	Site Description	Drainage Area (ac)	Multi-Pollutant Score	Metals Rank	Dioxin Rank	Total Samples	2015-2016 Samples
8	LPBMP0001-A	Lower lot sheetflow (post-gravel bag berms) - OLD	2.7	0.58	23	4	6	0
16	LPBMP0002	Lower parking lot influent to cistern, before treatment	29.9	0.49	70.5	5	15	8
18	LPBMP0003	Lower parking lot sediment basin outlet, before treatment	29.9	0.45	70.5	10	15	8
19	ILBMP0001	Lower parking lot 24" stormdrain bypass	30.2	0.45	70.5	11	26	3

Figure ES-4
Top 20 Ranked: Lower Lot Area

Santa Susana Field Laboratory
Ventura County, CA

October 2016



Legend

- With Downstream Treatment
- Without Downstream Treatment
- Active Site
- Top 20 Ranked Site
- Stormwater Background Monitoring Location
- BMP Subarea Monitoring Location
- Drainage
- Storm Drain
- Treatment BMPs
- Asphalt Removal
- Completed ISRA Area
- Untreated Drainage Area
- Drainage Area Treated by Biofilter
- Drainage Area Treated by CM-9
- Drainage Area Treated by Detention Bioswales

0 55 110 220 Feet

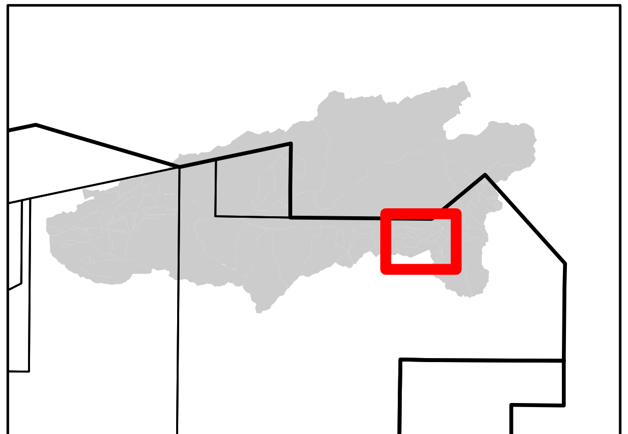
Figure ES-5
Top 20 Ranked: Detention Bioswales

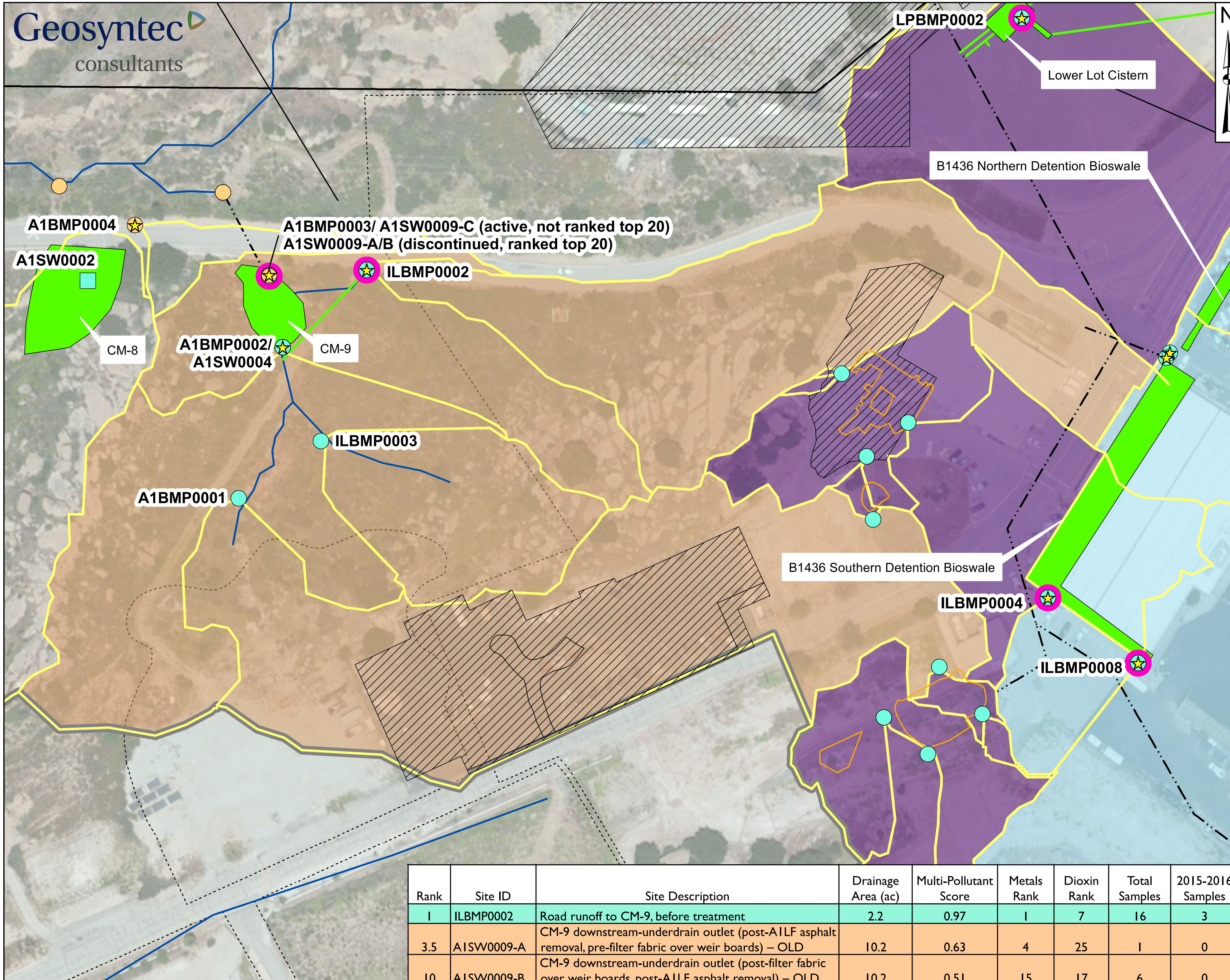
Santa Susana Field Laboratory
Ventura County, CA

October 2016

Rank	Site ID	Site Description	Drainage Area (ac)	Multi-Pollutant Score	Metals Rank	Dioxin Rank	Total Samples	2015-2016 Samples
9	ILBMP0008	US2 (B1436 Southern Detention Bioswale)	13.3	0.53	30	6	8	8
17	ILBMP0004	US1 (B1436 Southern Detention Bioswale)	0.4	0.47	36	9	7	7

Date: 8/25/2016, Path: P:\GIS\Projects\Boeing\SSFL\2016 SB0363W\Ranking Memo\2016 Priority Sites-DetBioswales_v4.mxd, User: OLincoln





Legend

- With Downstream Treatment
- Without Downstream Treatment
- Active Site
- Top 20 Ranked Site
- Stormwater Background Monitoring Location
- BMP Subarea Monitoring Location
- Drainage
- Storm Drain
- Treatment BMPs
- Asphalt Removal
- Completed ISRA Area
- Untreated Drainage Area
- Drainage Area Treated by Biofilter
- Drainage Area Treated by CM-9
- Drainage Area Treated by Detention Bioswale

0 50 100 200 Feet

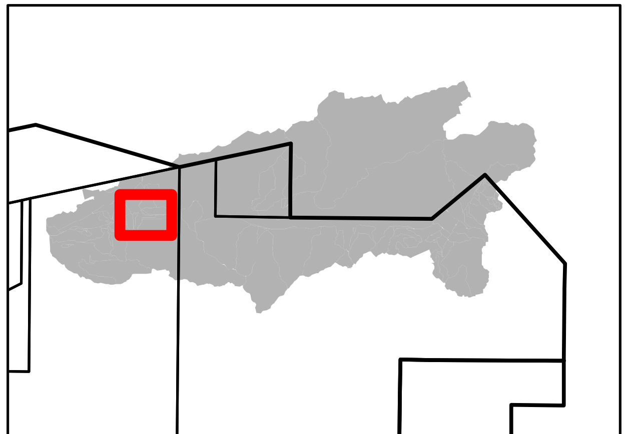
Rank	Site ID	Site Description	Drainage Area (ac)	Multi-Pollutant Score	Metals Rank	Dioxin Rank	Total Samples	2015-2016 Samples
1	ILBMP0002	Road runoff to CM-9, before treatment	2.2	0.97	1	7	16	3
3.5	A1SW0009-A	CM-9 downstream-underdrain outlet (post-A1LF asphalt removal, pre-filter fabric over weir boards) – OLD	10.2	0.63	4	25	1	0
10	A1SW0009-B	CM-9 downstream-underdrain outlet (post-filter fabric over weir boards, post-A1LF asphalt removal) – OLD	10.2	0.51	15	17	6	0

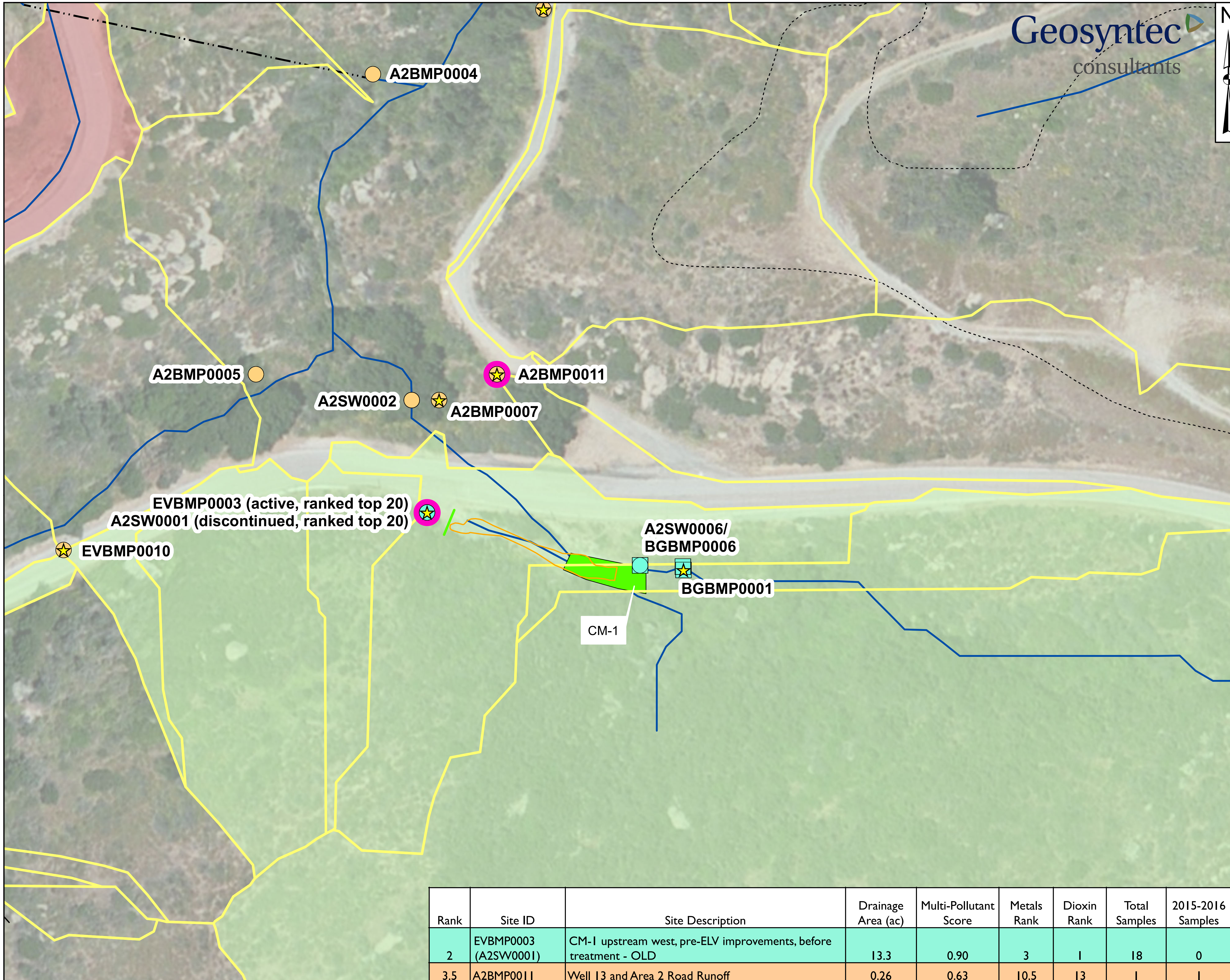
Figure ES-6
Top 20 Ranked: CM-9 Area

Santa Susana Field Laboratory
Ventura County, CA

October 2016

Date: 9/19/2016, Path: Z:\GIS\Projects\Boeing\SSFL\2016 SB0363W\Ranking Memo\2016 Priority Sites-CM9_v4.mxd, User: OLincoln





Legend

- With Downstream Treatment
- Without Downstream Treatment
- Active Site
- Top 20 Ranked Site
- Stormwater Background Monitoring Location
- BMP Subarea Monitoring Location
- Drainage
- Storm Drain
- Treatment BMPs
- Asphalt Removal
- Completed ISRA Area
- Untreated Drainage Area
- Drainage Area Treated by CM1
- Drainage Area Treated by ELV Treatment BMP

0 40 80 160 Feet

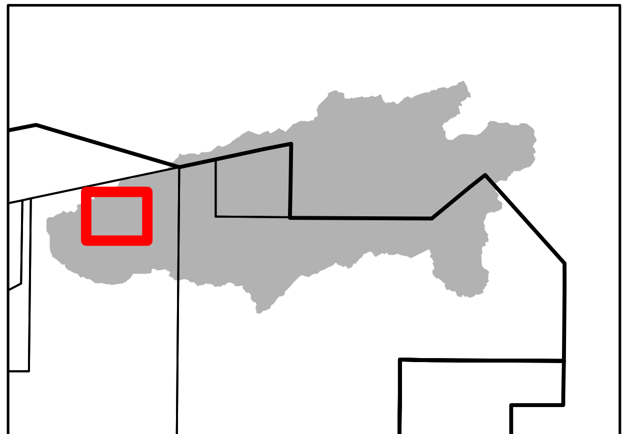
Rank	Site ID	Site Description	Drainage Area (ac)	Multi-Pollutant Score	Metals Rank	Dioxin Rank	Total Samples	2015-2016 Samples
2	EVBMP0003 (A2SW0001)	CM-1 upstream west, pre-ELV improvements, before treatment - OLD	13.3	0.90	3	1	18	0
3.5	A2BMP0011	Well 13 and Area 2 Road Runoff	0.26	0.63	10.5	13	1	1

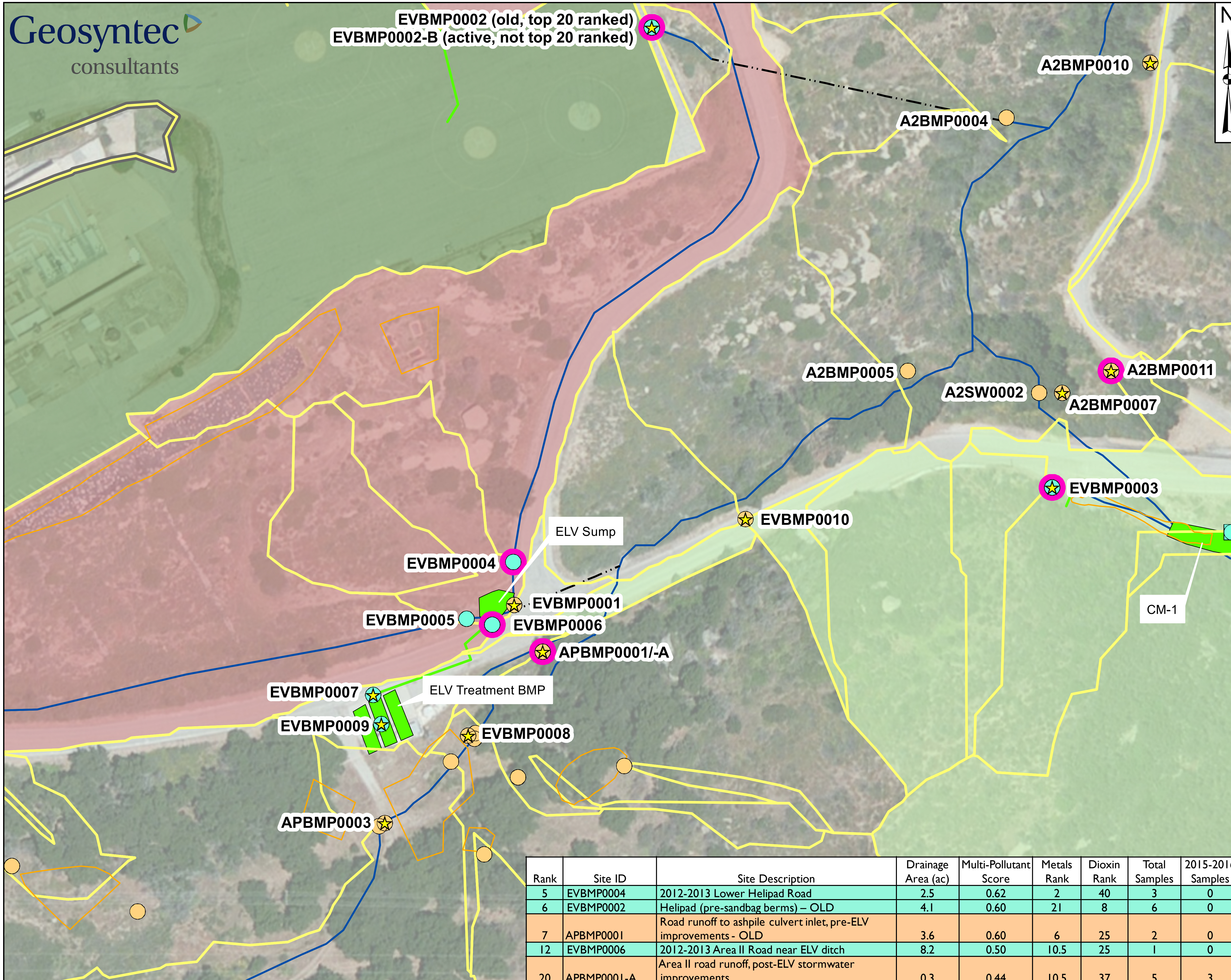
Figure ES-7
Top 20 Ranked: CM1 Area

Santa Susana Field Laboratory
Ventura County, CA

October 2016

Date: 8/25/2016, Path: P:\GIS\Projects\Boeing\SSFL\2016 SB0363W\Ranking Memo\2016 Priority Sites-CM1_v4.mxd, User: OLincoln





Rank	Site ID	Site Description	Drainage Area (ac)	Multi-Pollutant Score	Metals Rank	Dioxin Rank	Total Samples	2015-2016 Samples
5	EVBMP0004	2012-2013 Lower Helipad Road	2.5	0.62	2	40	3	0
6	EVBMP0002	Helipad (pre-sandbag berms) – OLD	4.1	0.60	21	8	6	0
7	APBMP0001	Road runoff to ashpile culvert inlet, pre-ELV improvements - OLD	3.6	0.60	6	25	2	0
12	EVBMP0006	2012-2013 Area II Road near ELV ditch	8.2	0.50	10.5	25	1	0
20	APBMP0001-A	Area II road runoff, post-ELV stormwater improvements	0.3	0.44	10.5	37	5	3

Legend

- With Downstream Treatment
- Without Downstream Treatment
- Active Site
- Top 20 Ranked Site
- Stormwater Background Monitoring Location
- BMP Subarea Monitoring Location
- Drainage
- Storm Drain
- Treatment BMPs
- Asphalt Removal
- Completed ISRA Area
- Untreated Drainage Area
- Drainage Area Treated by CM1
- Drainage Area Treated by ELV Treatment BMP
- Drainage Area Treated by Helipad BMP

0 50 100 200 Feet

Figure ES-8
Top 20 Ranked: ELV Area

Santa Susana Field Laboratory
Ventura County, CA

October 2016

Date: 10/20/2016, Path: Z:\GIS\Projects\Boeing\SSFL\2016 SB0363W\Ranking Memo\2016 Priority Sites-ELV_v4.mxd, User: OLincoln

1 Introduction

The purpose of this analysis is to rank subareas in the Santa Susana Field Laboratory (SSFL) Outfall 008 and 009 watersheds for potential implementation of new or enhanced stormwater controls[5], in order to improve National Pollutant Discharge Elimination System (NPDES) permit compliance at Outfalls 008 and 009. The SSFL Stormwater Expert Panel's (Panel's) recommended approach[6] is to:

1. Compare potential BMP subarea[7] monitoring results with subarea-specific stormwater background[8] data and NPDES permit limits[9];
2. Determine pollutant-specific "weighting factors" for each potential BMP subarea monitoring location based on this comparison (using a statistical methodology that accounts for sample size and number of results that are above both of these thresholds), with the highest weighting factors assigned to subareas that most frequently exceed both of these thresholds;
3. Determine multi-constituent ranking "scores" for each subarea based on the pollutant-specific weighting factors; and
4. Rank the potential best management practices (BMPs) monitoring subareas based on these multi-constituent ranking scores.

This general approach is summarized in the flow chart included as Attachment 1. SSFL stormwater background concentrations are established based on data from Interim Source Removal Action (ISRA) performance and potential BMP subarea monitoring locations that represent runoff from drainage areas with minimal to no RCRA Facility Investigations (RFI), ISRA, or developed (i.e., roof or pavement) areas. The selection process of potential BMP subarea monitoring locations is described in the December 16, 2010 sampling recommendations memo from the Expert Panel and Geosyntec (Geosyntec, 2010). Although this analysis is based on concentrations and does not account for pollutant load or watershed

[5] For the purpose of this report, the overarching term "stormwater controls" will be used to describe the standard suite of passive control practices, including erosion controls, sediment controls, and treatment controls. For detailed definitions or examples of erosion and sediment controls, see the CASQA Construction BMP Handbook at http://www.cabmphandbooks.com; for a detailed definition or examples of treatment controls, see the Ventura County Technical Guidance Manual for Stormwater Quality Control Measures at http://www.vcstormwater.org/documents/workproducts/technicalguidancemanual/2010final/Ventura_TGM%2011-4-10.pdf. The more general term, "Best Management Practice" (or BMP), is used in this report as a synonym for "stormwater control" but is used only for referencing the "potential BMP subarea monitoring locations," or monitoring locations where new stormwater controls are being contemplated based on a review of available monitoring results.

[6] The recommended approach outlined herein was developed jointly by the SSFL Stormwater Expert Panel and Geosyntec Consultants, with review from The Boeing Company, NASA, and the Los Angeles Regional Water Quality Control Board.

[7] "Potential BMP subarea monitoring locations" are defined here as drainage areas with an outlet location for stormwater runoff sampling, and including land uses that include ISRA, RCRA Facility Investigation (RFI), and/or developed areas (i.e., subareas containing buildings, asphalt parking lots, roads, etc.) so that impacted runoff quality might be expected and/or treatment BMPs might be necessary, pending an evaluation of the monitoring results.

[8] "Stormwater background monitoring locations" are defined here as locations in these watersheds that generally represent stormwater runoff from unimpacted areas, or areas that do not include ISRA, RFI, or significant development, thereby representing subarea-specific background (or reference) stormwater quality.

[9] The NPDES permit limits are only applicable to the outfalls and not to the subareas within the outfall drainage areas; however, the permit limits were used as benchmark values for the BMP subarea ranking analyses discussed herein.

size, monitoring locations were selected based on the goal of capturing runoff from nearly all known areas of potential anthropogenic pollutant sources within these two watersheds. In cases where the drainage areas are small, they generally include mostly paved surfaces, so runoff volumes are still significant.

The Outfall 008 and 009 watershed subarea monitoring locations used for this BMP evaluation are shown in the Attachment 2 map. The following details on the subarea monitoring locations are provided in Attachment 3. Each subarea is listed with its category (or data type), watershed, co-location (i.e., an alternate subarea identifier for the same location), a location description, and approximate drainage area. The drainage areas contributing to each of the treatment BMPs installed throughout Outfall 009 are shown in Attachment 4. Potential BMP subareas include the letters "BMP" in the subarea identifier, while ISRA performance monitoring locations include the letters "SW" in the subarea identifier. At the Expert Panel's recommendation, some ISRA and Culvert Modification (CM) performance monitoring locations are included here for BMP siting consideration, to verify/test the performance of some stormwater controls, and to verify that runoff from below an ISRA area is comparable to the runoff from above the ISRA area. NPDES compliance monitoring outfalls 008 and 009 were also included here for comparison and method testing purposes. The data summarized and their periods of record in this report are as follows:

- ISRA performance monitoring data: 12/2009 – 3/2015
- Culvert modification (CM) performance monitoring data: 12/2009 – 3/2016
- NPDES outfall monitoring data: 10/2004 – 3/2016
- Potential and active BMP subarea monitoring data: 12/2010 – 5/2016

The number of sampling event results currently available for each of the BMP subarea monitoring locations is based on one to twenty-six storms sampled, depending on the location. Where available, data from co-located ISRA subareas were combined with data from BMP subareas in order to provide a more robust dataset at potential BMP locations. Additionally, the maximum number of samples collected from a single subarea within the 008 watershed (up to 15 samples depending on parameter) is considerably fewer than the maximum number of samples collected from a single subarea in the 009 watershed (up to 26 samples depending on parameter) due in part to fewer events with sufficient runoff to enable sampling. The smaller frequency of runoff in the 008 watershed is likely due to the absence of directly connected impervious areas and hardened conveyance systems (e.g., paved roads, inlets, storm drains, and lined channels).

Measured precipitation varied by reporting year[10], with 19.04 inches recorded over 2009/2010, 23.38 inches recorded over 2010/2011, 11.41 inches recorded over 2011/2012, 8.09 inches recorded over 2012/2013, 6.07 inches recorded over 2013/2014, 12.10 inches recorded over 2014/2015, and 11.97 inches recorded over 2015/2016. Most of the rain in any reporting year occurred during the late fall to early spring periods, with very little rain occurring during the other months.

[10] The "reporting year" (previously referred to as the "rainy season") is defined herein as June 1 through May 31 (e.g., water quality samples collected from September 15, 2015 to May 6, 2016 were included in this memo and represent the 2015/2016 reporting year).

All stormwater sampling data reported herein were provided by MWH or Hayley Aldrich and selected analytes were validated by qualified lab quality review professionals[11]. All TCDD TEQ results include Bioaccumulation Equivalency Factors (BEFs), consistent with NPDES reporting requirements (see Appendix A of the 2012 BMP Subarea Ranking Analysis memo (Expert Panel and Geosyntec Consultants, 2012) for more information on the effects of BEFs on calculated TEQ results). For all parameters, lab results that are estimated (or "J-flagged," or results that are above the detection limit but below the reporting limit) are included in the analysis since it is the Expert Panel's view that the minor decrease in the statistical confidence in these individual results still enhances the overall confidence in the sample summary statistics by providing additional data observations, especially considering the limited number of data available for many locations (and it is these summary statistics that serve as the basis for the Expert Panel's BMP recommendations).

Although this analysis discusses current treatment controls and focuses on the identification of subareas that may require new treatment controls, the Expert Panel continues to strongly recommend the rigorous application of erosion and sediment control practices and stream channel stabilization measures throughout the 008 and 009 watersheds. The Panel also continues to recommend the stabilization of roadways and the implementation of source controls, including source removal, such as through the successful ongoing ISRA program.

This analysis follows prior reports prepared by the Panel on dioxins and metals stormwater background sources at the SSFL (SSFL Stormwater Expert Panel, 2010; SSFL Stormwater Expert Panel, 2009), and is based on the October 2010 BMP Plan for the Outfall 008 and 009 Watersheds (MWH et al., 2010). This analysis is the most refined of several generations of alternatives that were iteratively developed and tested by the Expert Panel and Geosyntec for the selection of potential BMP locations.

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[11] Data validation is the process of evaluating data for program, method and laboratory quality control compliance, and will determine the validity and usability of the data. A Level II validation was performed on all dioxins results for the BMP monitoring program and for dioxins results above the permit limit for the performance monitoring program. In addition, validation was performed to investigate anomalous results at a Level II and validation was performed to investigate the performance of the Dekaport Cone Splitter at a Level IV. A Level II validation involves a review of field methods and a high level review of laboratory methods. The primary purpose of performing a Level II validation on the dioxin results was to address blank contamination and estimated maximum possible concentration (EMPC) values. An EMPC value is assigned to a dioxin isomer when a peak is within the retention time window of a target dioxin or furan isomer; however, at least one of the identification criteria from the method was not met for that peak. Therefore, this peak cannot be positively identified as a dioxin or furan. The Level II validation process would evaluate the EMPC values and revise these values to non-detects at either the level of interference or the reporting limit, whichever is higher. A Level IV validation is a definitive evaluation of the data and involves a very detailed review of the field and laboratory processes including the raw data files used to identify and quantitate dioxins and furan. This level of validation requires the validator to reproduce a percentage of the result from the raw data files to ensure that systemic errors or errors of omission or transcription errors are not present in the final reported data.

2 Data Summary

2.1 Stormwater Background Monitoring Locations

Several subarea monitoring locations were selected to be representative of stormwater background runoff quality because they represent locations that are not expected to be impacted by historical or ongoing subarea activities. Due to the varying objectives of each of the monitoring programs, not all constituents of concern (COCs) were sampled at all subareas. For this BMP subarea ranking analysis, the COCs are defined as total suspended solids (TSS), cadmium (Cd), copper (Cu), lead (Pb), mercury (Hg), TCDD TEQ, and 2,3,7,8-TCDD because these constituents have periodically been measured at concentrations above the current NPDES permit limits at the 008 and 009 outfall monitoring stations, with the exception of TSS and 2,3,7,8-TCDD which are without permit limits but are included here as alternative indicators of COC generation. The number of samples for each COC at each stormwater background subarea is summarized in Table 1. These samples were collected for all events that occurred when flow was observed; few samples were therefore collected due to little flow occurring at many locations because of the unusually dry 2015/2016 reporting year[12]. All but three background locations have been discontinued as of this reporting year (e.g. A1SW0006 was discontinued after the 2010/2011 reporting year because the low concentrations of constituents in the samples limited the performance evaluation of CM-11 (MWH et al., 2013)); other background sites were discontinued for similar reasons, which is documented in prior years' Annual Reports and BMP Monitoring Sampling and analysis Plans (SAPs).

Table 1. Stormwater background monitoring location dataset summary

Location (Co-location)	Description	Number of Sample Results for Indicated COCs						
		TSS	Cd	Cu	Pb	Hg	TCDD TEQ	2,3,7,8 -TCDD
A1SW0002	Background - CM-8 upstream, before treatment	10	0	0	10	0	0	0
A1SW0006	Background - CM-11 upstream, before treatment	12	0	0	0	0	10	12
BGBMP0001 (A2BMP0006, A2SW0007)	Background - CM-1 upstream east tributary, before treatment	4	4	4	4	4	2	4
BGBMP0002 (LXSW0003)	Background - CM-3 upstream, before treatment	4	3	4	4	4	2	4
BGBMP0003	Background - Sage Ranch near LOX	5	5	5	5	5	2	5
BGBMP0004	Background - Sage Ranch near CM-5	3	3	3	3	3	3	3
BGBMP0006 (A2SW0006)	Background - CM-1 upstream east tributary (ponded footprint), before treatment	7	1	1	7	1	7	7
BGBMP0007 (LXSW0001)	Background - CM-3 upstream, before treatment	7	6	7	7	7	4	7
HZSW0008	Background - Happy Valley upstream	1	0	0	1	0	1	1
HZSW0011	Background - Happy Valley upstream	2	0	2	0	0	2	2

[12] Average rainfall at SSFL was 16.8 inches from 1959-2016. In contrast, 11.97 inches of total rainfall has been recorded to-date in the 2015/2016 reporting year.

Location (Co-location)	Description	Number of Sample Results for Indicated COCs						
		TSS	Cd	Cu	Pb	Hg	TCDD TEQ	2,3,7,8 -TCDD
HZSW0012	Background - Happy Valley upstream	1	0	0	1	0	0	0
HZSW0020 (HZSW0017)	Background - Happy Valley upstream	2	0	0	2	0	2	2
Total		58	22	26	44	24	35	47

Notes

- Gray text indicates historical subarea monitoring locations that are discontinued.
- Stormwater background locations with zero samples collected are excluded from this table.

Table 2 summarizes the total samples, non-detects (NDs), and J-flagged (DNQ) numbers of observations, along with the minimum, median, and maximum concentration values for each of the COCs for the complete combined stormwater background dataset. TSS values are summarized by watershed as well as combined for both watersheds. All stormwater background mercury and 2,3,7,8-TCDD results are ND. Stormwater background concentration values for COCs that are higher than current permit limits (which apply only at the NPDES compliance outfalls) are highlighted in yellow. These results confirm previous observations by the Expert Panel and others regarding natural background stormwater quality at the SSFL that occasionally exceeds NPDES permit limits for some metals (including copper and lead) as well as TCDD TEQ (although the Permit limit is technically applicable to TCDD TEQ, excluding DNQ congener results).

Table 2. Stormwater background results (all subareas combined) – concentrations

COC	# Samples	# NDs	# DNQ	Min	Median	95th Percentile	Max	Permit Limit for OF008 & OF009	% Samples Exceeding Permit Limit [b]
TSS - 008	6	0	3	2	17.5	74.3	76	NA	NA
TSS - 009	52	7	33	1	6.5	153.1	750	NA	NA
TSS	58	7	36	1	7	105.7	750	NA	NA
Cadmium	22	21	22	<0.1	<0.1	<0.2	<0.2	4	0%
Copper	26	0	11	1	2.35	7.2	19	13	4%
Lead	44	6	26	<0.2	0.77	15.7	64	5.2	20%
Mercury	24	24	24	<0.1	<0.1	<0.1	<0.1	0.13	0%
TCDD TEQ[a]	47	12	0	1E-12	8.5E-10	3.06E-07	6.61E-07	2.8E-08	19%
2,3,7,8-TCDD	47	47	47	<2.0E-08	<8.7E-07	<4.6E-06	<5.4E-06	NA	NA

Notes

- Units are in mg/L for TSS, µg/L otherwise
- (a) Permit limit applies to TCDD TEQ (no DNQ), while this comparison is made with TCDD TEQ (DNQ included).
- (b) The percent of samples exceeding the permit limit was calculated by dividing the sum of concentration results greater than the permit limit by the sum of all sampled results for each COC. If non-detect results (reported equal to the DL) are greater than the permit limit, they are included in this calculation.
- No substitution assumptions were made in the attempt to quantify NDs. For example, "< 0.20" refers to a non-detect with a detection limit of 0.20 µg/L.
- RWQCB split sample results excluded.
- Highlighted values exceed the permit limit for that COC (used here as benchmarks as the permit limits only apply to the outfall locations).
- J flagged/DNQ results are included for all COCs.
- With the exception of cadmium, which had all ND or J-flagged/estimated results, assumptions regarding the treatment of J-flag (or DNQ) results do not impact the 95th percentile stormwater background thresholds for any COC.
- Metals results shown here are for the total form only, consistent with the permit limits.

Particulate strength (PS) is a means to normalize stormwater pollutant concentrations by TSS and also indicate the treatability of the constituents. Normalizing pollutant concentrations by TSS is helpful for evaluating locations that have high COC concentrations in the runoff as a result of high TSS concentrations[13]. This is especially true for the COCs that are highly associated with particulates and are not found in significant quantities in filtered forms. This normalization with TSS to calculate PS for the stormwater background sites was performed to help identify critical COC source areas that may otherwise have mass discharges diluted by large flows. PS values have been previously used by the Expert Panel to assess sources of metals in SSFL NPDES outfall compliance monitoring data (SSFL Stormwater Expert Panel, 2009).

Filtered metals were only analyzed at 6 of the 12 sampled stormwater background monitoring locations. All of the remaining six locations are ISRA performance (upstream) sample locations. Therefore, to obtain PS estimates for the ISRA stormwater background locations, filtered concentrations were estimated by assuming that filtered fractions (i.e., percentage of the total metal concentration) for each sample was equal to the average filtered fraction at Outfalls 008 or 009. Filtered concentrations were

[13] By applying particulate strengths, the Panel is not suggesting that stormwater at SSFL be regulated using such metrics, but rather the Panel is recommending the use of this solely as a diagnostic metric for the identification of source areas and for the ranking of potential BMP monitoring subareas for placement of new stormwater controls.

then estimated for ISRA stormwater background subareas based on the watershed in which each subarea is located. This methodology was not necessary for the stormwater background subareas, since filtered metal measurements were available for those locations.

Only samples at Outfalls 008 and 009, where both the total and filtered concentrations were detectable, were used to determine the average filtered fractions. These average filtered fractions used in the PS calculations are shown in Table 3. TCDD TEQ and 2,3,7,8-TCDD are assumed to have a filtered fraction of zero because of their extremely low solubility and high affinity for solids. Filtered cadmium has been detected during two sampling events in the Outfall 008 watershed (10/18/05 and 1/18/10). At the recommendation of the Expert Panel, the average filtered fraction of cadmium in the Outfall 008 watershed was computed using the detection limits of the total cadmium analyses as a conservative estimate for filtered cadmium.

Table 3. Average filtered fraction of COCs based on all available monitoring data in defined watershed; used in determination of particulate strength when filtered COC not measured (e.g., ISRA and CM performance monitoring datasets)

	Outfall 008			Outfall 009		
COC	**% Filtered**	**# Samples**	**CV**	**% Filtered**	**# Samples**	**CV**
Copper	55	33	0.49	60	399	0.39
Lead	19	14	0.94	17	254	0.81
Cadmium	40	21	N/A	57	40	0.40

Notes

- CV = Coefficient of variation
- # samples = samples with both total and filtered detected and total > filtered (results with total < filtered were excluded from the analysis)
- Only one sample in the Outfall 008 watershed was analyzed for filtered cadmium as of May 2013. Filtered fraction was estimated based on the detection limits of the total cadmium analyses.

The procedure used to calculate stormwater background PS is described in Attachment 5. Results are shown in Table 4 for all stormwater background data combined. The 95th percentile and maximum values are generally unaffected by the ND or missing filtered data assumptions that were made for the PS estimates.

Table 4. Stormwater background results - particulate strength (mg/kg)

COC	# PS results	# NDs	Min	Median	95th Percentile	Max
Cadmium	18	17	ND	ND	ND	ND
Copper	22	0	0	75.6	308.6	670.3
Lead	44	6	9.5	77.4	273.5	1141.4
Mercury	24	24	ND	ND	ND	ND
TCDD TEQ	47	12	ND	6.2E-08	3.2E-05	2.5E-04
TCDD TEQ_NoDNQ	47	36	ND	ND	4.7E-08	2.2E-07
2,3,7,8-TCDD	47	47	ND	ND	ND	ND

Notes

- Cells with ND refer to values based on total concentration non-detect results.
- RWQCB split sample results excluded
- # NDs reflect the number of non-detects in the total concentration.
- Particulate strength computation: PS = (Total concentration – Filtered concentration) / Total Suspended Solids

- In instances where samples were reported as having filtered concentrations greater than total concentrations, these samples were omitted from the analysis.
- One lead sample was reported as having filtered concentrations greater than total concentrations. This sample was omitted from the analysis.

2.2 Stormwater BMP Subarea Monitoring Locations (Non-Background)

Table 5 provides a similar summary to Table 1, but shows the locations considered to be non-background sites (areas affected by site activities during historical laboratory operations and areas having buildings or paved surfaces, or otherwise disturbed by site operations). A map of the stormwater monitoring subareas is included as Attachment 2.

Table 5. Stormwater BMP subarea monitoring location dataset summary

Location (Co-location)	Description	Number of Sample Results for Indicated COCs						
		TSS	Cd	Cu	Pb	Hg	TCDD TEQ	2,3,7,8-TCDD
A1BMP0001	A1LF downstream, before treatment	5	5	5	5	4	5	5
A1BMP0002 (A1SW0004)	CM-9 upstream toward A1LF (pre-A1LF asphalt removal), before treatment - OLD	16	15	16	16	16	8	8
A1BMP0002-A (A1SW0004-A)	CM-9 upstream toward A1LF (post-A1LF asphalt removal), before treatment	7	7	7	7	7	6	6
A1BMP0004	Area 2 Road Runoff, SD inlet on north side of road	2	2	2	2	2	2	2
A1SW0003	CM-8 downstream (pre-filter fabric over weir boards) - OLD	10	0	0	10	0	0	0
A1SW0005	CM-9 downstream (pre-filter fabric over weir boards) - OLD	10	10	10	10	10	5	5
A1SW0007	CM-11 downstream (pre-filter fabric over weir boards) - OLD	12	0	0	0	0	12	12
A1SW0009-A	CM-9 downstream-underdrain outlet (post-A1LF asphalt removal, pre-filter fabric over weir boards) - OLD	1	1	1	1	1	1	1
A1SW0009-B	CM-9 downstream-underdrain outlet (post-filter fabric over weir boards, post-A1LF asphalt removal) - OLD	6	6	6	6	6	5	5
A1SW0009-C (A1BMP0003)	CM-9 downstream-underdrain outlet (post-perforated pipe and upper basin installed)	5	5	5	5	5	5	5
A2BMP0002	A2LF drainage east	1	1	1	1	1	1	1
A2BMP0003	A2 u/s of ND confluence	8	8	8	8	8	8	8
A2BMP0004	Helipad culvert outlet	3	3	3	3	3	3	3
A2BMP0005	A2 u/s of CM-1 confluence	4	4	4	4	4	4	4
A2BMP0010	Well 13 Road Runoff, west side	1	1	1	1	1	1	1
A2BMP0011	Well 13 and Area 2 Road Runoff	1	1	1	1	1	1	1
A2SW0002	CM-1 effluent (pre-filter fabric over weir boards) - OLD	16	0	0	16	0	16	16
A2SW0002-A (A2BMP0007)	CM-1 effluent (post-filter fabric over weir boards)	10	6	6	10	6	10	10
APBMP0001	Road runoff to ashpile culvert inlet, pre-ELV improvements - OLD	2	2	2	2	2	2	2

Location (Co-location)	Description	Number of Sample Results for Indicated COCs						
		TSS	Cd	Cu	Pb	Hg	TCDD TEQ	2,3,7,8-TCDD
APBMP0001-A	Area II road runoff, post-ELV stormwater improvements	5	5	5	5	4	5	5
APSW0014	AP/STP-1ABCDE downstream	2	2	2	2	2	2	2
B1BMP0001 (B1SW0010)	B1 media filter inlet (pre-media filter installation)	3	2	3	3	3	3	3
B1BMP0003 (B1BMP0002)	Upper parking lot / road runoff to B1 area culvert inlet	23	23	23	23	23	23	23
B1BMP0004 (B1BMP0004-5, B1SW0015)	B1 media filter inlet north, before treatment	21	21	21	21	21	21	21
B1BMP0005 (B1BMP0004-5, B1SW0011, B1SW0013)	B1 media filter inlet south, before treatment	26	26	26	26	26	26	26
B1BMP0007	B1, vegetated channel	12	12	12	12	12	12	12
B1BMP0008	B1 storm drain culvert outlet	2	2	2	2	2	2	2
B1SW0002	Woolsey Canyon Road Runoff, before treatment	2	2	2	2	2	2	2
B1SW0008	B1 upstream	2	2	0	0	0	2	2
B1SW0014-A	B1 media filter effluent (pre-media filter reconstruction) - OLD	1	1	1	1	1	1	1
B1SW0014-B	B1 media filter effluent (post-media filter reconstruction) - OLD	4	4	4	4	4	3	3
B1SW0014-C (B1BMP0006)	B1 media filter effluent (post-media filter reconstruction, post-curb cuts)	19	19	19	19	19	19	19
BGBMP0005	Sage Ranch near entrance	1	1	1	1	1	1	1
EVBMP0001-A	ELV culvert inlet (helipad road and ELV ditch, composite)	10	10	10	10	10	10	10
EVBMP0002	Helipad (pre-sandbag berms) - OLD	6	6	6	6	6	6	6
EVBMP0002-A	Helipad (post-sandbag berms) - OLD	5	5	5	5	5	5	5
EVBMP0002-B	Helipad (post-sandbag berms raised, post-drainage holes in asphalt)	7	7	7	7	7	7	7
EVBMP0003 (A2SW0001)	CM-1 upstream west, pre-ELV improvements, before treatment - OLD	18	9	9	18	9	18	18
EVBMP0003-A	CM-1 upstream west, post-ELV improvements, before treatment	6	6	6	6	6	6	6
EVBMP0004	2012-2013 Lower Helipad Road	3	3	3	3	3	3	3
EVBMP0005	2012-2013 ELV drainage ditch (pre-ELV-1C ISRA) - OLD	2	2	2	2	2	2	2
EVBMP0006	2012-2013 Area II Road near ELV ditch	1	1	1	1	1	1	1
EVBMP0007	Influent to ELV sedimentation, before treatment	6	6	6	6	6	6	6
EVBMP0008	Effluent from ELV treatment BMP	6	6	6	6	6	6	6
EVBMP0009	Influent to ELV media filter, before treatment	5	5	5	5	5	5	5
EVBMP0010	Area 2 Road Runoff, SD inlet on north side of road	1	1	1	1	1	1	1

Location (Co-location)	Description	Number of Sample Results for Indicated COCs						
		TSS	Cd	Cu	Pb	Hg	TCDD TEQ	2,3,7,8-TCDD
HZBMP0001 (HZSW0007)	Happy Valley downstream (pre-improvements) - OLD	13	6	13	13	6	12	12
HZBMP0002 (HZSW0004)	DRG downstream	4	4	4	4	4	4	4
HZBMP0003 (HZSW0003)	DRG downstream (furthest downstream)	15	7	15	15	7	15	15
HZSW0005	DRG upstream	1	0	0	0	0	1	1
HZSW0014	Happy Valley upstream	3	0	3	3	0	0	0
ILBMP0001	Lower parking lot 24" storm drain bypass	26	26	26	26	26	26	26
ILBMP0002	Road runoff to CM-9, before treatment	16	16	16	16	16	16	16
ILBMP0003	A1LF parking lot - OLD	4	4	4	3	4	4	4
ILBMP0004	Upstream 1 (B1436 Southern Detention Bioswale)	7	7	7	7	7	7	7
ILBMP0005 (ILBMP0005-7)	DS (B1436 Southern Detention Bioswale)	8	8	8	8	8	8	8
ILBMP0006	US (B1436 Northern Detention Bioswale)	1	1	1	1	1	1	1
ILBMP0007 (ILBMP0005-7)	NE Detention Bioswale Effluent	9	9	9	9	9	9	9
ILBMP0008	Upstream 2 (B1436 Southern Detention Bioswale influent)	8	8	8	8	8	8	8
ILSW0003	IEL-2 upstream	2	2	0	2	2	0	0
ILSW0004-A	IEL-2 downstream (post-ISRA excavation)	1	1	0	1	1	0	0
ILSW0007	IEL-2 upstream (2014-2015 reporting year)	1	1	0	1	1	0	0
ILSW0008	IEL-2 downstream (2014-2015 reporting year)	1	1	0	1	1	0	0
LFSW0002-A	CTLI downstream (post-ISRA excavation)	3	0	3	3	0	3	3
LPBMP0001	Lower lot sheetflow (pre-gravel bag berms) - OLD	2	2	2	2	2	2	2
LPBMP0001-A	Lower lot sheetflow (post-gravel bag berms)	6	6	6	6	6	6	6
LPBMP0002	Lower parking lot influent to cistern, before treatment	15	15	15	15	15	15	15
LPBMP0003	Lower parking lot sediment basin outlet, before treatment	15	15	15	15	15	15	15
LPBMP0004	Lower parking lot biofilter outlet	16	16	16	16	16	16	16
LXBMP0002	LOX mid - OLD	2	2	2	2	2	2	2
LXBMP0003	LOX east tributary - OLD	6	6	6	6	6	6	6
LXBMP0004	LOX southwest downstream of sandbag berm	5	5	5	5	5	5	5
LXBMP0005	LOX southeast downstream of sandbag berm	5	5	5	5	5	5	5
LXBMP0006 (LXSW0010)	LOX east, runoff along dirt road	5	5	5	5	5	5	4
LXBMP0007	LOX, inlet to western slope drain	1	1	1	1	1	1	1
LXBMP0009 (LXSW0009)	LOX, inlet to eastern slope drain	4	5	5	5	5	4	4

Location (Co-location)	Description	Number of Sample Results for Indicated COCs						
		TSS	Cd	Cu	Pb	Hg	TCDD TEQ	2,3,7,8-TCDD
LXSW0002	CM-3 downstream (pre-filter fabric over weir boards) - OLD	9	8	9	9	9	9	8
Total number of samples:		533	458	475	518	457	498	496

Notes

- Gray text indicates historical subarea monitoring locations that are discontinued.
- Locations where control practices are being evaluated where zero samples have been collected are excluded from this table.

Table 6 summarizes the total samples, non-detects (NDs), and J-flagged (DNQ) numbers of observations, along with the minimum, median, and maximum concentration values for each of the COCs for the complete non-background locations where control practices are being evaluated, as well as for Outfalls 008 and 009 data.

Table 6. BMP Subarea monitoring samples - Concentrations

COC	# Samples	# NDs	# DNQ	Min	Median	95th Percentile	Max	Permit Limit for OF008 & OF009	% Samples Exceeding Permit Limit [b]
TSS - 008	36	6	14	1	17	390	840	NA	NA
TSS - 009	497	32	95	0.7	23	255.2	4290	NA	NA
TSS	533	38	109	0.7	23	270	4290	NA	NA
Cadmium	458	298	274	<0.1	0.25	0.70	6.8	4	<1%
Copper	475	0	24	<0.6	6	21	86	13	14%
Lead	518	36	95	0.11	2.8	20.2	131	5.2	27%
Mercury	457	427	275	<0.05	<0.1	0.14	1.7	0.13	5%
TCDD TEQ[a]	498	38	0	<1.0E-12	1.1E-07	1.4E-05	4.0E-04	2.8E-08	64%
2,3,7,8-TCDD	496	481	323	<2.0E-08	<1.0E-06	<6.4E-06	2.2E-05	NA	NA

Notes

- Units are in mg/L for TSS, µg/L otherwise
- (a) Permit limit applies to TCDD TEQ (no DNQ), while this comparison is made with TCDD TEQ.
- (b) The percent of samples exceeding the permit limit was calculated by dividing the sum of concentration results greater than the permit limit by the sum of all sampled results for each COC. If non-detect results (reported equal to the DL) are greater than the permit limit, they are included in this calculation.
- No substitution assumptions were made in the attempt to quantify NDs. For example, “< 0.20” refers to a non-detect with a detection limit of 0.20 µg/L.
- RWQCB split sample results excluded.
- NA = No permit limit is defined for the given COC.
- Highlighted values exceed the permit limit for that COC, used here as benchmark values as the permit limits are only applied to the permitted outfall locations.
- J flagged/DNQ results are included for all COCs.
- With the exception of cadmium, which had all ND or J-flagged/estimated results, assumptions regarding the treatment of J-flag (or DNQ) results do not impact the 95th percentile stormwater background thresholds for any COC.
- Metals results shown here are for the total form only, consistent with the permit limits.

3 Statistical Analysis

To allow for a visual and probabilistic comparison of the available stormwater sampling data, Figure 2 through Figure 7 show probability plots of the COCs at locations grouped into the following categories:

- Stormwater background;
- Potential BMP subarea;
- Outfall 008 (for comparison only); and
- Outfall 009 (for comparison only).

Previous version of this analysis separated Outfall 008 and 009 results into pre-2009 and post-2009 datasets. Pre-2009 results represent grab samples and post-2009 results represent flow-weighted composite samples. However, recent statistical tests performed on these data showed no statistically significant difference between these datasets, and as such, these data have been presented as a single series for each outfall.

The x-axes show COC concentrations or PS and the y-axes show the probability of non-exceedance (or probability that values are below) the given x-axis values. The Cunnane equation (Helsel and Hirsch, 1992) was used to compute the plotting positions, and a best-fit line (assuming a lognormal distribution) is shown for the stormwater background data. Note that non-detect results were included in computing the plotting positions, but are not actually plotted (the other data observations are offset in their plotting position to appropriately consider the non-detect data in order to accurately estimate probability values). In general, these plots show that stormwater background concentrations exceed[14] NPDES permit limits for lead at ~18% probability, for TCDD TEQ at ~18% probability (although this estimated probability is zero when DNQ results are excluded), for copper at ~1% probability, and do not exceed the NPDES permit limits for cadmium. The 2,3,7,8-TCDD charts show very few data points because this congener is so rarely detected. Also, most of these 2,3,7,8-TCDD detections are lab estimates (i.e., DNQ) and not quantified at high reliability values. 2,3,7,8-TCDD was also never detected in a stormwater background sample. Furthermore, dioxin congener DNQ results are included for this analysis in contrast to NPDES reporting practice which does not include DNQs, therefore the NPDES outfall results that are shown above the permit limit here do not reflect past NPDES exceedances at concentrations shown.

Figure 1 provides a key for the COC probability charts. The yellow area includes observations that were less than background conditions, but still exceeded the permit limits. The blue area includes observations that were less than both the stormwater background best-fit line and the permit limit. The

[14] The term "exceed" is being used here as a statistical term only of the likely probability of occurrence. It indicates values that are greater than a given threshold. It is not intended to have regulatory or non-compliance implications. This is particularly true for TCDD TEQ data which include DNQ results here for statistical analysis purposes, in contrast to NPDES compliance assessment procedures, which require greater reliability for reporting and do not include DNQ results.

red area includes data that exceeded both the stormwater background conditions and permit limits, while the green area includes observations that exceeded the stormwater background conditions but not the permit limits. Fundamentally, the question is, "Which subareas most likely contribute to downstream permit limit exceedances as a result of elevated COC concentrations that are most likely due to particulate strengths that are above subarea-specific background levels?" These subareas will be identified by potential BMP subarea stormwater sampling results that fall to the right of the Permit limit in the concentration chart (yellow and red areas) **and** fall to the right of the stormwater background best-fit line on the particulate strength chart (in the green and red areas), or in other words, those samples and subareas which may contribute to downstream permit limit exceedances but their elevated COC concentrations are most likely due to particulate strengths that are above subarea-specific stormwater background levels. As will be discussed later in this report, the subareas with data that fall within the red area will receive the highest scores for prioritizing subareas for new or enhanced stormwater controls. Depending on the results for other COCs at an evaluation location, data within the green and yellow areas may also become a factor in prioritizing potential BMP subareas.

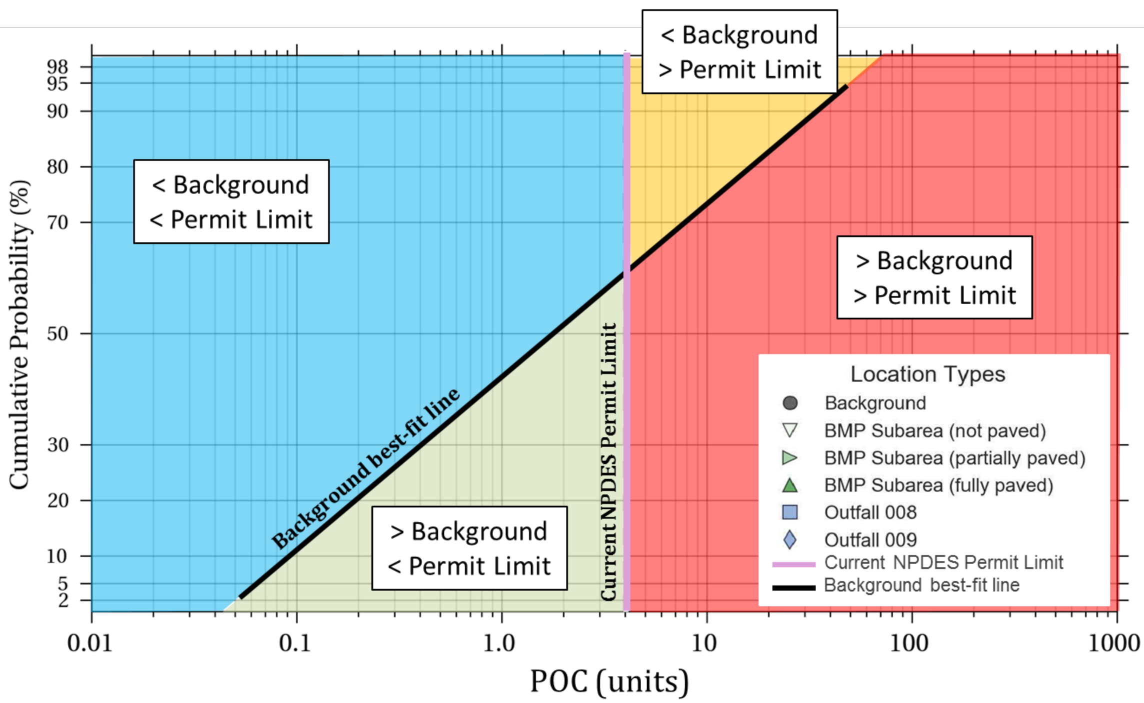

Figure 1. Probability Plot Key

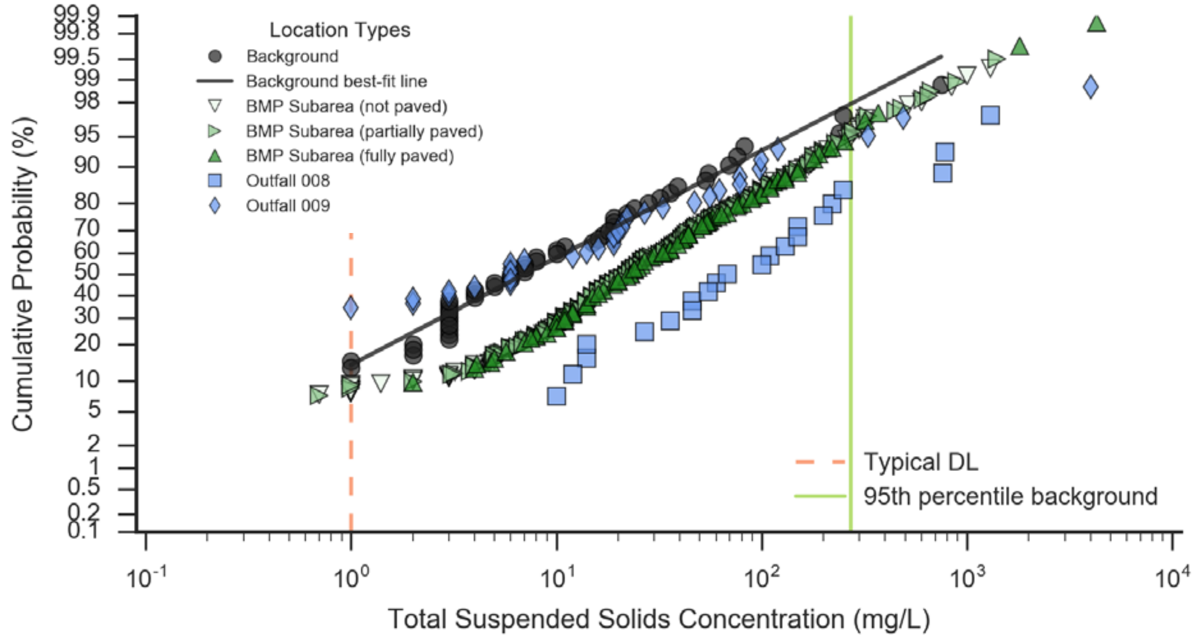

Figure 2. Probability plot for TSS concentrations[15]

[15] Note: Following the 2005 wildfire, an uncharacteristically high TSS value (4000 mg/L) was measured at Outfall 009 on 10/17/2005. This data point is shown near the upper right corner of Figure 2.

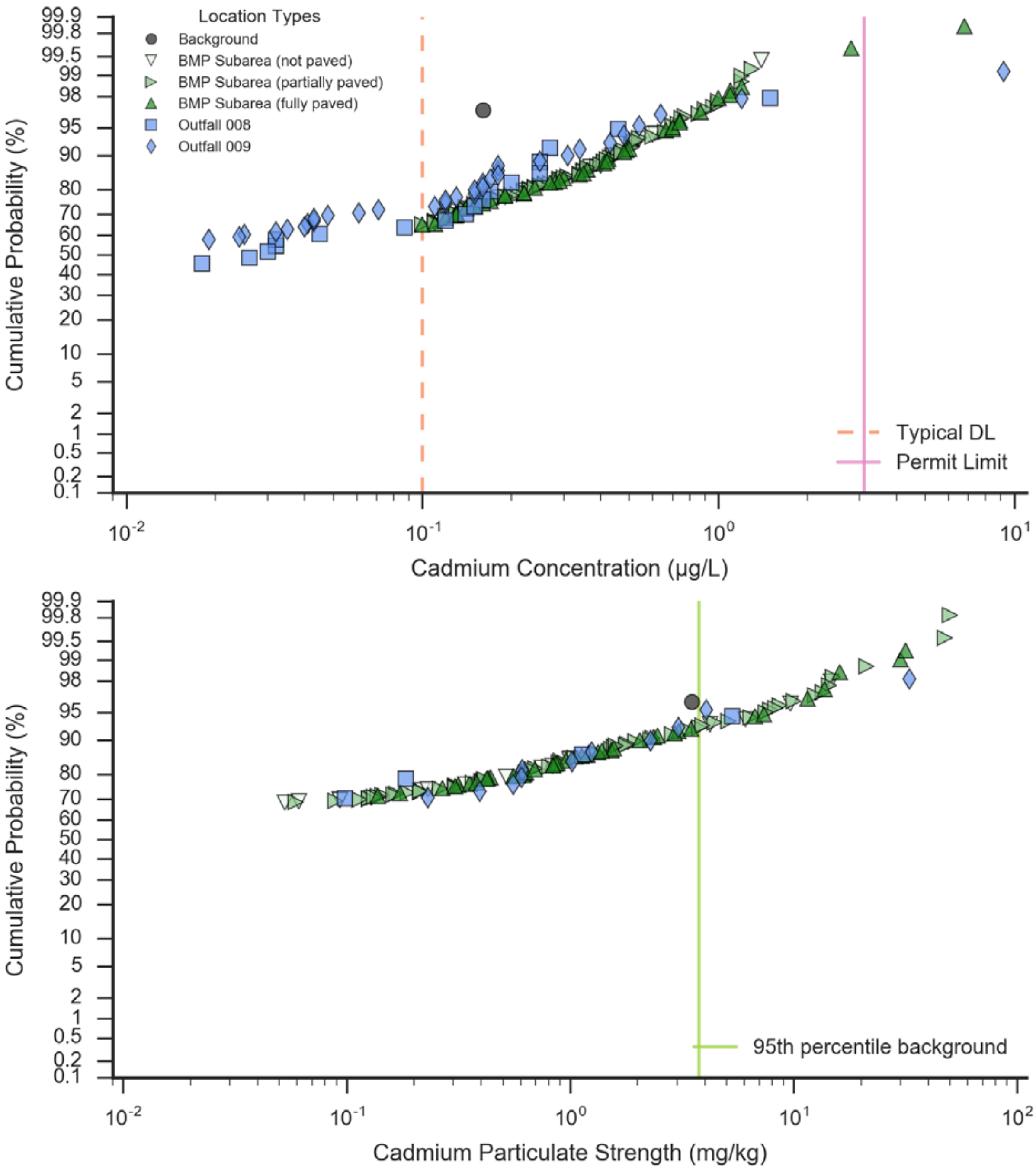

Figure 3. Probability plots for cadmium concentrations and particulate strengths[16, 17]

[16] Following the 2005 wildfires, an uncharacteristically high cadmium concentration (9.2 µg/L) was measured at Outfall 009 on 10/17/2005. This data point is shown in the upper right corner of the concentration plot in Figure 3.
[17] A background best-fit line was not provided for total cadmium due to the limited number of detected results.

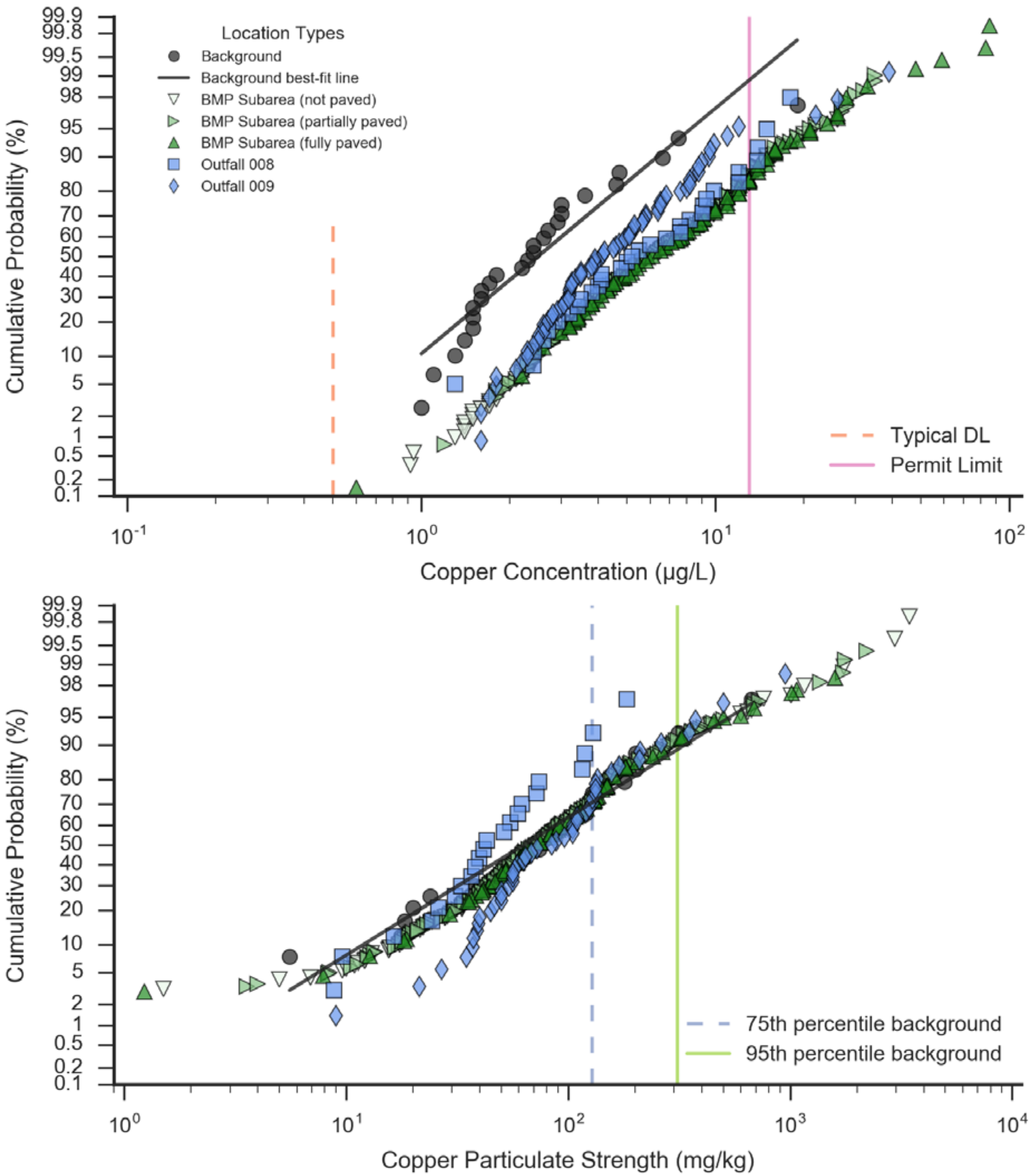

Figure 4. **Probability plots for copper concentrations and particulate strengths**[18]

[18] Following the 2005 wildfires, an uncharacteristically high copper concentration (39 µg/L) was measured at Outfall 009 on 10/17/2005. This data point is shown near the upper right corner of the concentration plot in Figure 4.

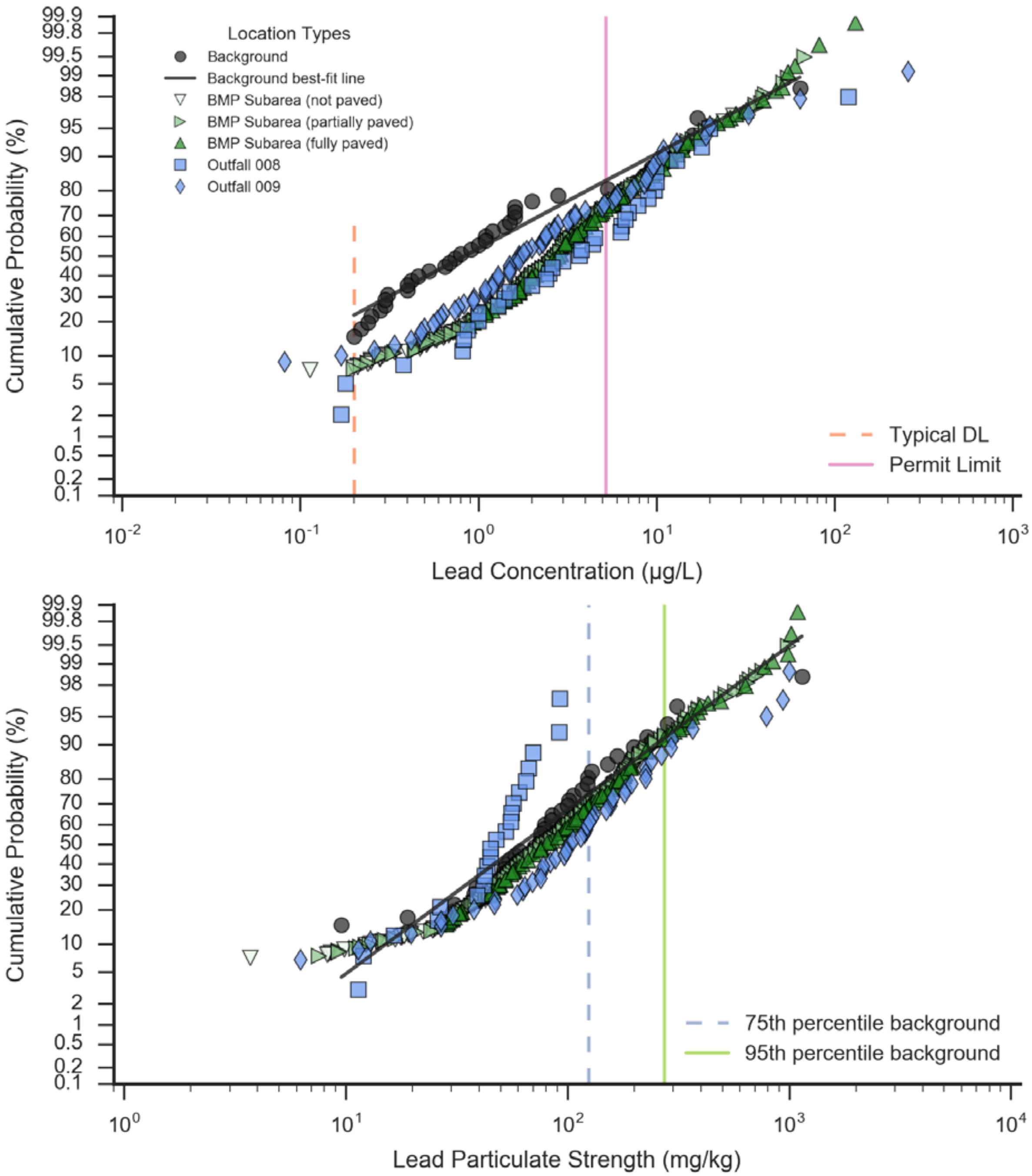

Figure 5. Probability plots for lead concentrations and particulate strengths[19]

[19] Following the 2005 wildfires, an uncharacteristically high lead concentration (260 µg/L) was measured at Outfall 009 on 10/17/2005. This data point is shown near the upper right corner of the concentration plot in Figure 5.

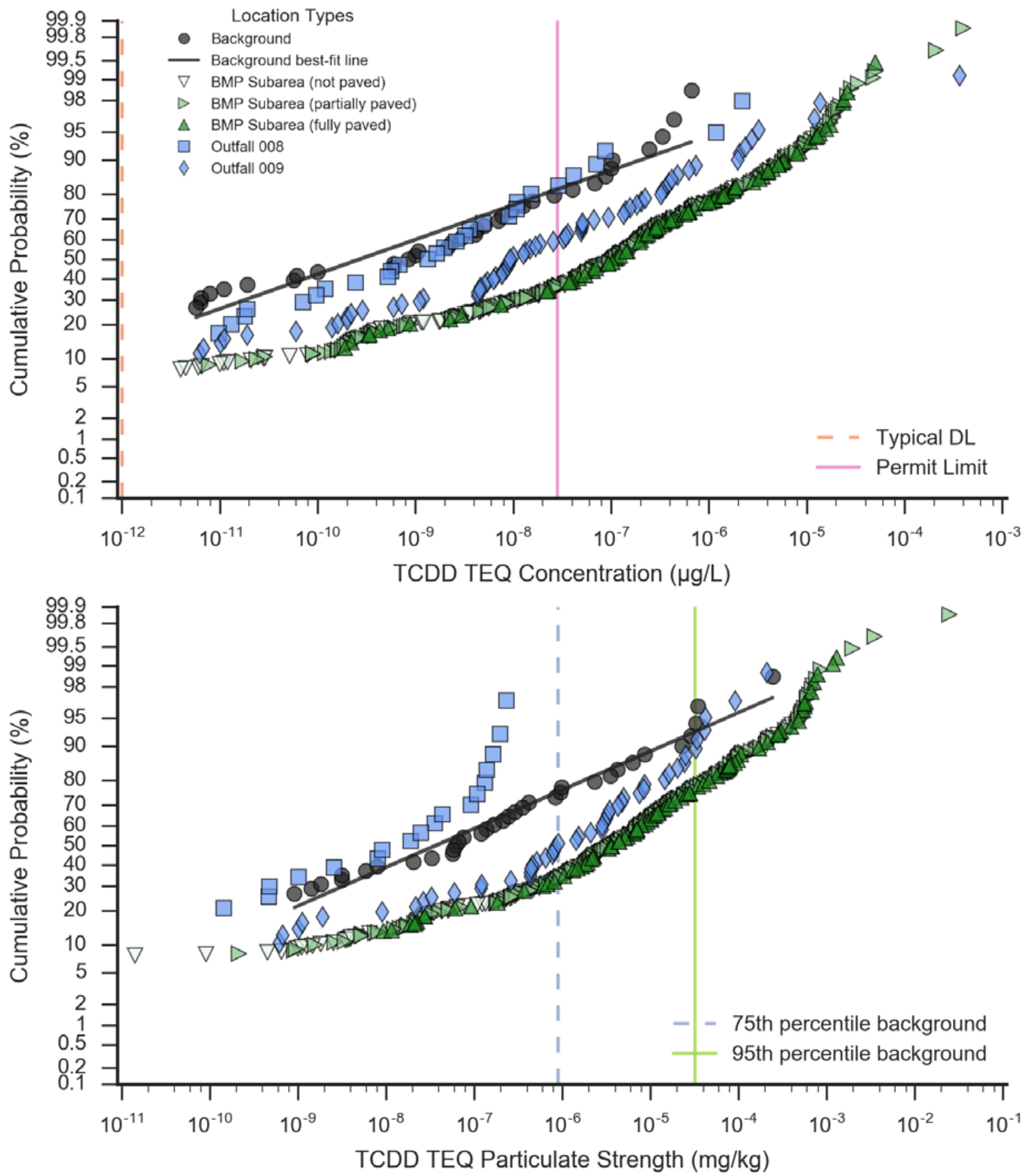

Figure 6. Probability plots for TCDD TEQ concentrations and particulate strengths[20]

[20] Following the 2005 wildfires, an uncharacteristically high TCDD TEQ concentration (3.6×10^{-4} µg/L) was measured at Outfall 009 on 10/17/2005. This data point is shown in the upper right corner of the concentration plot in Figure 6.

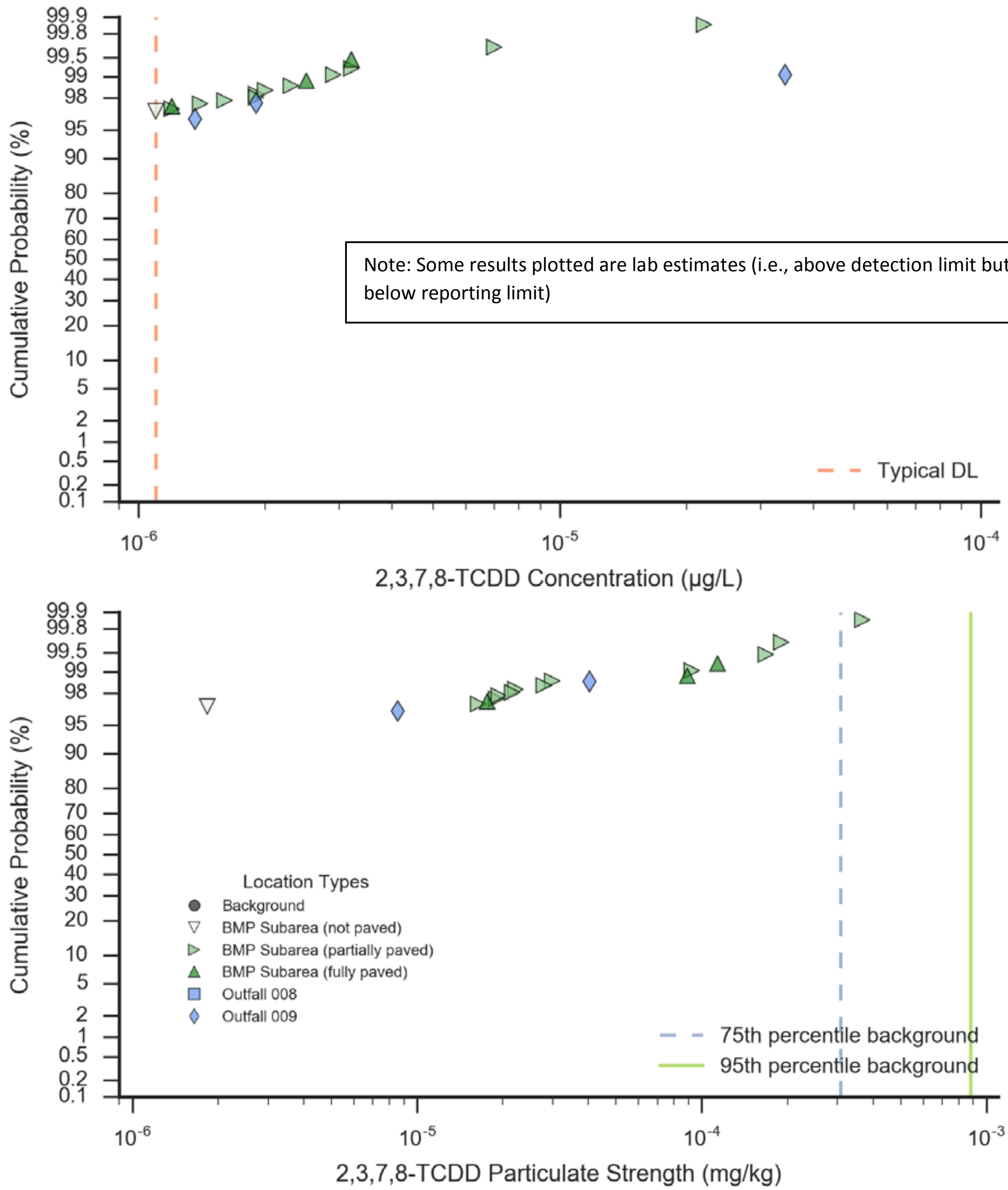

Figure 7. Probability plots for 2,3,7,8-TCDD concentrations and particulate strengths[21]

[21] Following the 2005 wildfires, an uncharacteristically high 2,3,7,8-TCDD concentration (3.4×10^{-5} µg/L) was measured at Outfall 009 on 10/17/2005. This data point is shown in the upper right corner of the concentration plot in Figure 7.

4 Results

Subareas were ranked based on the results of comparisons between (a) stormwater concentrations and permit limits, and (b) stormwater particulate strengths and stormwater background particulate strengths to identify potential stormwater control locations. A statistical methodology (see attachment 5) was developed to rank the subareas based on these comparison results, while accounting for the number of useable data available at each subarea as well as number of data observations that fall above these thresholds (i.e., reflecting statistical confidence in how frequently each subarea will exceed the comparison thresholds). This methodology relies on "weighting factors" (WFs) that are calculated for each COC for each subarea. The potential BMP subareas have been weighted based on general guidelines for small sample sets. The weighting methodology is described in more detail in Attachment 5.

Pollutant-specific weighting factors are summed for each potential BMP subarea to produce a multi-constituent score to allow for relative ranking amongst the potential BMP subareas. The highest ranked subareas are then recommended for consideration for new or enhanced stormwater control placement. In the case of tied scores, the average of the ranks is assigned to both subareas. Results for each BMP subarea and background monitoring subarea are summarized in Tables 7, 8, and 9 (subareas are organized by weight, ranked highest to lowest).

Table 7. Metals Weighting Factor Results, by Subarea

Rank	Potential BMP Subarea (Co-location)	Watershed	Description	Maximum Metal Weight
1	**ILBMP0002**	Outfall 009	Road runoff to CM-9, before treatment	0.99
2	**EVBMP0004**	Outfall 009	2012-2013 Lower Helipad Road	0.89
3	**EVBMP0003** (A2SW0001)	Outfall 009	CM-1 upstream west, pre-ELV improvements, before treatment - OLD	0.80
4	**A1SW0009-A**	Outfall 009	CM-9 downstream-underdrain outlet (post-A1LF asphalt removal, pre-filter fabric over weir boards) - OLD	0.75
5	**ILBMP0007 (ILBMP0005-7)**	Outfall 009	NE Detention Bioswale Effluent	0.70
6	**APBMP0001**	Outfall 009	Ashpile culvert/inlet road runoff, pre-ELV improvements - OLD	0.69
10.5	HZSW0020 (HZSW0017)	Outfall 008	Background - Happy Valley upstream	0.50
10.5	**APBMP0001-A**	Outfall 009	Area II road runoff, post-ELV stormwater improvements	0.50
10.5	EVBMP0006	Outfall 009	2012-2013 Area II Road near ELV ditch	0.50
10.5	LXBMP0004	Outfall 009	LOX southwest downstream of sandbag berm	0.50
10.5	B1SW0014-A	Outfall 009	B1 media filter effluent (pre-media filter reconstruction) - OLD	0.50
10.5	**B1SW0002**	Outfall 009	Woolsey Canyon Road Runoff, before treatment	0.50
10.5	B1BMP0001 (B1SW0010)	Outfall 009	B1 media filter inlet (pre-media filter installation)	0.50

Rank	Potential BMP Subarea (Co-location)	Watershed	Description	Maximum Metal Weight
10.5	A2BMP0011	Outfall 009	Well 13 and Area 2 Road Runoff	0.50
15	**A1SW0009-B**	Outfall 009	CM-9 downstream-underdrain outlet (post-filter fabric over weir boards, post-A1LF asphalt removal) - OLD	0.39
18	A1BMP0004	Outfall 009	Area 2 Road Runoff, SD inlet on north side of road	0.31
18	HZSW0011	Outfall 008	Background - Happy Valley upstream	0.31
18	LXBMP0002	Outfall 009	LOX mid - OLD	0.31
18	APSW0014	Outfall 009	AP/STP-1ABCDE downstream	0.31
18	LPBMP0001	Outfall 009	Lower lot sheetflow (pre-gravel bag berms) - OLD	0.31
21	**EVBMP0002**	Outfall 009	Helipad (pre-sandbag berms) - OLD	0.27
22	A1BMP0001	Outfall 009	A1LF downstream, before treatment	0.25
23	LPBMP0001-A	Outfall 009	Lower lot sheetflow (post-gravel bag berms)	0.17
24	**A1BMP0002-A (A1SW0004-A)**	Outfall 009	CM-9 upstream toward A1LF (post-A1LF asphalt removal), before treatment	0.13
27	BGBMP0004	Outfall 009	Background - Sage Ranch near CM-5	0.11
27	LFSW0002-A	Outfall 009	CTLI downstream (post-ISRA excavation)	0.11
27	BGBMP0002 (LXSW0003)	Outfall 009	Background - CM-3 upstream, before treatment	0.11
27	A2BMP0004	Outfall 009	Helipad culvert outlet	0.11
27	HZBMP0002 (HZSW0004)	Outfall 008	DRG downstream	0.11
30	**ILBMP0008**	Outfall 009	US2 (B1436 Southern Detention Bioswale)	0.11
31	BGBMP0001 (A2BMP0006, A2SW0007)	Outfall 009	Background - CM-1 upstream east tributary, before treatment	0.06
32	**A1SW0009-C (A1BMP0003)**	Outfall 009	CM-9 downstream-underdrain outlet (post-perforated pipe and upper basin installed)	0.05
33.5	A2BMP0005	Outfall 009	A2 u/s of CM-1 confluence	0.04
33.5	B1SW0014-B	Outfall 009	B1 media filter effluent (post-media filter reconstruction) - OLD	0.04
36	**ILBMP0004**	Outfall 009	US1 (B1436 Southern Detention Bioswale)	0.03
36	**EVBMP0002-B**	Outfall 009	Helipad (post-sandbag berms raised, post-drainage holes in asphalt)	0.03
36	**LXBMP0003**	Outfall 009	LOX east tributary - OLD	0.03
38	**EVBMP0001-A**	Outfall 009	ELV culvert inlet (helipad road and ELV ditch, composite)	0.02
40.5	LXBMP0009 (LXSW0009)	Outfall 009	LOX, inlet to eastern slope drain	0.02
40.5	ILBMP0005 (ILBMP0005-7)	Outfall 009	DS (B1436 Southern Detention Bioswale)	0.02
40.5	**A2SW0002-A (A2BMP0007)**	Outfall 009	CM-1 effluent (post-filter fabric over weir boards)	0.02
40.5	EVBMP0009	Outfall 009	Influent to ELV media filter, before treatment	0.02
46	**BGBMP0006 (A2SW0006)**	Outfall 009	Background - CM-1 upstream east tributary (ponded footprint), before treatment	0.01
46	**BGBMP0007 (LXSW0001)**	Outfall 009	Background - CM-3 upstream, before treatment	0.01
46	EVBMP0002-A	Outfall 009	Helipad (post-sandbag berms) - OLD	0.01

Rank	Potential BMP Subarea (Co-location)	Watershed	Description	Maximum Metal Weight
46	LXBMP0006 (LXSW0010)	Outfall 009	LOX east, runoff along dirt road	0.01
46	LXBMP0005	Outfall 009	LOX southeast downstream of sandbag berm	0.01
46	EVBMP0007	Outfall 009	Influent to ELV sedimentation, before treatment	0.01
46	**HZBMP0003 (HZSW0003)**	Outfall 008	DRG downstream (furthest downstream)	0.01
70.5	**ILBMP0001**	Outfall 009	Lower parking lot 24" storm drain bypass	0.00
70.5	**A1SW0002**	Outfall 009	Background - CM-8 upstream, before treatment	0.00
70.5	LXSW0002	Outfall 009	CM-3 downstream (pre-filter fabric over weir boards) - OLD	0.00
70.5	A2BMP0003	Outfall 009	A2 u/s of ND confluence	0.00
70.5	**A1BMP0002 (A1SW0004)**	Outfall 009	CM-9 upstream toward A1LF (pre-A1LF asphalt removal), before treatment - OLD	0.00
70.5	**A2SW0002**	Outfall 009	CM-1 effluent (pre-filter fabric over weir boards) - OLD	0.00
70.5	A1SW0005	Outfall 009	CM-9 downstream (pre-filter fabric over weir boards) - OLD	0.00
70.5	**B1BMP0004 (B1BMP0004-5, B1SW0015)**	Outfall 009	B1 media filter inlet north, before treatment	0.00
70.5	LPBMP0002	Outfall 009	Lower parking lot influent to cistern, before treatment	0.00
70.5	Outfall 008**	Outfall 008	NPDES Outfall 008	0.00
70.5	A1SW0003	Outfall 009	CM-8 downstream (pre-filter fabric over weir boards) - OLD	0.00
70.5	B1BMP0007	Outfall 009	B1, vegetated channel	0.00
70.5	**LPBMP0004**	Outfall 009	Lower parking lot biofilter outlet	0.00
70.5	**B1BMP0003** (B1BMP0002)	Outfall 009	B1 parking lot / road runoff to culvert inlet	0.00
70.5	**HZBMP0001 (HZSW0007)**	Outfall 008	Happy Valley downstream (pre-improvements) - OLD	0.00
70.5	LPBMP0003	Outfall 009	Lower parking lot sediment basin outlet, before treatment	0.00
70.5	B1SW0014-C (B1BMP0006)	Outfall 009	B1 media filter effluent (post-media filter reconstruction, post-curb cuts)	0.00
70.5	**B1BMP0005 (B1BMP0004-5, B1SW0011, B1SW0013)**	Outfall 009	B1 media filter inlet south, before treatment	0.00
70.5	**Outfall 009****	Outfall 009	NPDES Outfall 009	0.00
70.5	B1BMP0008	Outfall 009	B1 storm drain culvert outlet	0.00
70.5	LXBMP0007	Outfall 009	LOX, inlet to western slope drain	0.00
70.5	A2BMP0010	Outfall 009	Well 13 Road Runoff, west side	0.00
70.5	BGBMP0003	Outfall 009	Background - Sage Ranch near LOX	0.00
70.5	B1SW0008	Outfall 009	B1 upstream	0.00
70.5	BGBMP0005	Outfall 009	Sage Ranch near entrance	0.00
70.5	EVBMP0010	Outfall 009	Area 2 Road Runoff, SD inlet on north side of road	0.00

Rank	Potential BMP Subarea (Co-location)	Watershed	Description	Maximum Metal Weight
70.5	ILSW0007	Outfall 009	IEL-2 upstream (2014-2015 reporting year)	0.00
70.5	ILSW0003	Outfall 009	IEL-2 upstream	0.00
70.5	ILBMP0006	Outfall 009	US (B1436 Northern Detention Bioswale)	0.00
70.5	EVBMP0003-A	Outfall 009	CM-1 upstream west, post-ELV improvements, before treatment	0.00
70.5	A2BMP0002	Outfall 009	A2LF drainage east	0.00
70.5	ILBMP0003	Outfall 009	A1LF parking lot - OLD	0.00
70.5	EVBMP0005	Outfall 009	2012-2013 ELV drainage ditch (pre-ELV-1C ISRA) - OLD	0.00
70.5	A1SW0006	Outfall 009	Background - CM-11 upstream, before treatment	0.00
70.5	HZSW0014	Outfall 008	Happy Valley upstream	0.00
70.5	HZSW0012	Outfall 008	Background - Happy Valley upstream	0.00
70.5	A1SW0007	Outfall 009	CM-11 downstream (pre-filter fabric over weir boards) - OLD	0.00
70.5	HZSW0008	Outfall 008	Background - Happy Valley upstream	0.00
70.5	HZSW0005	Outfall 008	DRG upstream	0.00
70.5	EVBMP0008	Outfall 009	Effluent from ELV treatment BMP	0.00
70.5	ILSW0008	Outfall 009	IEL-2 downstream (2014-2015 reporting year)	0.00
70.5	ILSW0004-A	Outfall 009	IEL-2 downstream (post-ISRA excavation)	0.00

Notes

- Potential BMP subareas sorted by maximum weight for the COC group, computed as described in Attachment 5.
- (**)NPDES outfalls are included for comparison and method testing purposes only; stormwater controls are not being contemplated at these locations.
- The rounding of weights may account for similar weights being ranked differently.
- **Bolded** locations indicate that both the metals NPDES permit limit and 95th percentile background particulate strength threshold were exceeded (for at least one metals COC).
- Gray text indicates historical subarea monitoring locations that are discontinued.
- Monitoring locations with zero samples collected are excluded from this table.

Table 8. Dioxins Weighting Factor Results, by Subarea

Rank	Potential BMP Subarea (Co-location)	Watershed	Description	Maximum Dioxin Weight
1	**EVBMP0003** (A2SW0001)	Outfall 009	CM-1 upstream west, pre-ELV improvements, before treatment - OLD	1.00
2	**B1BMP0004 (B1BMP0004-5,** B1SW0015)	Outfall 009	B1 media filter inlet north, before treatment	0.99
3	**B1BMP0003** (B1BMP0002)	Outfall 009	Upper parking lot / road runoff to B1 area culvert inlet	0.99
4	LPBMP0001-A	Outfall 009	Lower lot sheetflow (post-gravel bag berms)	0.98
5	**LPBMP0002**	Outfall 009	Lower parking lot influent to cistern, before treatment	0.98
6	**ILBMP0008**	Outfall 009	Upstream 2 (B1436 Southern Detention Bioswale influent)	0.96
7	**ILBMP0002**	Outfall 009	Road runoff to CM-9, before treatment	0.94
8	**EVBMP0002**	Outfall 009	Helipad (pre-sandbag berms) - OLD	0.93
9	**ILBMP0004**	Outfall 009	Upstream 1 (B1436 Southern Detention Bioswale)	0.91
10	**LPBMP0003**	Outfall 009	Lower parking lot sediment basin outlet, before treatment	0.90
11	**ILBMP0001**	Outfall 009	Lower parking lot 24" storm drain bypass	0.89
12	**EVBMP0003-A**	Outfall 009	CM-1 upstream west, post-ELV improvements, before treatment	0.81
13	**A2BMP0011**	Outfall 009	Well 13 and Area 2 Road Runoff	0.75
14.5	B1SW0008	Outfall 009	B1 upstream	0.69
14.5	EVBMP0005	Outfall 009	2012-2013 ELV drainage ditch (pre-ELV-1C ISRA) - OLD	0.69
16	A2BMP0005	Outfall 009	A2 u/s of CM-1 confluence	0.64
17	A1SW0009-B	Outfall 009	CM-9 downstream-underdrain outlet (post-filter fabric over weir boards, post-A1LF asphalt removal) - OLD	0.63
18	**EVBMP0001-A**	Outfall 009	ELV culvert inlet (helipad road and ELV ditch, composite)	0.59
25	B1SW0002	Outfall 009	Woolsey Canyon Road Runoff, before treatment	0.50
25	LFSW0002-A	Outfall 009	CTLI downstream (post-ISRA excavation)	0.50
25	**EVBMP0007**	Outfall 009	Influent to ELV sedimentation, before treatment	0.50
25	B1SW0014-A	Outfall 009	B1 media filter effluent (pre-media filter reconstruction) - OLD	0.50
25	B1SW0014-B	Outfall 009	B1 media filter effluent (post-media filter reconstruction) - OLD	0.50
25	B1BMP0008	Outfall 009	B1 storm drain culvert outlet	0.50
25	LPBMP0001	Outfall 009	Lower lot sheetflow (pre-gravel bag berms) - OLD	0.50
25	A2BMP0002	Outfall 009	A2LF drainage east	0.50
25	A1SW0009-A	Outfall 009	CM-9 downstream-underdrain outlet (post-A1LF asphalt removal, pre-filter fabric over weir boards) - OLD	0.50
25	LXBMP0002	Outfall 009	LOX mid - OLD	0.50

Rank	Potential BMP Subarea (Co-location)	Watershed	Description	Maximum Dioxin Weight
25	EVBMP0006	Outfall 009	2012-2013 Area II Road near ELV ditch	0.50
25	**A1BMP0004**	Outfall 009	Area 2 Road Runoff, SD inlet on north side of road	0.50
25	APBMP0001	Outfall 009	Road runoff to ashpile culvert inlet, pre-ELV improvements - OLD	0.50
32	**B1BMP0005 (B1BMP0004-5, B1SW0011, B1SW0013)**	Outfall 009	B1 media filter inlet south, before treatment	0.44
33	**B1SW0014-C (B1BMP0006)**	Outfall 009	B1 media filter effluent (post-media filter reconstruction, post-curb cuts)	0.44
34	**B1BMP0007**	Outfall 009	B1, vegetated channel	0.42
35	**EVBMP0002-B**	Outfall 009	Helipad (post-sandbag berms raised, post-drainage holes in asphalt)	0.40
36	**A1BMP0002-A (A1SW0004-A)**	Outfall 009	CM-9 upstream toward A1LF (post-A1LF asphalt removal), before treatment	0.39
37	APBMP0001-A	Outfall 009	Area II road runoff, post-ELV stormwater improvements	0.38
38	HZBMP0002 (HZSW0004)	Outfall 008	DRG downstream	0.36
40	B1BMP0001 (B1SW0010)	Outfall 009	B1 media filter inlet (pre-media filter installation)	0.34
40	A2BMP0004	Outfall 009	Helipad culvert outlet	0.34
40	**EVBMP0004**	Outfall 009	2012-2013 Lower Helipad Road	0.34
42	APSW0014	Outfall 009	AP/STP-1ABCDE downstream	0.31
43	**A2SW0002**	Outfall 009	CM-1 effluent (pre-filter fabric over weir boards) - OLD	0.19
45	EVBMP0002-A	Outfall 009	Helipad (post-sandbag berms) - OLD	0.17
45	A1SW0009-C (A1BMP0003)	Outfall 009	CM-9 downstream-underdrain outlet (post-perforated pipe and upper basin installed)	0.17
45	**LXBMP0005**	Outfall 009	LOX southeast downstream of sandbag berm	0.17
47	**A2SW0002-A (A2BMP0007)**	Outfall 009	CM-1 effluent (post-filter fabric over weir boards)	0.13
48	BGBMP0004	Outfall 009	Background - Sage Ranch near CM-5	0.11
49.5	ILBMP0005 (ILBMP0005-7)	Outfall 009	DS (B1436 Southern Detention Bioswale)	0.11
49.5	**A2BMP0003**	Outfall 009	A2 u/s of ND confluence	0.11
51	LXBMP0003	Outfall 009	LOX east tributary - OLD	0.07
53.5	LXBMP0006 (LXSW0010)	Outfall 009	LOX east, runoff along dirt road	0.05
53.5	**A1BMP0001**	Outfall 009	A1LF downstream, before treatment	0.05
53.5	**A1SW0005**	Outfall 009	CM-9 downstream (pre-filter fabric over weir boards) - OLD	0.05
53.5	EVBMP0009	Outfall 009	Influent to ELV media filter, before treatment	0.05
56.5	BGBMP0002 (LXSW0003)	Outfall 009	Background - CM-3 upstream, before treatment	0.04
56.5	ILBMP0003	Outfall 009	A1LF parking lot - OLD	0.04
58	**BGBMP0006 (A2SW0006)**	Outfall 009	Background - CM-1 upstream east tributary (ponded footprint), before treatment	0.03
59	**A1SW0006**	Outfall 009	Background - CM-11 upstream, before treatment	0.01
60.5	BGBMP0003	Outfall 009	Background - Sage Ranch near LOX	0.01

Rank	Potential BMP Subarea (Co-location)	Watershed	Description	Maximum Dioxin Weight
60.5	LXBMP0004	Outfall 009	LOX southwest downstream of sandbag berm	0.01
76.5	EVBMP0010	Outfall 009	Area 2 Road Runoff, SD inlet on north side of road	0
76.5	BGBMP0001 (A2BMP0006, A2SW0007)	Outfall 009	Background - CM-1 upstream east tributary, before treatment	0
76.5	A2BMP0010	Outfall 009	Well 13 Road Runoff, west side	0
76.5	**LPBMP0004**	Outfall 009	Lower parking lot biofilter outlet	0
76.5	A1SW0003	Outfall 009	CM-8 downstream (pre-filter fabric over weir boards) - OLD	0
76.5	A1SW0002	Outfall 009	Background - CM-8 upstream, before treatment	0
76.5	A1BMP0002 (A1SW0004)	Outfall 009	CM-9 upstream toward A1LF (pre-A1LF asphalt removal), before treatment - OLD	0
76.5	LXBMP0007	Outfall 009	LOX, inlet to western slope drain	0
76.5	LXBMP0009 (LXSW0009)	Outfall 009	LOX, inlet to eastern slope drain	0
76.5	**LXSW0002**	Outfall 009	CM-3 downstream (pre-filter fabric over weir boards) - OLD	0
76.5	**A1SW0007**	Outfall 009	CM-11 downstream (pre-filter fabric over weir boards) - OLD	0
76.5	ILSW0008	Outfall 009	IEL-2 downstream (2014-2015 reporting year)	0
76.5	ILSW0003	Outfall 009	IEL-2 upstream	0
76.5	ILSW0004-A	Outfall 009	IEL-2 downstream (post-ISRA excavation)	0
76.5	HZBMP0001 (HZSW0007)	Outfall 008	Happy Valley downstream (pre-improvements) - OLD	0
76.5	EVBMP0008	Outfall 009	Effluent from ELV treatment BMP	0
76.5	**HZBMP0003 (HZSW0003)**	Outfall 008	DRG downstream (furthest downstream)	0
76.5	HZSW0005	Outfall 008	DRG upstream	0
76.5	HZSW0008	Outfall 008	Background - Happy Valley upstream	0
76.5	HZSW0011	Outfall 008	Background - Happy Valley upstream	0
76.5	ILSW0007	Outfall 009	IEL-2 upstream (2014-2015 reporting year)	0
76.5	HZSW0012	Outfall 008	Background - Happy Valley upstream	0
76.5	HZSW0020 (HZSW0017)	Outfall 008	Background - Happy Valley upstream	0
76.5	Outfall 008**	Outfall 008	NPDES Outfall 008	0
76.5	BGBMP0007 (LXSW0001)	Outfall 009	Background - CM-3 upstream, before treatment	0
76.5	BGBMP0005	Outfall 009	Sage Ranch near entrance	0
76.5	ILBMP0006	Outfall 009	US (B1436 Northern Detention Bioswale)	0
76.5	ILBMP0007 (ILBMP0005-7)	Outfall 009	NE Detention Bioswale Effluent	0
76.5	HZSW0014	Outfall 008	Happy Valley upstream	0
76.5	**Outfall 009****	Outfall 009	NPDES Outfall 009	0

Notes:

- Potential BMP subareas sorted by maximum weight for the COC group, computed as described in Section 5.
- (**)NPDES outfalls are included for comparison and method testing purposes only; stormwater controls are not being contemplated at these locations.
- The rounding of weights may account for similar weights being ranked differently.
- **Bolded** locations indicate that both the dioxins NPDES permit limit and 95th percentile background particulate strength threshold were exceeded (for at least one dioxin COC).
- Gray text indicates historical subarea monitoring locations that are discontinued.
- Locations with zero samples collected are excluded from this table.

Table 9. TSS Weighting Factor Results, by Subarea

Rank	Potential BMP Subarea (Co-location)	Watershed	Description	TSS Weight
1	B1BMP0001 (B1SW0010)	Outfall 009	B1 media filter inlet (pre-media filter installation)	0.87
7	LXBMP0002	Outfall 009	LOX mid - OLD	0.5
7	EVBMP0006	Outfall 009	2012-2013 Area II Road near ELV ditch	0.5
7	HZSW0020 (HZSW0017)	Outfall 008	Background - Happy Valley upstream	0.5
7	BGBMP0004	Outfall 009	Background - Sage Ranch near CM-5	0.5
7	HZBMP0001 (HZSW0007)	Outfall 008	Happy Valley downstream (pre-improvements) - OLD	0.5
7	LXBMP0004	Outfall 009	LOX southwest downstream of sandbag berm	0.5
7	APBMP0001-A	Outfall 009	Area II road runoff, post-ELV stormwater improvements	0.5
7	EVBMP0010	Outfall 009	Area 2 Road Runoff, SD inlet on north side of road	0.5
7	A1BMP0002-A (A1SW0004-A)	Outfall 009	CM-9 upstream toward A1LF (post-A1LF asphalt removal), before treatment	0.5
7	B1SW0008	Outfall 009	B1 upstream	0.5
7	LXBMP0005	Outfall 009	LOX southeast downstream of sandbag berm	0.5
13	Outfall 008**	Outfall 008	NPDES Outfall 008	0.5
14	LXBMP0003	Outfall 009	LOX east tributary - OLD	0.34
15.5	BGBMP0002 (LXSW0003)	Outfall 009	Background - CM-3 upstream, before treatment	0.31
15.5	LXBMP0009 (LXSW0009)	Outfall 009	LOX, inlet to eastern slope drain	0.31
17.5	LXBMP0006 (LXSW0010)	Outfall 009	LOX east, runoff along dirt road	0.19
17.5	A1SW0009-C (A1BMP0003)	Outfall 009	CM-9 downstream-underdrain outlet (post-perforated pipe and upper basin installed)	0.19
19.5	A2BMP0003	Outfall 009	A2 u/s of ND confluence	0.14
19.5	ILBMP0008	Outfall 009	Upstream 2 (B1436 Southern Detention Bioswale influent)	0.14
21.5	LPBMP0001-A	Outfall 009	Lower lot sheetflow (post-gravel bag berms)	0.11
21.5	A1SW0009-B	Outfall 009	CM-9 downstream-underdrain outlet (post-filter fabric over weir boards, post-A1LF asphalt removal) - OLD	0.11
23	BGBMP0006 (A2SW0006)	Outfall 009	Background - CM-1 upstream east tributary (ponded footprint), before treatment	0.06
24	EVBMP0001-A	Outfall 009	ELV culvert inlet (helipad road and ELV ditch, composite)	0.05
25	ILBMP0002	Outfall 009	Road runoff to CM-9, before treatment	0.038406372
26.5	HZBMP0003 (HZSW0003)	Outfall 008	DRG downstream (furthest downstream)	0.02

Rank	Potential BMP Subarea (Co-location)	Watershed	Description	TSS Weight
26.5	LXSW0002	Outfall 009	CM-3 downstream (pre-filter fabric over weir boards) - OLD	0.02
59.5	HZSW0008	Outfall 008	Background - Happy Valley upstream	0
59.5	HZSW0011	Outfall 008	Background - Happy Valley upstream	0
59.5	HZSW0005	Outfall 008	DRG upstream	0
59.5	HZSW0012	Outfall 008	Background - Happy Valley upstream	0
59.5	HZBMP0002 (HZSW0004)	Outfall 008	DRG downstream	0
59.5	HZSW0014	Outfall 008	Happy Valley upstream	0
59.5	A1BMP0001	Outfall 009	A1LF downstream, before treatment	0
59.5	ILBMP0003	Outfall 009	A1LF parking lot - OLD	0
59.5	LXBMP0007	Outfall 009	LOX, inlet to western slope drain	0
59.5	LPBMP0004	Outfall 009	Lower parking lot biofilter outlet	0
59.5	LPBMP0003	Outfall 009	Lower parking lot sediment basin outlet, before treatment	0
59.5	LPBMP0002	Outfall 009	Lower parking lot influent to cistern, before treatment	0
59.5	LPBMP0001	Outfall 009	Lower lot sheetflow (pre-gravel bag berms) - OLD	0
59.5	LFSW0002-A	Outfall 009	CTLI downstream (post-ISRA excavation)	0
59.5	ILBMP0001	Outfall 009	Lower parking lot 24" storm drain bypass	0
59.5	ILSW0008	Outfall 009	IEL-2 downstream (2014-2015 reporting year)	0
59.5	ILSW0004-A	Outfall 009	IEL-2 downstream (post-ISRA excavation)	0
59.5	ILSW0003	Outfall 009	IEL-2 upstream	0
59.5	ILBMP0007 (ILBMP0005-7)	Outfall 009	NE Detention Bioswale Effluent	0
59.5	ILBMP0006	Outfall 009	US (B1436 Northern Detention Bioswale)	0
59.5	ILBMP0005 (ILBMP0005-7)	Outfall 009	DS (B1436 Southern Detention Bioswale)	0
59.5	ILBMP0004	Outfall 009	Upstream 1 (B1436 Southern Detention Bioswale)	0
59.5	ILSW0007	Outfall 009	IEL-2 upstream (2014-2015 reporting year)	0
59.5	EVBMP0009	Outfall 009	Influent to ELV media filter, before treatment	0
59.5	EVBMP0003 (A2SW0001)	Outfall 009	CM-1 upstream west, pre-ELV improvements, before treatment - OLD	0
59.5	EVBMP0007	Outfall 009	Influent to ELV sedimentation, before treatment	0
59.5	APBMP0001	Outfall 009	Road runoff to ashpile culvert inlet, pre-ELV improvements - OLD	0
59.5	A2SW0002-A (A2BMP0007)	Outfall 009	CM-1 effluent (post-filter fabric over weir boards)	0

Rank	Potential BMP Subarea (Co-location)	Watershed	Description	TSS Weight
59.5	A2SW0002	Outfall 009	CM-1 effluent (pre-filter fabric over weir boards) - OLD	0
59.5	A2BMP0011	Outfall 009	Well 13 and Area 2 Road Runoff	0
59.5	A2BMP0010	Outfall 009	Well 13 Road Runoff, west side	0
59.5	A2BMP0005	Outfall 009	A2 u/s of CM-1 confluence	0
59.5	A2BMP0004	Outfall 009	Helipad culvert outlet	0
59.5	APSW0014	Outfall 009	AP/STP-1ABCDE downstream	0
59.5	A2BMP0002	Outfall 009	A2LF drainage east	0
59.5	A1SW0007	Outfall 009	CM-11 downstream (pre-filter fabric over weir boards) - OLD	0
59.5	A1SW0006	Outfall 009	Background - CM-11 upstream, before treatment	0
59.5	A1SW0005	Outfall 009	CM-9 downstream (pre-filter fabric over weir boards) - OLD	0
59.5	A1SW0003	Outfall 009	CM-8 downstream (pre-filter fabric over weir boards) - OLD	0
59.5	A1SW0002	Outfall 009	Background - CM-8 upstream, before treatment	0
59.5	A1BMP0004	Outfall 009	Area 2 Road Runoff, SD inlet on north side of road	0
59.5	A1BMP0002 (A1SW0004)	Outfall 009	CM-9 upstream toward A1LF (pre-A1LF asphalt removal), before treatment - OLD	0
59.5	A1SW0009-A	Outfall 009	CM-9 downstream-underdrain outlet (post-A1LF asphalt removal, pre-filter fabric over weir boards) - OLD	0
59.5	EVBMP0008	Outfall 009	Effluent from ELV treatment BMP	0
59.5	B1BMP0003 (B1BMP0002)	Outfall 009	Upper parking lot / road runoff to B1 area culvert inlet	0
59.5	B1BMP0005 (B1BMP0004-5, B1SW0011, B1SW0013)	Outfall 009	B1 media filter inlet south, before treatment	0
59.5	EVBMP0005	Outfall 009	2012-2013 ELV drainage ditch (pre-ELV-1C ISRA) - OLD	0
59.5	EVBMP0004	Outfall 009	2012-2013 Lower Helipad Road	0
59.5	EVBMP0003-A	Outfall 009	CM-1 upstream west, post-ELV improvements, before treatment	0
59.5	EVBMP0002-B	Outfall 009	Helipad (post-sandbag berms raised, post-drainage holes in asphalt)	0
59.5	EVBMP0002-A	Outfall 009	Helipad (post-sandbag berms) - OLD	0
59.5	EVBMP0002	Outfall 009	Helipad (pre-sandbag berms) - OLD	0
59.5	BGBMP0007 (LXSW0001)	Outfall 009	Background - CM-3 upstream, before treatment	0
59.5	B1BMP0004 (B1BMP0004-5, B1SW0015)	Outfall 009	B1 media filter inlet north, before treatment	0
59.5	BGBMP0005	Outfall 009	Sage Ranch near entrance	0

Rank	Potential BMP Subarea (Co-location)	Watershed	Description	TSS Weight
59.5	BGBMP0001 (A2BMP0006, A2SW0007)	Outfall 009	Background - CM-1 upstream east tributary, before treatment	0
59.5	B1SW0014-C (B1BMP0006)	Outfall 009	B1 media filter effluent (post-media filter reconstruction, post-curb cuts)	0
59.5	B1SW0014-B	Outfall 009	B1 media filter effluent (post-media filter reconstruction) - OLD	0
59.5	B1SW0014-A	Outfall 009	B1 media filter effluent (pre-media filter reconstruction) - OLD	0
59.5	B1SW0002	Outfall 009	Woolsey Canyon Road Runoff, before treatment	0
59.5	B1BMP0008	Outfall 009	B1 storm drain culvert outlet	0
59.5	B1BMP0007	Outfall 009	B1, vegetated channel	0
59.5	BGBMP0003	Outfall 009	Background - Sage Ranch near LOX	0
59.5	Outfall 009**	Outfall 009	NPDES Outfall 009	0

Notes

- (**)NPDES outfalls are included for comparison and method testing purposes only, stormwater controls are not being contemplated at these locations.
- The rounding of weights may account for similar weights being ranked differently.
- Gray text indicates historical subarea monitoring locations that are discontinued.
- Locations with zero samples collected are excluded from this table.

A "multi-constituent" score was then calculated for each potential BMP subarea monitoring location by taking the arithmetic mean of the maximum metals and the maximum dioxins weighting factor values (Table 10). To be consistent with the methodology used in previous years' BMP ranking analyses, these two pollutant category values were weighted equally for the multi-constituent score. Between 2004 and 2016, the exceedance probability of TCDD TEQ (when compared to the TCDD TEQ, no DNQ permit limit) is approximately 18% at Outfall 008 (noting that samples have not been collected since the 2013/2014 reporting year), and approximately 40% at Outfall 009. Between 2004 and 2016, the lead (most problematic metal) permit limit exceedance probability is approximately 40% at Outfall 008 and approximately 25% at Outfall 009. 2,3,7,8-TCDD was detected at four locations in the 2015/2016 reporting year— B1BMP0005, ILBMP0001, LPBMP0002, and ILBMP0004. Water quality at stormwater background locations was generally good with no location ranked above 38, though there were several instances of concentrations greater than NPDES permit limits at those locations.

A complete summary of the weights computed by potential BMP subarea monitoring location (including number of samples, number of NDs, median, maximum, comparison to background percentiles, weight, and rank) is included as Attachment 6. For purposes of comparison, the Permit limit for TCDD TEQ has also been applied to 2,3,7,8-TCDD results.

Table 10. Subareas Ranked by Multi-Constituent Score

Rank	Potential BMP Subarea (Co-locations)	Watershed	Description	Approximate Upgradient Drainage Area (ac)	Multi-Constituent Score	Rank from Maximum Metal Weighting	Rank from Maximum Dioxin Weighting	Number of Events Sampled	Number of Events Sampled in 2015/16
1	**ILBMP0002**	Outfall 009	Road runoff to CM-9, before treatment	2.2	0.970	1	7	16	3
2	**EVBMP0003 (A2SW0001)**	Outfall 009	CM-1 upstream west, pre-ELV improvements, before treatment - OLD	4.9	0.898	3	1	18	0
3.5	A1SW0009-A	Outfall 009	CM-9 downstream-underdrain outlet (post-A1LF asphalt removal, pre-filter fabric over weir boards) - OLD	10.2	0.625	4	25	1	0
3.5	**A2BMP0011**	Outfall 009	Well 13 and Area 2 Road Runoff	0.30	0.625	10.5	13	1	1
5	EVBMP0004	Outfall 009	2012-2013 Lower Helipad Road	2.5	0.615	2	40	3	0
6	**EVBMP0002**	Outfall 009	Helipad (pre-sandbag berms) - OLD	4.1	0.6	21	8	6	0
7	**APBMP0001**	Outfall 009	Road runoff to ashpile culvert inlet, pre-ELV improvements - OLD	3.6	0.595	6	25	2	0
8	LPBMP0001-A	Outfall 009	Lower lot sheetflow (post-gravel bag berms)	2.7	0.575	23	4	6	0
9	**ILBMP0008**	Outfall 009	Upstream 2 (B1436 Southern Detention Bioswale influent)	13.3	0.533	30	6	8	8
10	A1SW0009-B	Outfall 009	CM-9 downstream-underdrain outlet (post-filter fabric over weir boards, post-A1LF asphalt removal) - OLD	10.2	0.51	15	17	6	0
12	B1SW0014-A	Outfall 009	B1 media filter effluent (pre-media filter reconstruction) - OLD	8.6	0.5	10.5	25	1	0
12	B1SW0002	Outfall 009	Woolsey Canyon Road Runoff, before treatment	3.8	0.5	10.5	25	2	0
12	EVBMP0006	Outfall 009	2012-2013 Area II Road near ELV ditch	8.2	0.5	10.5	25	1	0
14	**B1BMP0004 (B1BMP0004-5, B1SW0015)**	Outfall 009	B1 media filter inlet north, before treatment	6.7	0.495	70.5	2	21	5
15	**B1BMP0003 (B1BMP0002)**	Outfall 009	Upper parking lot / road runoff to B1 area culvert inlet	4.8	0.494	70.5	3	23	2
16	**LPBMP0002**	Outfall 009	Lower parking lot influent to cistern, before treatment	29.9	0.489	70.5	5	15	8

Rank	Potential BMP Subarea (Co-locations)	Watershed	Description	Approximate Upgradient Drainage Area (ac)	Multi-Constituent Score	Rank from Maximum Metal Weighting	Rank from Maximum Dioxin Weighting	Number of Events Sampled	Number of Events Sampled in 2015/16
17	**ILBMP0004**	Outfall 009	Upstream 1 (B1436 Southern Detention Bioswale)	0.40	0.47	36	9	7	7
18	**LPBMP0003**	Outfall 009	Lower parking lot sediment basin outlet, before treatment	29.9	0.450	70.5	10	15	8
19	**ILBMP0001**	Outfall 009	Lower parking lot 24" storm drain bypass	30.2	0.447	70.5	11	26	3
20	**APBMP0001-A**	Outfall 009	Area II road runoff, post-ELV stormwater improvements	0.32	0.44	10.5	37	5	3
21	B1BMP0001 (B1SW0010)	Outfall 009	B1 media filter inlet (pre-media filter installation)	8.6	0.42	10.5	40	3	0
23.5	LPBMP0001	Outfall 009	Lower lot sheetflow (pre-gravel bag berms) - OLD	2.3	0.405	18	25	2	0
23.5	**A1BMP0004**	Outfall 009	Area 2 Road Runoff, SD inlet on north side of road	0.27	0.405	18	25	2	2
23.5	**EVBMP0003-A**	Outfall 009	CM-1 upstream west, post-ELV improvements, before treatment	1.4	0.405	70.5	12	6	3
23.5	LXBMP0002	Outfall 009	LOX mid - OLD	9.1	0.405	18	25	2	0
26	**ILBMP0007 (ILBMP0005-7)**	Outfall 009	NE Detention Bioswale Effluent	2.6	0.350	5	76.5	9	8
27.5	**B1SW0008**	Outfall 009	B1 upstream	0.47	0.345	70.5	14.5	2	0
27.5	**EVBMP0005**	Outfall 009	2012-2013 ELV drainage ditch (pre-ELV-1C ISRA) - OLD	11.0	0.345	70.5	14.5	2	0
29	**A2BMP0005**	Outfall 009	A2 u/s of CM-1 confluence	43.3	0.34	33.5	16	4	0
30	APSW0014	Outfall 009	AP/STP-1ABCDE downstream	29.3	0.31	18	42	2	0
31	**LFSW0002-A**	Outfall 009	CTLI downstream (post-ISRA excavation)	1.4	0.305	27	25	3	0
32	**EVBMP0001-A**	Outfall 009	ELV culvert inlet (helipad road and ELV ditch, composite)	6.6	0.304	38	18	10	0
33	B1SW0014-B	Outfall 009	B1 media filter effluent (post-media filter reconstruction) - OLD	8.6	0.27	33.5	25	4	0
34	**A1BMP0002-A (A1SW0004-A)**	Outfall 009	CM-9 upstream toward A1LF (post-A1LF asphalt removal), before treatment	6.6	0.26	24	36	7	1

Rank	Potential BMP Subarea (Co-locations)	Watershed	Description	Approximate Upgradient Drainage Area (ac)	Multi-Constituent Score	Rank from Maximum Metal Weighting	Rank from Maximum Dioxin Weighting	Number of Events Sampled	Number of Events Sampled in 2015/16
35.5	LXBMP0004	Outfall 009	LOX southwest downstream of sandbag berm	11.7	0.255	10.5	60.5	5	0
35.5	**EVBMP0007**	Outfall 009	Influent to ELV sedimentation, before treatment	6.6	0.255	46	25	6	3
38	HZSW0020 (HZSW0017)	Outfall 008	Background - Happy Valley upstream	0.20	0.25	10.5	76.5	2	0
38	B1BMP0008	Outfall 009	B1 storm drain culvert outlet	43.2	0.25	70.5	25	2	2
38	A2BMP0002	Outfall 009	A2LF drainage east	3.2	0.25	70.5	25	1	0
40	HZBMP0002 (HZSW0004)	Outfall 008	DRG downstream	23.2	0.235	27	38	4	0
41	A2BMP0004	Outfall 009	Helipad culvert outlet	9.0	0.225	27	40	3	0
42	**B1BMP0005 (B1BMP0004-5, B1SW0011, B1SW0013)**	Outfall 009	B1 media filter inlet south, before treatment	0.19	0.222	70.5	32	26	5
43	**B1SW0014-C (B1BMP0006)**	Outfall 009	B1 media filter effluent (post-media filter reconstruction, post-curb cuts)	8.6	0.218	70.5	33	19	6
44	**EVBMP0002-B**	Outfall 009	Helipad (post-sandbag berms raised, post-drainage holes in asphalt)	9.0	0.215	36	35	7	2
45	**B1BMP0007**	Outfall 009	B1, vegetated channel	50.6	0.210	70.5	34	12	3
46	HZSW0011	Outfall 008	Background - Happy Valley upstream	0.10	0.155	18	76.5	2	0
47	**A1BMP0001**	Outfall 009	A1LF downstream, before treatment	3.5	0.15	22	53.5	5	0
48	**A1SW0009-C (A1BMP0003)**	Outfall 009	CM-9 downstream-underdrain outlet (post-perforated pipe and upper basin installed)	10.2	0.11	32	45	5	1
49	BGBMP0004	Outfall 009	Background - Sage Ranch near CM-5	81.1	0.11	27	48	3	0
50	**A2SW0002**	Outfall 009	CM-1 effluent (pre-filter fabric over weir boards) - OLD	42.4	0.094	70.5	43	16	0
51.5	**LXBMP0005**	Outfall 009	LOX southeast downstream of sandbag berm	11.7	0.09	46	45	5	0
51.5	EVBMP0002-A	Outfall 009	Helipad (post-sandbag berms) - OLD	4.1	0.09	46	45	5	0
53	**A2SW0002-A (A2BMP0007)**	Outfall 009	CM-1 effluent (post-filter fabric over weir boards)	42.4	0.076	40.5	47	10	0

Rank	Potential BMP Subarea (Co-locations)	Watershed	Description	Approximate Upgradient Drainage Area (ac)	Multi-Constituent Score	Rank from Maximum Metal Weighting	Rank from Maximum Dioxin Weighting	Number of Events Sampled	Number of Events Sampled in 2015/16
54	BGBMP0002 (LXSW0003)	Outfall 009	Background - CM-3 upstream, before treatment	16.8	0.075	27	56.5	4	0
55	ILBMP0005 (ILBMP0005-7)	Outfall 009	DS (B1436 Southern Detention Bioswale)	15.6	0.063	40.5	49.5	8	8
56	A2BMP0003	Outfall 009	A2 u/s of ND confluence	103	0.053	70.5	49.5	8	0
57	LXBMP0003	Outfall 009	LOX east tributary - OLD	21.3	0.05	36	51	6	0
58	EVBMP0009	Outfall 009	Influent to ELV media filter, before treatment	6.6	0.035	40.5	53.5	5	3
59	LXBMP0006 (LXSW0010)	Outfall 009	LOX east, runoff along dirt road	0.28	0.03	46	53.5	5	2
60	BGBMP0001 (A2BMP0006, A2SW0007)	Outfall 009	Background - CM-1 upstream east tributary, before treatment	39.3	0.03	31	76.5	4	0
61	A1SW0005	Outfall 009	CM-9 downstream (pre-filter fabric over weir boards) - OLD	10.2	0.0250	70.5	53.5	10	0
62.5	BGBMP0006 (A2SW0006)	Outfall 009	Background - CM-1 upstream east tributary (ponded footprint), before treatment	39.3	0.02	46	58	7	0
62.5	ILBMP0003	Outfall 009	A1LF parking lot - OLD	0.97	0.02	70.5	56.5	4	0
64	LXBMP0009 (LXSW0009)	Outfall 009	LOX, inlet to eastern slope drain	11.7	0.01	40.5	76.5	5	2
65	A1SW0006	Outfall 009	Background - CM-11 upstream, before treatment	3.9	0.00566396 1	70.5	59	12	0
67	BGBMP0007 (LXSW0001)	Outfall 009	Background - CM-3 upstream, before treatment	16.8	0.005	46	76.5	7	0
67	HZBMP0003 (HZSW0003)	Outfall 008	DRG downstream (furthest downstream)	29.6	0.005	46	76.5	15	0
67	BGBMP0003	Outfall 009	Background - Sage Ranch near LOX	20.8	0.005	70.5	60.5	5	0
80	HZBMP0001 (HZSW0007)	Outfall 008	Happy Valley downstream (pre-improvements) - OLD	21.4	0	70.5	76.5	13	0
80	EVBMP0010	Outfall 009	Area 2 Road Runoff, SD inlet on north side of road	0.55	0	70.5	76.5	1	1
80	EVBMP0008	Outfall 009	Effluent from ELV treatment BMP	6.6	0	70.5	76.5	6	3
80	HZSW0008	Outfall 008	Background - Happy Valley upstream	NA	0	70.5	76.5	1	0

Rank	Potential BMP Subarea (Co-locations)	Watershed	Description	Approximate Upgradient Drainage Area (ac)	Multi-Constituent Score	Rank from Maximum Metal Weighting	Rank from Maximum Dioxin Weighting	Number of Events Sampled	Number of Events Sampled in 2015/16
80	**A1SW0007**	Outfall 009	CM-11 downstream (pre-filter fabric over weir boards) - OLD	5.7	0	70.5	76.5	12	0
80	HZSW0012	Outfall 008	Background - Happy Valley upstream	0.40	0	70.5	76.5	1	0
80	HZSW0014	Outfall 008	Happy Valley upstream	0.10	0	70.5	76.5	3	0
80	Outfall 008**	Outfall 008	NPDES Outfall 008	62.0	0	70.5	76.5	34	0
80	HZSW0005	Outfall 008	DRG upstream	21.0	0	70.5	76.5	1	0
80	**A1BMP0002 (A1SW0004)**	Outfall 009	CM-9 upstream toward A1LF (pre-A1LF asphalt removal), before treatment - OLD	6.6	0	70.5	76.5	16	0
80	**LPBMP0004**	Outfall 009	Lower parking lot biofilter outlet	29.9	0	70.5	76.5	16	8
80	ILSW0004-A	Outfall 009	IEL-2 downstream (post-ISRA excavation)	1.2	0	70.5	76.5	1	0
80	A1SW0003	Outfall 009	CM-8 downstream (pre-filter fabric over weir boards) - OLD	2.6	0	70.5	76.5	10	0
80	ILBMP0006	Outfall 009	US (B1436 Northern Detention Bioswale)	2.6	0	70.5	76.5	1	1
80	ILSW0003	Outfall 009	IEL-2 upstream	1.2	0	70.5	76.5	2	0
80	ILSW0008	Outfall 009	IEL-2 downstream (2014-2015 reporting year)	0.11	0	70.5	76.5	1	0
80	**A1SW0002**	Outfall 009	Background - CM-8 upstream, before treatment	2.6	0	70.5	76.5	10	0
80	A2BMP0010	Outfall 009	Well 13 Road Runoff, west side	1.4	0	70.5	76.5	1	1
80	ILSW0007	Outfall 009	IEL-2 upstream (2014-2015 reporting year)	NA/small	0	70.5	76.5	1	0
80	**LXSW0002**	Outfall 009	CM-3 downstream (pre-filter fabric over weir boards) - OLD	16.8	0	70.5	76.5	9	0
80	LXBMP0007	Outfall 009	LOX, inlet to western slope drain	11.7	0	70.5	76.5	1	1
80	BGBMP0005	Outfall 009	Sage Ranch near entrance	29.8	0	70.5	76.5	1	0
80	**Outfall 009****	Outfall 009	NPDES Outfall 009	536	0	70.5	76.5	77	3

Notes

- Potential BMP subareas sorted by multi-constituent score, computed as described in Section 5.
- (**) NPDES outfalls are included for comparison and method testing purposes only, stormwater controls are not being contemplated at these locations.
- The rounding of weights may account for similar weights being ranked differently.
- Approximate drainage areas based on the cumulative drainage area of the SWMM catchment in which the monitoring location is located (Geosyntec, 2011). At locations where the monitoring point is upstream of the catchment outfall a "<" sign is used.
- **Bolded** locations indicate that both the NPDES permit limit and 95th percentile background particulate strength threshold were exceeded for any one COC.
- Gray text indicates historical subarea monitoring locations that are discontinued.
- "OLD" in the location description means that the location is now sampled under a new suffix (-A, -B, etc.) due to a change in the upstream watershed, typically BMP implementation.

5 Discussion

The results presented previously are discussed below and will be used to support BMP and other subarea-specific recommendations in the 2015/2016 Site-Wide Annual Report.

5.1 Subarea-Specific Evaluation of Top Ranked Subareas

The monitoring locations in Table 11[22] are identified as the highest ranked subareas, with multi-constituent scores for all subareas ranging from 0.44 to 0.97 out of a maximum score of 1.0. Scores closer to 1.0 indicate the monitoring locations with poorer historical water quality. Table 11 is limited to the top-ranked subareas discussed below; a complete summary table is provided in the main report as Table 10. Besides the multi-constituent scores, information within Table 11 is also of significance because:

- Only four of the top twenty monitoring locations (A2BMP0011, B1BMP0003, ILBMP0001, and APBMP0001-A) are both active (i.e., not discontinued[23]) and not upstream of an existing BMP (i.e., without adequate downstream stormwater treatment);
- All of the above four monitoring locations are targeted for a new control recommendation (as described in the 2016 Annual Report);
- It contains two (ILBMP0002 and EVBMP0003) of the three subareas (ILBMP0002, EVBMP0003, B1BMP0005) where 2,3,7,8-TCDD[24] was detected (but not quantified) in the 2012/2013 reporting year and three (ILBMP0001, LPBMP0002, ILBMP0004) of the four subareas (B1BMP0005, ILBMP0001, LPBMP0002, ILBMP0004) where 2,3,7,8-TCDD was detected (but not quantified in the 2015/2016 reporting year. 2,3,7,8-TCDD was not detected in any samples collected during the 2013/2014 or 2014/2015 reporting years;
- The top ten highest ranked monitoring locations for dioxins; and
- The top four highest ranked monitoring locations for metals.

In some cases, the analysis results reflect conditions prior to or following implementation of temporary measures or corrective actions; this is described in the "description" column in the table. It should be noted that all top 20 monitoring locations described below are located in the Outfall 009 drainage area, with none in the Outfall 008 drainage area. No events produced observable runoff sampled at Outfall 008 during the current reporting year, indicating that retention occurred within the watershed during the small storms observed.

Recommendations for specific site areas are summarized after the discussion of individual site results. The highest ranked subareas contain some historical subarea monitoring locations that are

[22] Subarea monitoring locations with zero samples could not have scores calculated and are not included in Table 10.

[23] No site was discontinued if it had known water quality issues. Sites were typically discontinued due to reclassification due to upstream BMP implementation, redundancy, or termination of the required ISRA monitoring period.

[24] 2,3,7,8-TCDD is a congener that potentially indicates unweathered anthropogenic dioxin contamination.

discontinued, indicated by gray text[25]; no Expert Panel recommendations are provided for these locations. It should also be noted that the 2015/2016 reporting year was unusually dry with 11.97 inches of total rainfall having been recorded to-date , as compared to the average rainfall at SSFL of 16.8 inches (based on rainfall record 1959-2016).[26] Therefore, there are relatively few new data observations this year for updating the location rankings.

[25] Monitoring locations were discontinued for a number of reasons, including location improvements, changes in treatment type, and planned end of monitoring activities.

[26]Data from the Simi Hills – Rocketdyne Lab gauge (Ventura County Watershed Protection District site 249) was used to determine annual rainfall from 1958/1959 through 2000/2001. However, rainfall data was not available at this gauge from 1977/1978 through 1984/1985. Data from the Area 4 gauge (which was moved to Area 1 on January 1, 2013) was used to determine annual rainfall from 2001/2002 through 2015/2016. This results in a period of record (POR) of 50 years. Due to the reporting timeline for the Annual Report, reporting years have been defined as June 1 – May 31.

Table 11. Top-Ranked Subarea Ranking and Recommendation Details

BMP Subarea (Co-Location)	Description	Drainage Area (ac)	Total Number of Events Sampled	Multi-Constituent Score	Rank				Subarea Notes	Conclusions
					Overall	Dioxin	Metals	TSS		
ILBMP0002	Road runoff to CM-9, before treatment	2.2	16	1	0.97	7	1	25	ILBMP0002 drains to CM-9, which filters runoff through a horizontal media bed (sizing is currently estimated to achieve 10% long-term average runoff volume capture[1]). The other influent stream to CM-9, monitored at A1BMP0002-A, is ranked 34th overall, 36th for dioxins, 24th for metals, and 7th for TSS. The effluent from CM-9 (A1SW0009-C (A1BMP0003)) is ranked 48th overall, 45th for dioxins, 32nd for metals, and 17.5th for TSS.	Large improvement in water quality compared to the upstream, untreated runoff from both ILBMP0002 and A1BMP0002-A, showing that the improvements are not due to dilution alone.
EVBMP0003 (A2SW0001)	CM-1 upstream west, pre-ELV improvements, before treatment - OLD	4.9	18	2	0.90	1	3	53.5	CM-1, to which EVBMP0003 drains, is an existing CM that treats runoff from a 53 acre subwatershed (sizing is estimated to achieve around 7% long-term runoff volume capture under current conditions, with the new ELV treatment BMP in place). Based on ten events, the CM-1 effluent subarea (A2SW0002-A) is ranked 53rd overall (multi-constituent score = 0.076), ranked 47th for dioxins, 40.5th for metals, and 59.5th for TSS. The ELV area previously drained to EVBMP0003 and CM-1 due to an existing degraded asphalt channel below the ELV hillside that diverted a portion of this runoff onto the Area II Road and to EVBMP0003. This channel was improved and a stormwater treatment BMP was installed before the start of the 2013/2014 reporting year. Before the 2015/16 reporting year, CM-1 upstream sand bags were replaced with rip-rap.	Large water quality improvement achieved by CM-1.
fA1SW0009-A	CM-9 downstream-underdrain outlet (post-A1LF asphalt removal, pre-filter fabric over weir boards) - OLD	10.2	1	3.5	0.63	25	4	76.5	Monitoring in this subarea, added during the 2012/13 reporting year and discontinued during the 2013/2014 reporting year, reflects treated runoff (estimated at 10% capture[1]) from an area consisting of road runoff (ILBMP0002), a stabilized dirt road, rocky hillsides, and the AILF. In January of 2012, filter fabric was installed over the weir boards to reduce and filter seepage flows. In March of 2013, perforated flow spreader pipe and the upper basin were installed.	Based on five events following the March 2013 improvements, this subarea (now named A1SW0009-C) is ranked 48th overall, 45th for dioxins, 32nd for metals, and 17.5th for TSS. There have been five samples collected since the most recent BMP improvements completed in March, 2013.
A2BMP0011	Well 13 and Area 2 Road Runoff	0.30	1	3.5	0.63	13	10.5	56.5	This subarea represents flow from the culvert outlet on the west side of Well 13 Road, just north of Service Area Road.	More data are needed to form the basis of any conclusions
EVBMP0004	2012-2013 Lower Helipad Road	2.5	3	5	0.62	40	2	76.5	Added during the 2012/2013 reporting year; reflects flow from the paved Area II (NASA) Helipad Road. The monitoring location was discontinued after the ELV Treatment BMP was installed to treat runoff from this area, among others.	Not applicable as this location has been discontinued.
EVBMP0002	Helipad (pre-sandbag berms) - OLD	4.1	6	6	0.60	8	21	76.5	Reflects runoff from the paved Helipad area, pre-sandbag berms raised and pre-drainage holes in asphalt). This monitoring location has since been improved (EVBMP0002-B), reflecting Helipad runoff, post-sandbag berms raised, post-drainage holes in asphalt. The improved location ranks 44th overall (multi-constituent score = 0.22), 35th for dioxins, 36th for metals, and 59.5th for TSS. The BMPs include two raised sandbag berms that collect and retain the runoff, ultimately pumping it to the Silvernale treatment facility. Currently the storage volume behind the berms is expected to equate to approximately a 1.5 inch rainfall event, given the larger drainage area. This past reporting year, EVBMP0002-B represented runoff only from direct rainfall on the downstream side of the berm (approximately a 0.06 ac drainage area), not berm overflow.	Not applicable as this location has been improved.
APBMP0001	Road runoff to ashpile culvert inlet, pre-ELV improvements - OLD	3.6	2	7	0.60	25	6	53.5	This Area II (NASA) subarea represents runoff from several flat ISRA areas distributed throughout a relatively flat drainage area, as well as road runoff. This location was replaced with an alternate site ID after the ELV improvements were made, which altered the upstream drainage area.	Not applicable as this location has been improved

BMP Subarea (Co-Location)	Description	Drainage Area (ac)	Total Number of Events Sampled	Multi-Constituent Score	Rank				Subarea Notes	Conclusions
					Overall	Dioxin	Metals	TSS		
LPBMP0001-A	Lower lot sheetflow (post-gravel bag berms)	2.7	6	8	0.58	4	23	25	This discontinued monitoring subarea, which has been replaced by the cistern influent sample at LPBMP0002 (ranked 16th overall), reflects runoff from mostly paved parking and road areas, after the gravel bag berms were installed in September of 2011 to slow runoff and allow for some detention. Soil management and contractor staging activities are also planned to occur here, but were not present during the period reflected by this dataset.	Not applicable as this location has been discontinued
ILBMP0008	Upstream 2 (B1436 Southern Detention Bioswale influent)	13.3	8	9	0.53	6	30	25	This subarea reflects runoff into the B1436 Southern Detention Bioswale, which is a concrete swale that diverts sheetflow into a rock crib. ILBMP0008 drains to ILBMP0005, which is representative of the water quality at the downstream end of the bioswale. Based on 8 samples, ILBMP0005 (ILBMP0005-7) is ranked 55th overall, 49.5th for dioxins, 40.5th for metals, and 59.5th for TSS.	Notable improvement in water quality between the upstream and downstream end of the B1436 Southern Detention Bioswale.
A1SW0009-B	CM-9 downstream-underdrain outlet (post-filter fabric over weir boards, post-A1LF asphalt removal) - OLD	10.2	6	10	0.51	17	15	25	Monitoring in this subarea, added during the 2011/12 reporting year and discontinued following improvements during the 2012/2013 reporting year, reflects treated runoff (estimated at 10% capture [1]) from a 10.2 acre drainage area, consisting of road runoff (ILBMP0002), a stabilized dirt road, rocky hillsides, and the AILF. In January of 2012, filter fabric was installed over the weir boards to reduce and filter seepage flows. In March of 2013, perforated flow spreader pipe and the upper basin were installed. Based on five events following the March 2013 improvements, this subarea (now named A1SW0009-C) is ranked 48th overall, 45th for dioxins, 32nd for metals, and 17.5th for TSS.	Not applicable as this location has been improved.
B1SW0014-A	B1 media filter effluent (pre-media filter reconstruction) - OLD	8.6	1	12	0.50	25	10.5	76.5	Treated stormwater runoff from Facility Road that discharged through the originally constructed B1 media filter. This sampling location was discontinued after the B1 media filter was reconstructed with a new underdrain system in December of 2011. This area contributing to this former sampling location was also improved through the addition of improved hillside erosion controls and curb cuts, which occurred in December of 2011, respectively. Based on 19 events, this subarea (now named B1SW0014-C) is now ranked 43rd overall but has been discontinued and replaced with location B1BMP0006 (collocated), which reflects effluent from the reconstructed B1 media filter.	Not applicable as this location has been improved.
B1SW0002	Woolsey Canyon Road Runoff, before treatment	3.8	2	12	0.50	25	10.5	76.5	This discontinued monitoring subarea, which has been replaced by sampling location B1BMP0004, reflects overland and shallow concentrated runoff from mostly paved road at the intersection of Facility Road and Woolsey Canyon Road. This area drains toward the north inlet of the B1 media filter along an earthen channel with rip rap check structures.	Not applicable as this location has been discontinued.
EVBMP0006	2012-2013 Area II Road near ELV ditch	8.2	1	12	0.50	25	10.5	3	This monitoring subarea reflects Area II Road runoff near the ELV ditch. EVBMP0006 monitoring was discontinued following installation of the ELV Treatment BMP, installed to treat runoff from this area, among others.	Not applicable as this location has been discontinued.
B1BMP0004 (B1BMP0004-5, B1SW0015)	B1 media filter inlet north, before treatment	6.7	21	14	0.50	2	70.5	76.5	This monitoring subarea reflects runoff from paved road and post-ISRA restored hillside. This subarea drains to a series of rock check dams and the B1 media filter which, after filtering runoff, discharges to a natural vegetated drainage across the main entrance at Facility Road. In 2012, hillside erosion controls were improved and curb cuts were added to even the distribution of inflows to the B1 media filter on the south and north sides.	Based on 19 events, the B1 media filter effluent (B1SW0014-C) is ranked 43rd overall, demonstrating an improvement in water quality compared to the inlet.
B1BMP0003 (B1BMP0002)	Upper parking lot / road runoff to B1 area culvert inlet	4.8	23	15	0.49	3	70.5	76.5	This location continues to be highly ranked, reflecting runoff from 4.8 acres of mixed paved area, and not treated downstream.	A treatment BMP is recommended at this location, and is currently under review.
LPBMP0002	Lower parking lot influent to cistern, before treatment	29.9	15	16	0.49	5	70.5	40	LPBMP0002 reflects influent to the Lower Parking Lot cistern, which is located upstream of the Lower Parking Lot sediment basin (LPBMP0003) and Lower Parking Lot biofilter (LPBMP0004), arranged in series. As shown in Table 12, water quality improvement is demonstrated between the cistern influent and the sediment basin outlet, and is even further improved at the biofilter	Based on rankings, notable water quality improvement achieved by the Lower Parking Lot BMP system.

BMP Subarea (Co-Location)	Description	Drainage Area (ac)	Total Number of Events Sampled	Multi-Constituent Score	Rank Overall	Rank Dioxin	Rank Metals	Rank TSS	Subarea Notes	Conclusions
									outlet (LPBMP0004). Based on 16 samples, LPBMP0004 is ranked 80th overall, 76.5th for dioxins, 70.5th for metals, and 59.5th for TSS.	
ILBMP0004	Upstream 1 (B1436 Southern Detention Bioswale)	0.40	7	17	0.47	9	36	49.5	ILBMP0004 drains to ILBMP0005, which is representative of the water quality at the downstream end of the bioswale. Based on 8 samples, ILBMP0004 is ranked 55th overall, 49.5th for dioxins, 40.5th for metals, and 60th for TSS.	Based on rankings, notable water quality improvement between the upstream and downstream end of the B1436 Southern Detention Bioswale.
LPBMP0003	Lower parking lot sediment basin outlet, before treatment	29.9	15	18	0.45	10	70.5	38	LPBMP0003 represents flow from the Lower Parking Lot sediment basin outlet, prior to entering the Lower Parking Lot biofilter (LPBMP0004). Based on 16 samples, LPBMP0004 is ranked 77.5 overall, 76.5 for dioxins, 70.5 for metals, and 60th for TSS.	Based on rankings, notable water quality improvement achieved by the Lower Parking Lot BMP system.
ILBMP0001	Lower parking lot 24" storm drain bypass	30.2	26	19	0.45	11	70.5	42	This monitoring subarea reflects flow from paved parking areas, building rooftops, paved storage areas, the detention bioswale outlet, and undeveloped hillsides. Runoff from these areas is conveyed by a storm drain collection system to a 24-inch storm drain located beneath the Lower Parking Lot. This storm drain passes through a low flow diversion (LFD) vault before discharging via a concrete outlet spillway to the Northern Drainage on Sage Ranch property. The LFD vault contains a weir that diverts a portion of runoff to the biofilter for treatment. The height of the LFD weir was increased from 2 to 4 inches in November 2015, which is expected to result in approximately 90% of this flow being diverted and treated by the lower lot biofilter during an average year. Building 1436 was demolished in 2014, and has resulted in the removal of approximately one acre of impervious area; the demolition footprint was covered with erosion controls, such as wattles and hydroseed. Two detention bioswales were also constructed in November and December of 2014 to detain runoff from this area before releasing it to the lower Lot cistern for treatment through the biofilter.	Treatment options near the upper temporary administrative building are currently under review.
APBMP0001-A	Area II road runoff, post-ELV stormwater improvements	0.32	5	20	0.44	37	10.5	8	This Area II (NASA) subarea is very small, and primarily reflects runoff from a short section of the Area II Road. This road runoff drains under the Area II Road to the tributary eventually meeting the Northern Drainage.	A potential sand bag diversion berm, to route runoff to CM-1, is currently under review.

[1] Overflows also get partial sedimentation through temporary ponding behind weir boards.

- Gray text indicates historical subarea monitoring locations that are discontinued.

5.2 Other Observations

The following are additional observations based on the results of the ranking analysis; these findings will also be considered in the development of any new BMPs:

- Dioxins (TCDD TEQ) and lead are the COCs most frequently responsible for producing high dioxins and metals weighting factors, respectively. In the 2015/2016 reporting year, Permit limit exceedances were only observed at Outfall 009 for these same parameters (one for TCDD TEQ, no DNQ and one for lead).
- Table 12 summarizes the key locations that have both an influent and effluent paired location, focusing on the locations ranked in the top 20 from the multi-constituent ranking analysis. This comparison demonstrates that treatment through the BMPs resulted in improved water quality. For example, two influent streams within the B1 area (ranked 14 and 42) are both ranked higher than the B1 effluent, which is ranked 43. A similar occurrence is observed for the influent/effluent ranks for CM-1, CM-9, the ELV treatment BMP, and the lower parking lot sedimentation basin and biofilter.
- Table 13 summarizes a select subset of locations ranked in the top 20 that are associated with BMP modifications. In most cases, the location rank based on the multi-constituent score was reduced after the BMP was implemented, demonstrating that BMP implementation has generally resulted in improved water quality. The lower lot sheetflow shows an increase in rank but was technically discontinued when the lower lot biofilter was constructed to treat these flows.
- 2,3,7,8-TCDD was detected at B1BMP0005, ILBMP0001, ILBMP0004, and LPBMP0002 during the 2015/2016 reporting year, in contrast to the 2014/2015 reporting year where it was not detected in any samples. Potential dioxin sources are being examined more closely in the Special Monitoring Studies for the 009 Watershed (SSFL and Geosyntec, 2016).
- Similar to last year, all CM effluent monitoring locations are ranked lower than (i.e., better water quality) or equal to their most impacted influent streams (i.e., where two influent streams enter a CM, the effluent ranking is lower than or equal to that of the poorer quality influent), indicating that the CMs are performing well. This finding is consistent with the conclusions of the statistical analysis of influent/effluent data in the 2012 *Performance Evaluation Memorandum* (Geosyntec and Expert Panel, 2012). This finding is also consistent with the fact that, as part of the intended maintenance program, Boeing has removed substantial quantities of sediment that have accumulated in the CMs illustrating continued CM functionality and pollutant removal. However, this finding may also be associated with dilution by the less impacted influent stream.
- The most highly ranked subareas for TSS is the B1 media filter inlet (pre-media filter reconstruction) (B1BMP0001 [B1SW0010]). This is a discontinued monitoring location (replaced by B1BMP0004 and B1BMP0005 in order to characterize the northern and southern influent separately) and does not reflect the current influent quality to the B1 media filter. Regardless, B1SW0014-C, representing the paired B1 effluent monitoring point to B1BMP0001 shows an improvement in TSS ranking through the media filter.

- Seventeen of the top twenty overall ranked subareas represent drainage areas with either full or mixed runoff contributions from paved surfaces (mostly parking lots and roads). This may indicate that the remaining elevated COC concentrations in the 009 watershed may be derived from asphalt itself, activities occurring on the asphalt such as vehicle use or material/equipment storage, or from atmospheric deposition (which occurs relatively evenly across the site) onto directly connected impervious surfaces (e.g., asphalt) which are more efficient at washing off and transporting contaminants than pervious surfaces. These hypotheses are being examined more closely in the Special Monitoring Studies for the 009 Watershed (SSFL and Geosyntec, 2015).

- The top 20-ranked subareas based on the multi-constituent score include thirteen subareas on Boeing property – B1BMP0004 (the B1 media filter inlet north, before treatment), ILBMP0001 (Lower Lot 24" storm drain outlet), ILBMP0002 (road runoff to CM-9, before treatment), ILBMP0008 (Upstream 2 (B1436 Southern Detention Bioswale), A1SW0009-A and A1SW0009-B (CM-9 downstream-underdrain outlet (post-A1LF asphalt removal, pre- and post-filter fabric over weir boards) - OLD), LPBMP0001-A (Lower Lot sheetflow (post-gravel bag berms)), B1SW0002 (Woolsey Canyon Road runoff, before treatment), B1SW0014-A (B1 media filter effluent (pre-media filter reconstruction – OLD), LPBMP0002 (lower parking lot influent to cistern, before treatment), ILBMP0004 (Upstream 1 (B1436 Southern Detention Bioswale)), LPBMP0003 (lower parking lot sediment basin outlet, before treatment), and B1BMP0003 (Upper parking lot / road runoff to B1 area culvert inlet). All thirteen subareas, with the exception of ILBMP0001 and B1BMP0003, are either upstream of existing treatment BMPs or were discontinued due to system improvements (e.g., A1SW0009-B). Of these subareas, B1BMP0004 is ranked highest for dioxins.

- The top 20-ranked subareas based on the multi-constituent score include seven subareas on Boeing property EVBMP0003 (CM-1 upstream west, pre-ELV improvements, before treatment – OLD), EVBMP0002 (Helipad (pre-sandbag berms) - OLD), A2BMP0011 (Well 13 and Area II road runoff), EVBMP0004 (2012/2013 Lower Helipad Road), APBMP0001 and APBMP0001-A (Area II Road runoff, pre- and post-ELV stormwater improvements, respectively), and EVBMP0006 (2012/2013 Area II Road near ELV ditch). Four these sites are currently upstream of an existing treatment BMP: EVBMP0003 (CM-1); EVBMP0002 (Helipad sandbag berms); and EVBMP0004 and EVBMP0006, runoff from which now flow to ELV treatment system. Runoff from subareas A2BMP0011 and APBMP0001/-A is currently not treated. Across all seven monitoring locations, EVBMP0003 was ranked highest for dioxins.

- As shown in Figure 2, channel processes appear to be a significant source of TSS for Watershed 008 (based on observations from previous years) and less so for Watershed 009, where outfall TSS concentrations are near background. Northern Drainage improvements and stabilization measures are expected to continue providing a water quality benefit to these channels, particularly if the upcoming winter is wetter and helps channel vegetation to grow.

- While the analysis approach is concentration-based rather than load-based, because such a large percentage of the watersheds (and of the watersheds developed or known impacted areas) are represented by the monitoring locations, the approach roughly addresses load reduction aspects, noting that actual runoff coefficients do vary between subareas.

Table 12. Ranking Comparison of Top Ranked Monitoring Locations and their Influent/Effluent Pairs

BMP Area	Influent Monitoring Location: Monitoring Location	Influent Monitoring Location: Description	Influent Monitoring Location: Influent Rank	Effluent Monitoring Location: Monitoring Location	Effluent Monitoring Location: Description	Effluent Monitoring Location: Effluent Rank	Rank Change
CM-9	**ILBMP0002**	Road runoff to CM-9	1	A1SW0009-C (A1BMP0003)	CM-9 downstream-underdrain outlet (post-A1LF asphalt removal, post-filter fabric over weir boards, post-perforated pipe and rip-rap berm)	48	-47
	A1BMP0002-A (A1SW0004-A)	CM-9 upstream toward A1LF (post-A1LF asphalt removal), before treatment	34				
CM-1	EVBMP0003-A	CM-1 upstream west	23.5	A2SW0002-A (A2BMP0007)	CM-1 effluent (post-filter fabric over weir boards)	53	-29.5
B1 Media Filter	**B1BMP0004 (B1SW0015, B1BMP0004-5)**	B1 media filter inlet north	14	B1SW0014-C (B1BMP0006)	B1 media filter effluent (post-media filter reconstruction, post-curb cuts)	43	-29
	B1BMP0005 (B1SW0013, B1SW0011, B1BMP0004-5)	B1 media filter inlet south	42				-1
Lower Lot Sediment Basin	**LPBMP0002**	Lower parking lot influent to cistern	16	**LPBMP0003**	Lower parking lot sediment basin outlet	18	-2
				LPBMP0004	Lower parking lot biofilter outlet	80	-64
Southern Detention Bioswale	**ILBMP0004**	Upstream 1 (B1436 Southern Detention Bioswale)	17	ILBMP0005 (ILBMP0005-7)	DS (B1436 Southern Detention Bioswale)	55	-38
	ILBMP0008	Upstream 2 (B1436 Southern Detention Bioswale)	9				-46
ELV Treatment BMP	EVBMP0007	Influent to ELV treatment BMP	35.5	EVBMP0009	Influent to ELV media filter, before treatment	58	-22.5
				EVBMP0008	Effluent from ELV treatment BMP	80	-44.5

Notes

- **Bolded** locations indicate that the monitoring location is ranked within the top 20 of the multi-constituent table (Table ES-1).
- Gray text indicates historical subarea monitoring locations that are discontinued.

Table 13. Ranking Comparison of Top Ranked Monitoring Locations Pre- vs. Post-BMP

Original Location Name	Description	Pre-BMP Rank	Suffix	Implementation Date	Description	Post-BMP Rank 1	Suffix	Implementation Date	Description	Post-BMP Rank 2	Suffix	Implementation Date	Description	Current BMP Rank
B1SW0014	B1 culvert effluent (no media filter) – OLD	N/A[1]	-A	9/1/2011[2]	B1 media filter effluent (pre-media filter reconstruction) - OLD	12	-B	12/16/2011	B1 media filter effluent (post-media filter reconstruction) - OLD	33	-C (B1BMP0006)	11/2/2012	B1 media filter effluent (post-media filter reconstruction, post-curb cuts)	43
A1SW0009	CM-9 downstream-underdrain outlet (pre-A1LF asphalt removal, pre-filter fabric over weir boards, pre-perforated pipe and rip-rap berm) - OLD	N/A[1]	-A	9/1/2012[2]	CM-9 downstream-underdrain outlet (post-A1LF asphalt removal, pre-filter fabric over weir boards, pre-perforated pipe and rip-rap berm) - OLD	3.5	-B	1/20/2012	CM-9 downstream-underdrain outlet (post-A1LF asphalt removal, post-filter fabric over weir boards, pre-perforated pipe and rip-rap berm) - OLD	10	-C (A1BMP0003)	3/1/2013	CM-9 downstream-underdrain outlet (post-A1LF asphalt removal, post-filter fabric over weir boards, post-perforated pipe and rip-rap berm)	48
EVBMP0002	Helipad (pre-sandbag berms) - OLD	6	-A	11/14/2011	Helipad (post-sandbag berms) - OLD	51.5	-B	9/5/2012	Helipad (post-sandbag berms raised, post-drainage holes in asphalt)	44	N/A			
LPBMP0001	Lower Lot sheetflow (pre-gravel bag berms) - OLD	23.5	-A	9/26/2011	Lower Lot sheetflow (post-gravel bag berms)	8	N/A							
APBMP0001	Road runoff to ashpile culvert inlet, pre-ELV improvements - OLD	7	**-A**	11/7/2013	Area II Road runoff, post-ELV stormwater improvements	20	N/A							

Original Location Name	Description	Pre-BMP Rank	Suffix	Implemen-tation Date	Description	Post-BMP Rank 1	Suffix	Implemen-tation Date	Description	Post-BMP Rank 2	Suffix	Implemen-tation Date	Description	Current BMP Rank
EVBMP0003 (A2SW0001)	CM-1 upstream west, pre-ELV improvements, before treatment - OLD	2	-A	11/1/2013	CM-1 upstream west, post-ELV improvements, before treatment	23.5	N/A							

Notes

- ([1]) "N/A" means there were no samples collected at this location under the specified name designation and therefore the monitoring location is not ranked.
- ([2]) Dates of 9/1/20XX assume work completed in the summer, prior to the start of the reporting year, but are not confirmed.
- **Bold** locations are ranked in the top 20 of the multi-constituent table (Table 10).
- Gray text indicates historical subarea monitoring locations that are discontinued.

6 References

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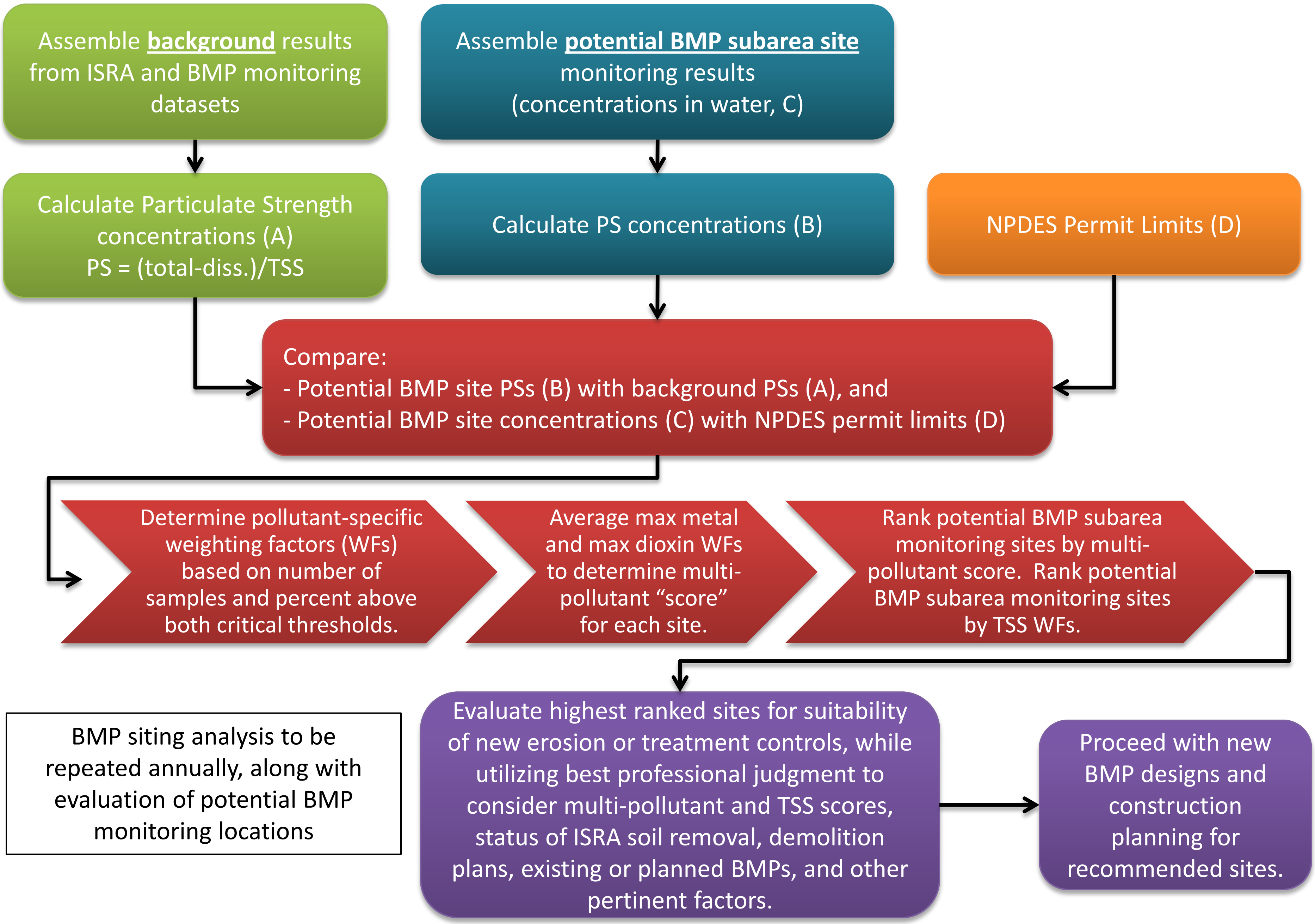
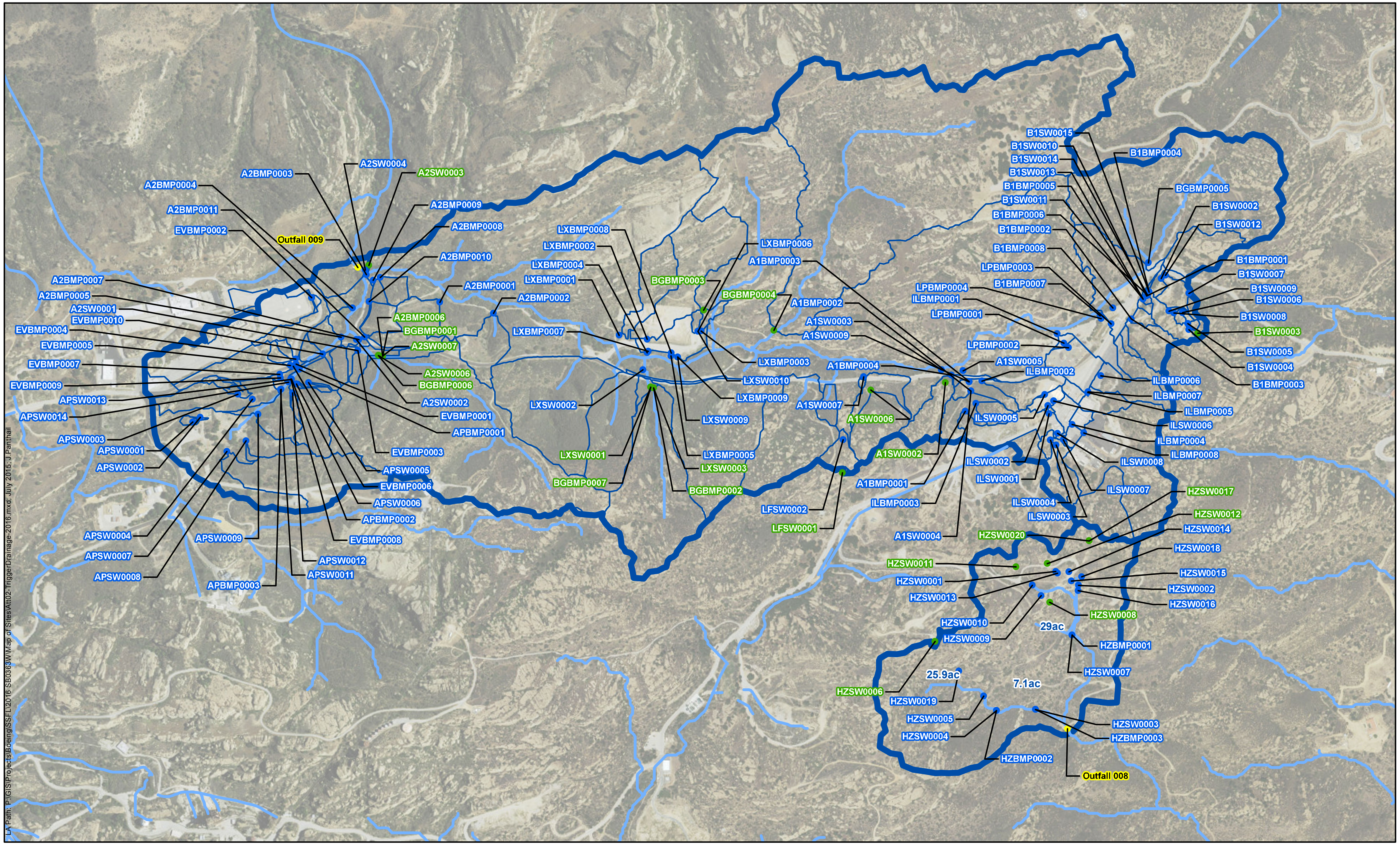
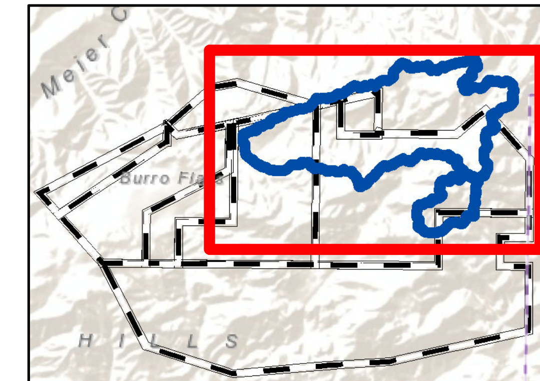
Attachment 1. Summary Flowchart for BMP Site Ranking Analysis Approach







Outfall Watersheds
Property Boundary

N

Legend

- BMP Subarea
- Background
- NPDES
- Streams
- Outfall watershed boundary

Site Legend

Potential BMP subarea site
Stormwater background site
Outfalls

1,000 500 0 1,000
Feet

Notes:
1) NPDES outfalls are included for comparison and method testing purposes only. Stormwater controls are not being contemplated at these locations.

ATTACHMENT 2

Locations Used in Site Ranking Analsysis Outfall 008/009 Watersheds

Santa Susana Field Laboratory
Ventura County, CA

Geosyntec consultants

Los Angeles, CA	October 2016

Attachment 3. Outfall 008 and 009 Watershed Subarea Monitoring Locations

Site Identifier (Co-location)	Subcategory	Prioritization Category	Watershed	Description	Approximate Upstream Drainage Area (ac)	Reason for Discontinuation
A1BMP0001	Subarea for BMP Siting Analysis	BMP Subarea	Outfall 009	A1LF downstream, before treatment	3.5	2011-2012 reporting year: Discontinued based on results from the 2010-2011 reporting year below NPDES permit limits. Replaced by A1BMP0002 (co-located with A1SW0004) further downstream.
A1BMP0002 (A1SW0004)	Existing BMP Performance	BMP Subarea	Outfall 009	CM-9 upstream toward A1LF (pre-A1LF asphalt removal), before treatment - OLD	6.6	2012-2013 reporting year: Discontinued A1SW0004 as it had been monitored for three reporting years under the ISRA performance monitoring program. Continued monitoring at co-located BMP monitoring location A1BMP0002.
A1BMP0002-A (A1SW0004-A)	Existing BMP Performance	BMP Subarea	Outfall 009	CM-9 upstream toward A1LF (post-A1LF asphalt removal), before treatment	6.6	*See description A1BMP0002/A1SW0004.*
A1BMP0004	Subarea for BMP Siting Analysis	BMP Subarea	Outfall 009	Area 2 Road Runoff, SD inlet on north side of road	0.27	n/a
A1SW0002	ISRA Performance	Background	Outfall 009	Background - CM-8 upstream, before treatment	2.6	2011-2012 reporting year: Discontinued A1SW0002 due to the low concentrations observed in results from the previous reporting year.
A1SW0003	ISRA Performance	BMP Subarea	Outfall 009	CM-8 downstream (pre-filter fabric over weir boards) - OLD	2.6	2011-2012 reporting year: Discontinued A1SW0003 due to the low concentrations observed in results from the previous reporting year.
A1SW0003-A	ISRA Performance	BMP Subarea	Outfall 009	CM-8 downstream (post-filter fabric over weir boards)	2.6	*See description for A1SW0003.*
A1SW0005	ISRA Performance	BMP Subarea	Outfall 009	CM-9 downstream (pre-filter fabric over weir boards) - OLD	10.2	2011-2012 reporting year: A1SW0005 was replaced with A1SW0009, in order to monitor discharge from the CM-9 underdrains as the downstream monitoring point.

Site Identifier (Co-location)	Subcategory	Prioritization Category	Watershed	Description	Approximate Upstream Drainage Area (ac)	Reason for Discontinuation
A1SW0005-A	ISRA Performance	BMP Subarea	Outfall 009	CM-9 downstream (post-filter fabric over weir boards)	10.2	*See description for A1SW0005.*
A1SW0006	ISRA Performance	Background	Outfall 009	Background - CM-11 upstream, before treatment	3.9	2011-2012 reporting year: Discontinued A1SW0006 due to the low concentrations observed in results from the previous reporting year.
A1SW0007	ISRA Performance	BMP Subarea	Outfall 009	CM-11 downstream (pre-filter fabric over weir boards) - OLD	5.7	2011-2012 reporting year: Discontinued A1SW0007 due to the low concentrations observed in results from the previous reporting year.
A1SW0007-A	ISRA Performance	BMP Subarea	Outfall 009	CM-11 downstream (post-filter fabric over weir boards)	5.7	*See description for A1SW0007.*
A1SW0009	ISRA Performance	BMP Subarea	Outfall 009	CM-9 downstream-underdrain outlet (pre-A1LF asphalt removal, pre-filter fabric over weir boards) - OLD	10.2	2013-2014 reporting year: Discontinued ISRA performance monitoring at A1SW0009 and was replaced by BMP monitoring location A1BMP0003.
A1SW0009-A	ISRA Performance	BMP Subarea	Outfall 009	CM-9 downstream-underdrain outlet (post-A1LF asphalt removal, pre-filter fabric over weir boards) - OLD	10.2	*See description for A1SW0009.*
A1SW0009-B	ISRA Performance	BMP Subarea	Outfall 009	CM-9 downstream-underdrain outlet (post-filter fabric over weir boards, post-A1LF asphalt removal) - OLD	10.2	*See description for A1SW0009.*
A1SW0009-C (A1BMP0003)	ISRA Performance	BMP Subarea	Outfall 009	CM-9 downstream-underdrain outlet (post-perforated pipe and upper basin installed)	10.2	*See description for A1SW0009.*

Site Identifier (Co-location)	Subcategory	Prioritization Category	Watershed	Description	Approximate Upstream Drainage Area (ac)	Reason for Discontinuation
A2BMP0001	Subarea for BMP Siting Analysis	BMP Subarea	Outfall 009	A2LF drainage west	2.2	n/a
A2BMP0002	Subarea for BMP Siting Analysis	BMP Subarea	Outfall 009	A2LF drainage east	3.2	n/a
A2BMP0003	Subarea for BMP Siting Analysis	BMP Subarea	Outfall 009	A2 u/s of ND confluence	103	2014-2015 reporting year: Discontinued A2BMP003 as the location had been monitored for three years and sufficient data had been collected.
A2BMP0004	Subarea for BMP Siting Analysis	BMP Subarea	Outfall 009	Helipad culvert outlet	9.0	2012-2013 reporting year: Discontinued A2BMP0004 as it was determined the upstream Helipad monitoring location (EVBMP0002) provided sufficient data.
A2BMP0005	Subarea for BMP Siting Analysis	BMP Subarea	Outfall 009	A2 u/s of CM-1 confluence	43.3	2014-2015 reporting year: Discontinued A2BMP005 as the location had been monitored for three years and sufficient data had been collected.
A2BMP0008	Subarea for BMP Siting Analysis	BMP Subarea	Outfall 009	Well 13 Road Runoff, north side	NA	n/a
A2BMP0009	Subarea for BMP Siting Analysis	BMP Subarea	Outfall 009	Well 13 Road Runoff, east of OF0009 autosamplers	NA	n/a
A2BMP0010	Subarea for BMP Siting Analysis	BMP Subarea	Outfall 009	Well 13 Road Runoff, west side	1.4	n/a
A2BMP0011	Subarea for BMP Siting Analysis	BMP Subarea	Outfall 009	Well 13 and Area 2 Road Runoff	0.30	n/a
A2SW0002	ISRA Performance	BMP Subarea	Outfall 009	CM-1 effluent (pre-filter fabric over weir boards) - OLD	42.4	2012-2013 reporting year: Discontinued ISRA performance monitoring at A2SW0002 as it had been monitored for three years. Monitoring continued at co-located BMP monitoring location A2BMP0007.
A2SW0002-A (A2BMP0007)	ISRA Performance	BMP Subarea	Outfall 009	CM-1 effluent (post-filter fabric over weir boards)	42.4	*See description for A2SW0002.*

Site Identifier (Co-location)	Subcategory	Prioritization Category	Watershed	Description	Approximate Upstream Drainage Area (ac)	Reason for Discontinuation
A2SW0003	ISRA Performance	Background	Outfall 009	A2LF1 upstream	433	2012-2013 reporting year: Discontinued ISRA performance monitoring at A2LF-1 locations as they had been monitored for three years.
A2SW0004	ISRA Performance	BMP Subarea	Outfall 009	A2 downstream	433	2012-2013 reporting year: Discontinued ISRA performance monitoring at A2LF-1 locations as they had been monitored for three years.
APBMP0001	Subarea for BMP Siting Analysis	BMP Subarea	Outfall 009	Ashpile culvert/inlet road runoff, pre-ELV improvements - OLD	3.6	n/a
APBMP0001-A	Subarea for BMP Siting Analysis	BMP Subarea	Outfall 009	Area II road runoff, post-ELV stormwater improvements	0.32	n/a
APSW0001	ISRA Performance	BMP Subarea	Outfall 009	AP/STP-1A upstream	NA	2012-2013 reporting year: Discontinued ISRA performance monitoring at APSW0001 as it had been monitored for two years.
APSW0002	ISRA Performance	BMP Subarea	Outfall 009	AP/STP-1A downstream	NA	2012-2013 reporting year: Discontinued ISRA performance monitoring at APSW0002 as it had been monitored for two years.
APSW0003	ISRA Performance	BMP Subarea	Outfall 009	AP/STP-1D upstream	NA	2012-2013 reporting year: Discontinued ISRA performance monitoring at APSW0003 as it had been monitored for two years.
APSW0004	ISRA Performance	BMP Subarea	Outfall 009	AP/STP-1D downstream	NA	2012-2013 reporting year: Discontinued ISRA performance monitoring at APSW0004 as it had been monitored for two years.
APSW0005	ISRA Performance	BMP Subarea	Outfall 009	AP/STP-1F upstream	0.06	2012-2013 reporting year: Discontinued ISRA performance monitoring at APSW0005 as it had been monitored for two years.

Site Identifier (Co-location)	Subcategory	Prioritization Category	Watershed	Description	Approximate Upstream Drainage Area (ac)	Reason for Discontinuation
APSW0006	ISRA Performance	BMP Subarea	Outfall 009	AP/STP-1F (pre-ISRA excavation) - OLD	0.12	2011-2012 reporting year: Discontinued APSW0006 as monitoring at APSW0013 was considered sufficient for downstream monitoring.
APSW0006-A	ISRA Performance	BMP Subarea	Outfall 009	AP/STP-1F (post-ISRA excavation)	0.12	*See description for APSW0006.*
APSW0007	ISRA Performance	BMP Subarea	Outfall 009	AP/STP-1B upstream	NA	ISRA program completed
APSW0008	ISRA Performance	BMP Subarea	Outfall 009	AP/STP-1C-2 upstream	NA	ISRA program completed
APSW0009	ISRA Performance	BMP Subarea	Outfall 009	AP/STP-1ABC downstream	NA	ISRA program completed
APSW0011	ISRA Performance	BMP Subarea	Outfall 009	AP/STP-1ABCD downstream	5.6	ISRA program completed
APSW0012	ISRA Performance	BMP Subarea	Outfall 009	AP/STP-1E-3 upstream	0.25	ISRA program completed
APSW0013 (APBMP0002)	ISRA Performance	BMP Subarea	Outfall 009	AP downstream	33.1	2013-2014 reporting year: Discontinued co-located monitoring locations APSW0013/APBMP0002 following installation of the ELV treatment BMP and was replaced by APSW0014.
APSW0014	ISRA Performance	BMP Subarea	Outfall 009	AP/STP-1ABCDE downstream	29.3	ISRA program completed
B1BMP0001 (B1SW0010)	Subarea for BMP Siting Analysis	BMP Subarea	Outfall 009	B1 media filter inlet (pre-media filter installation)	8.6	2011-2012 reporting year: Co-located monitoring locations B1SW0010/B1BMP0001 was replaced with B1SW0014, following installation of the B-1 Media Filter.
B1BMP0001-A (B1SW0010-A)	Existing BMP Performance	BMP Subarea	Outfall 009	B1 media filter inlet (post-media filter installation), before treatment	8.6	*See description for B1BMP0001.*
B1BMP0003 (B1BMP0002)	Subarea for BMP Siting Analysis	BMP Subarea	Outfall 009	B1 parking lot / road runoff to culvert inlet	4.8	2011-2012 reporting year: B1BMP0002 was replaced with monitoring location

Site Identifier (Co-location)	Subcategory	Prioritization Category	Watershed	Description	Approximate Upstream Drainage Area (ac)	Reason for Discontinuation
						B1BMP0003, following the installation of the B-1 Retention Basin.
B1BMP0004 (B1BMP0004-5, B1SW0015)	Existing BMP Performance	BMP Subarea	Outfall 009	B1 media filter inlet north, before treatment	6.7	2012-2013 reporting year: Discontinued ISRA performance monitoring at B1SW0015 as it had been monitored for two years and sufficient data had been collected to show a general decrease in downstream results.
B1BMP0005 (B1BMP0004-5, B1SW0011, B1SW0013)	Existing BMP Performance	BMP Subarea	Outfall 009	B1 media filter inlet south, before treatment	0.19	2011-2012 reporting year: B1SW0011 was replaced with B1SW0013, following the reconfiguration of the B-1 Retention Basin discharge pipe. 2012-2013 reporting year: Discontinued ISRA performance monitoring at B1SW0013 as that location had been monitored for two years and sufficient data had been collected to show a general decrease in downstream results.
B1BMP0007	Subarea for BMP Siting Analysis	BMP Subarea	Outfall 009	B1, vegetated channel	50.6	n/a
B1BMP0008	Existing BMP Performance	BMP Subarea	Outfall 009	B1 storm drain culvert outlet	43.2	n/a
B1SW0002	ISRA Performance	BMP Subarea	Outfall 009	Woolsey Canyon Road Runoff, before treatment	3.8	2012-2013 reporting year: Discontinued ISRA performance monitoring at B-1 Area locations as they had been monitored for two years and sufficient data had been collected to show a general decrease in downstream results.
B1SW0003	ISRA Performance	Background	Outfall 009	B1 upstream	NA	2012-2013 reporting year: Discontinued ISRA performance monitoring at B-1 Area locations as they had been monitored for two years and sufficient data had been

Site Identifier (Co-location)	Subcategory	Prioritization Category	Watershed	Description	Approximate Upstream Drainage Area (ac)	Reason for Discontinuation
						collected to show a general decrease in downstream results.
B1SW0004	ISRA Performance	BMP Subarea	Outfall 009	B1 downstream (pre-ISRA excavation) - OLD	0.12	2012-2013 reporting year: Discontinued ISRA performance monitoring at B-1 Area locations as they had been monitored for two years and sufficient data had been collected to show a general decrease in downstream results.
B1SW0004-A	ISRA Performance	BMP Subarea	Outfall 009	B1 downstream (post-ISRA excavation)	0.12	*See description for B1SW0004.*
B1SW0005	ISRA Performance	BMP Subarea	Outfall 009	B1 downstream (pre-ISRA excavation) - OLD	0.12	2012-2013 reporting year: Discontinued ISRA performance monitoring at B-1 Area locations as they had been monitored for two years and sufficient data had been collected to show a general decrease in downstream results.
B1SW0005-A	ISRA Performance	BMP Subarea	Outfall 009	B1 downstream (post-ISRA excavation)	0.12	*See description for B1SW0005.*
B1SW0006	ISRA Performance	BMP Subarea	Outfall 009	B1 downstream (pre-ISRA excavation) - OLD	0.38	2012-2013 reporting year: Discontinued ISRA performance monitoring at B-1 Area locations as they had been monitored for two years and sufficient data had been collected to show a general decrease in downstream results.
B1SW0006-A	ISRA Performance	BMP Subarea	Outfall 009	B1 downstream (post-ISRA excavation)	0.38	*See description for B1SW0006.*
B1SW0007	ISRA Performance	BMP Subarea	Outfall 009	B1 downstream	0.41	2012-2013 reporting year: Discontinued ISRA performance monitoring at B-1 Area locations as they had been monitored for two years and sufficient data had been collected to show a general decrease in downstream results.

Site Identifier (Co-location)	Subcategory	Prioritization Category	Watershed	Description	Approximate Upstream Drainage Area (ac)	Reason for Discontinuation
B1SW0008	ISRA Performance	BMP Subarea	Outfall 009	B1 upstream	0.47	2012-2013 reporting year: Discontinued ISRA performance monitoring at B-1 Area locations as they had been monitored for two years and sufficient data had been collected to show a general decrease in downstream results.
B1SW0009	ISRA Performance	BMP Subarea	Outfall 009	B1 downstream	0.62	2012-2013 reporting year: Discontinued ISRA performance monitoring at B-1 Area locations as they had been monitored for two years and sufficient data had been collected to show a general decrease in downstream results.
B1SW0012	ISRA Performance	BMP Subarea	Outfall 009	B1 north road runoff, before treatment	0.25	2011-2012 reporting year: Discontinued B1SW0012 as this location was slightly upstream of B1SW002 and it was determined that only one monitoring location was needed.
B1SW0014	ISRA Performance	BMP Subarea	Outfall 009	B1 culvert effluent (no media filter) - OLD	8.2	2012-2013 reporting year: B1SW0014 was replaced by monitoring location B1BMP0006.
B1SW0014-A	ISRA Performance	BMP Subarea	Outfall 009	B1 media filter effluent (pre-media filter reconstruction) - OLD	8.6	*See description for B1SW0014.*
B1SW0014-B	ISRA Performance	BMP Subarea	Outfall 009	B1 media filter effluent (post-media filter reconstruction) - OLD	8.6	*See description for B1SW0014.*
B1SW0014-C (B1BMP0006)	ISRA Performance	BMP Subarea	Outfall 009	B1 media filter effluent (post-media filter reconstruction, post-curb cuts)	8.6	*See description for B1SW0014.*
BGBMP0001 (A2BMP0006, A2SW0007)	Existing BMP Performance	Background	Outfall 009	Background - CM-1 upstream east tributary, before treatment	39.3	2011-2012 reporting year: Discontinued BGBMP0001 based on a review of results from the previous reporting year for

Site Identifier (Co-location)	Subcategory	Prioritization Category	Watershed	Description	Approximate Upstream Drainage Area (ac)	Reason for Discontinuation
						background monitoring locations on Sage Ranch and finding these to be sufficient data for the program. 2012-2013 reporting year: Discontinued A2SW0007 as it had been monitored for two years and sufficient data had been collected. Monitoring continued at co-located BMP monitoring location A2BMP0006.
BGBMP0002 (LXSW0003)	Subarea for BMP Siting Analysis	Background	Outfall 009	Background - CM-3 upstream, before treatment	16.8	2011-2012 reporting year: Discontinued LXSW0003 due to the low concentrations observed in results from the previous reporting year. Monitoring continued at BGBMP0002 as a background location. 2012-2013 reporting year: Discontinued BGBMP0002 as sufficient data had been collected at all remaining background locations.
BGBMP0003	Subarea for BMP Siting Analysis	Background	Outfall 009	Background - Sage Ranch near LOX	20.8	2012-2013 reporting year: Monitoring at all remaining background locations was discontinued as sufficient data had been collected but has been reinstated since the 2014/15 monitoring period.
BGBMP0004	Subarea for BMP Siting Analysis	Background	Outfall 009	Background - Sage Ranch near CM-5	81.1	2012-2013 reporting year: Monitoring at all remaining background locations was discontinued as sufficient data had been collected but has been reinstated since the 2014/15 monitoring period.
BGBMP0005	Subarea for BMP Siting Analysis	BMP Subarea	Outfall 009	Sage Ranch near entrance	29.8	2012-2013 reporting year: Monitoring at all remaining background locations was discontinued as sufficient data had been collected.

Site Identifier (Co-location)	Subcategory	Prioritization Category	Watershed	Description	Approximate Upstream Drainage Area (ac)	Reason for Discontinuation
BGBMP0006 (A2SW0006)	Subarea for BMP Siting Analysis	Background	Outfall 009	Background - CM-1 upstream east tributary (ponded footprint), before treatment	39.3	During the 2010-2011 reporting year, co-located monitoring location A2SW0006/BGBMP0006 was observed to be in ponded water. These monitoring locations were discontinued and replaced by A2SW0007/BGBMP0001 added further upstream.
BGBMP0007 (LXSW0001)	Subarea for BMP Siting Analysis	Background	Outfall 009	Background - CM-3 upstream, before treatment	16.8	During the 2010-2011 reporting year, co-located monitoring locations LXSW0001/BGBMP0007 were observed to be in ponded water. These monitoring locations were discontinued and replaced by LXSW0003/BGBMP0002 added further upstream.
EVBMP0001	Subarea for BMP Siting Analysis	BMP Subarea	Outfall 009	ELV culvert inlet (helipad road gutter) - OLD	6.6	EVBMP001 was discontinued at the start of the 2012-2013 reporting year and was replaced by monitoring locations EVBMP0004 and EVBMP0005. Location was re-instated at the start of the 2013-2014 reporting year to monitor overflow from the ELV treatment BMP retention basin during extended rain events.
EVBMP0001-A	Subarea for BMP Siting Analysis	BMP Subarea	Outfall 009	ELV culvert inlet (helipad road and ELV ditch, composite)	6.6	n/a
EVBMP0002	Subarea for BMP Siting Analysis	BMP Subarea	Outfall 009	Helipad (pre-sandbag berms) - OLD	4.1	n/a
EVBMP0002-A	Subarea for BMP Siting Analysis	BMP Subarea	Outfall 009	Helipad (post-sandbag berms) - OLD	4.1	n/a
EVBMP0002-B	Subarea for BMP Siting Analysis	BMP Subarea	Outfall 009	Helipad (post-sandbag berms raised, post-drainage holes in asphalt)	9.0	n/a

Site Identifier (Co-location)	Subcategory	Prioritization Category	Watershed	Description	Approximate Upstream Drainage Area (ac)	Reason for Discontinuation
EVBMP0003 (A2SW0001)	Existing BMP Performance	BMP Subarea	Outfall 009	CM-1 upstream west, pre-ELV improvements, before treatment - OLD	4.9	2012-2013 reporting year: Discontinued ISRA performance monitoring at A2SW0001 as it had been monitored for three years. Monitoring continued at co-located BMP monitoring location EVBMP0003.
EVBMP0003-A	Existing BMP Performance	BMP Subarea	Outfall 009	CM-1 upstream west, post-ELV improvements, before treatment	1.4	n/a
EVBMP0004	Subarea for BMP Siting Analysis	BMP Subarea	Outfall 009	2012-2013 Lower Helipad Road	2.5	2013-2014 reporting year: Discontinued EVBMP0004 following installation of the ELV treatment BMP.
EVBMP0005	Subarea for BMP Siting Analysis	BMP Subarea	Outfall 009	2012-2013 ELV drainage ditch (pre-ELV-1C ISRA) - OLD	11.0	2013-2014 reporting year: Discontinued EVBMP0005 following installation of the ELV treatment BMP.
EVBMP0005-A	Subarea for BMP Siting Analysis	BMP Subarea	Outfall 009	2012-2013 ELV drainage ditch (post-ELV-1C ISRA)	3.3	*See description for EVBMP0005.*
EVBMP0006	Subarea for BMP Siting Analysis	BMP Subarea	Outfall 009	2012-2013 Area II Road near ELV ditch	8.2	2013-2014 reporting year: Discontinued EVBMP0006 following installation of the ELV treatment BMP.
EVBMP0007	Existing BMP Performance	BMP Subarea	Outfall 009	Influent to ELV sedimentation, before treatment	6.6	n/a
EVBMP0008	Existing BMP Performance	BMP Subarea	Outfall 009	Effluent from ELV treatment BMP	6.6	n/a
EVBMP0009	Existing BMP Performance	BMP Subarea	Outfall 009	Influent to ELV media filter, before treatment	6.6	n/a
EVBMP0010	Subarea for BMP Siting Analysis	BMP Subarea	Outfall 009	Area 2 Road Runoff, SD inlet on north side of road	0.55	n/a
HZBMP0001 (HZSW0007)	Subarea for BMP Siting Analysis	BMP Subarea	Outfall 008	Happy Valley downstream (pre-improvements) - OLD	21.4	2012-2013 reporting year: Discontinued HZSW0007 as all OF008 ISRA performance monitoring locations had been monitored for three years and sufficient data had

Site Identifier (Co-location)	Subcategory	Prioritization Category	Watershed	Description	Approximate Upstream Drainage Area (ac)	Reason for Discontinuation
						been collected to show a general decrease in downstream results. Monitoring continued at the co-located BMP monitoring location HZBMP0001. 2014-2015 reporting year: Discontinued HZBMP0001 as the location had been monitored for four years.
HZBMP0001-A	Subarea for BMP Siting Analysis	BMP Subarea	Outfall 008	Happy Valley downstream (post-improvements)	20.4	*See description for HZBMP0001.*
HZBMP0002 (HZSW0004)	Subarea for BMP Siting Analysis	BMP Subarea	Outfall 008	DRG downstream	23.2	2011-2012 reporting year: Discontinued HZBMP0002. Location monitored the CYN/DRG drainage along with HZBMP0003. Results for the 2010-2011 reporting year for both locations were below NPDES permit limits, therefore it was determined that only one location was needed to monitor this drainage. Monitoring continued at the ISRA performance monitoring location HZSW0004. 2012-2013 reporting year: Discontinued HZSW0004 as all OF008 ISRA performance monitoring locations had been monitored for three years and sufficient data had been collected to show a general decrease in downstream results.
HZBMP0003 (HZSW0003)	Subarea for BMP Siting Analysis	BMP Subarea	Outfall 008	DRG downstream (furthest downstream)	29.6	2012-2013 reporting year: Discontinued HZSW0003 as all OF008 ISRA performance monitoring locations had been monitored for three years and sufficient data had

Site Identifier (Co-location)	Subcategory	Prioritization Category	Watershed	Description	Approximate Upstream Drainage Area (ac)	Reason for Discontinuation
						been collected to show a general decrease in downstream results. Monitoring continued at the co-located BMP monitoring location HZBMP0003. 2014-2015 reporting year: Discontinued HZBMP0003 as the location had been monitored for four years.
HZSW0001	ISRA Performance	BMP Subarea	Outfall 008	Happy Valley downstream	<29.0	2012-2013 reporting year: Discontinued monitoring at all OF008 ISRA performance monitoring locations as they had been monitored for three years and sufficient data had been collected to show a general decrease in downstream results.
HZSW0002	ISRA Performance	BMP Subarea	Outfall 008	Happy Valley downstream	<29.0	2012-2013 reporting year: Discontinued monitoring at all OF008 ISRA performance monitoring locations as they had been monitored for three years and sufficient data had been collected to show a general decrease in downstream results.
HZSW0005	ISRA Performance	BMP Subarea	Outfall 008	DRG upstream	21.0	2012-2013 reporting year: Discontinued monitoring at all OF008 ISRA performance monitoring locations as they had been monitored for three years and sufficient data had been collected to show a general decrease in downstream results.
HZSW0006	ISRA Performance	Background	Outfall 008	CYN upstream	NA	2012-2013 reporting year: Discontinued monitoring at all OF008 ISRA performance monitoring locations as they had been monitored for three years and sufficient data had been collected to show a general decrease in downstream results.
HZSW0008	ISRA Performance	Background	Outfall 008	Background - Happy Valley upstream	NA	2012-2013 reporting year: Discontinued monitoring at all OF008 ISRA performance

Site Identifier (Co-location)	Subcategory	Prioritization Category	Watershed	Description	Approximate Upstream Drainage Area (ac)	Reason for Discontinuation
						monitoring locations as they had been monitored for three years and sufficient data had been collected to show a general decrease in downstream results.
HZSW0009	ISRA Performance	BMP Subarea	Outfall 008	Happy Valley downstream	0.20	2012-2013 reporting year: Discontinued monitoring at all OF008 ISRA performance monitoring locations as they had been monitored for three years and sufficient data had been collected to show a general decrease in downstream results.
HZSW0010	ISRA Performance	BMP Subarea	Outfall 008	Happy Valley downstream	2.2	2012-2013 reporting year: Discontinued monitoring at all OF008 ISRA performance monitoring locations as they had been monitored for three years and sufficient data had been collected to show a general decrease in downstream results.
HZSW0011	ISRA Performance	Background	Outfall 008	Background - Happy Valley upstream	0.10	2012-2013 reporting year: Discontinued monitoring at all OF008 ISRA performance monitoring locations as they had been monitored for three years and sufficient data had been collected to show a general decrease in downstream results.
HZSW0012	ISRA Performance	Background	Outfall 008	Background - Happy Valley upstream	0.40	2012-2013 reporting year: Discontinued monitoring at all OF008 ISRA performance monitoring locations as they had been monitored for three years and sufficient data had been collected to show a general decrease in downstream results.
HZSW0013	ISRA Performance	BMP Subarea	Outfall 008	Happy Valley downstream	0.30	2012-2013 reporting year: Discontinued monitoring at all OF008 ISRA performance monitoring locations as they had been monitored for three years and sufficient data had been collected to show a general decrease in downstream results.

Site Identifier (Co-location)	Subcategory	Prioritization Category	Watershed	Description	Approximate Upstream Drainage Area (ac)	Reason for Discontinuation
HZSW0014	ISRA Performance	BMP Subarea	Outfall 008	Happy Valley upstream	0.10	2012-2013 reporting year: Discontinued monitoring at all OF008 ISRA performance monitoring locations as they had been monitored for three years and sufficient data had been collected to show a general decrease in downstream results.
HZSW0015	ISRA Performance	BMP Subarea	Outfall 008	Happy Valley downstream	0.40	2012-2013 reporting year: Discontinued monitoring at all OF008 ISRA performance monitoring locations as they had been monitored for three years and sufficient data had been collected to show a general decrease in downstream results.
HZSW0016	ISRA Performance	BMP Subarea	Outfall 008	Happy Valley downstream	4.8	2012-2013 reporting year: Discontinued monitoring at all OF008 ISRA performance monitoring locations as they had been monitored for three years and sufficient data had been collected to show a general decrease in downstream results.
HZSW0018	ISRA Performance	BMP Subarea	Outfall 008	Happy Valley downstream	1.4	2012-2013 reporting year: Discontinued monitoring at all OF008 ISRA performance monitoring locations as they had been monitored for three years and sufficient data had been collected to show a general decrease in downstream results.
HZSW0019	ISRA Performance	BMP Subarea	Outfall 008	CYN downstream	2.6	2012-2013 reporting year: Discontinued monitoring at all OF008 ISRA performance monitoring locations as they had been monitored for three years and sufficient data had been collected to show a general decrease in downstream results.
HZSW0020 (HZSW0017)	ISRA Performance	Background	Outfall 008	Background - Happy Valley upstream	0.20	2011-2012 reporting year: HZSW0017 was replaced by HZSW0020 which was placed

Site Identifier (Co-location)	Subcategory	Prioritization Category	Watershed	Description	Approximate Upstream Drainage Area (ac)	Reason for Discontinuation
						upstream of a disturbed soil area and silt fence. 2012-2013 reporting year: Discontinued monitoring at all OF008 ISRA performance monitoring locations as they had been monitored for three years and sufficient data had been collected to show a general decrease in downstream results.
ILBMP0001	Subarea for BMP Siting Analysis	BMP Subarea	Outfall 009	Lower parking lot 24" storm drain bypass	30.2	n/a
ILBMP0002	Existing BMP Performance	BMP Subarea	Outfall 009	Road runoff to CM-9, before treatment	2.2	n/a
ILBMP0003	Subarea for BMP Siting Analysis	BMP Subarea	Outfall 009	A1LF parking lot - OLD	0.97	2011-2012 reporting year: Discontinued ILBMP0003 based on results from the previous reporting year below the NPDES permit limits and was replaced with A1BMP002 (co-located with A1SW004) further upstream.
ILBMP0004	Existing BMP Performance	BMP Subarea	Outfall 009	US1 (B1436 Southern Detention Bioswale)	0.40	n/a
ILBMP0005 (ILBMP0005-7)	Existing BMP Performance	BMP Subarea	Outfall 009	DS (B1436 Southern Detention Bioswale)	15.6	n/a
ILBMP0006	Existing BMP Performance	BMP Subarea	Outfall 009	US (B1436 Northern Detention Bioswale)	2.6	n/a
ILBMP0007 (ILBMP0005-7)	Existing BMP Performance	BMP Subarea	Outfall 009	NE Detention Bioswale Effluent	2.6	n/a
ILBMP0008	Existing BMP Performance	BMP Subarea	Outfall 009	US2 (B1436 Southern Detention Bioswale)	13.3	n/a
ILSW0001	ISRA Performance	BMP Subarea	Outfall 009	IEL-3 upstream	NA/small	2012-2013 reporting year: Discontinued ISRA performance monitoring at IEL-1 as it had been monitored for two years.

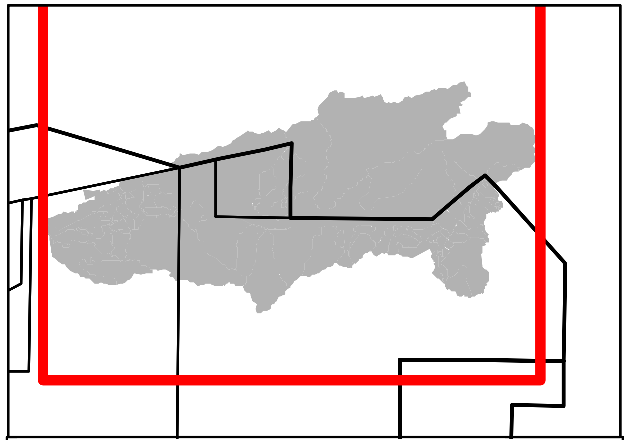
Site Identifier (Co-location)	Subcategory	Prioritization Category	Watershed	Description	Approximate Upstream Drainage Area (ac)	Reason for Discontinuation
ILSW0002	ISRA Performance	BMP Subarea	Outfall 009	IEL-3 downstream (pre-ISRA excavation) - OLD	NA/small	2012-2013 reporting year: Discontinued ISRA performance monitoring at IEL-1 as it had been monitored for two years.
ILSW0002-A	ISRA Performance	BMP Subarea	Outfall 009	IEL-1 downstream (post-ISRA excavation)	NA/small	*See description for ILSW0002.*
ILSW0003	ISRA Performance	BMP Subarea	Outfall 009	IEL-2 upstream	1.2	ISRA program completed
ILSW0004	ISRA Performance	BMP Subarea	Outfall 009	IEL-2 downstream (pre-ISRA excavation) - OLD	1.2	ISRA program completed
ILSW0004-A	ISRA Performance	BMP Subarea	Outfall 009	IEL-2 downstream (post-ISRA excavation)	1.2	ISRA program completed
ILSW0005	ISRA Performance	BMP Subarea	Outfall 009	IEL-3 upstream	NA/small	ISRA program completed
ILSW0006	ISRA Performance	BMP Subarea	Outfall 009	IEL-3 downstream (pre-ISRA excavation) - OLD	0.86	ISRA program completed
ILSW0006-A	ISRA Performance	BMP Subarea	Outfall 009	IEL-3 downstream (post-ISRA excavation)	0.86	ISRA program completed
ILSW0007	ISRA Performance	BMP Subarea	Outfall 009	IEL-2 upstream (2014-2015 reporting year)	NA/small	ISRA program completed
ILSW0008	ISRA Performance	BMP Subarea	Outfall 009	IEL-2 downstream (2014-2015 reporting year)	0.11	ISRA program completed
LFSW0001	ISRA Performance	Background	Outfall 009	CTLI upstream	NA	2012-2013 reporting year: Discontinued ISRA performance monitoring at CTLI as it had been monitored for two years.
LFSW0002	ISRA Performance	BMP Subarea	Outfall 009	CTLI downstream (pre-ISRA excavation) - OLD	1.4	2012-2013 reporting year: Discontinued ISRA performance monitoring at CTLI as it had been monitored for two years.
LFSW0002-A	ISRA Performance	BMP Subarea	Outfall 009	CTLI downstream (post-ISRA excavation)	1.4	*See description for LFSW0002.*
LPBMP0001	Subarea for BMP Siting Analysis	BMP Subarea	Outfall 009	Lower lot sheetflow (pre-gravel bag berms) - OLD	2.3	2012-2013 reporting year: Discontinued LPBMP0001 following the installation of the Lower Parking Lot BMP.

Site Identifier (Co-location)	Subcategory	Prioritization Category	Watershed	Description	Approximate Upstream Drainage Area (ac)	Reason for Discontinuation
LPBMP0001-A	Subarea for BMP Siting Analysis	BMP Subarea	Outfall 009	Lower lot sheetflow (post-gravel bag berms)	2.7	*See description for LPBMP0001.*
LPBMP0002	Existing BMP Performance	BMP Subarea	Outfall 009	Lower parking lot influent to cistern, before treatment	29.9	n/a
LPBMP0003	Existing BMP Performance	BMP Subarea	Outfall 009	Lower parking lot sediment basin outlet, before treatment	29.9	n/a
LPBMP0004	Existing BMP Performance	BMP Subarea	Outfall 009	Lower parking lot biofilter outlet	29.9	n/a
LXBMP0001	Subarea for BMP Siting Analysis	BMP Subarea	Outfall 009	LOX west - OLD	3.8	2011-2012 reporting year: LXBMP0001 was replaced by monitoring location LXBMP0004, following installation of the LOX sandbag berm.
LXBMP0002	Subarea for BMP Siting Analysis	BMP Subarea	Outfall 009	LOX mid - OLD	9.1	2011-2012 reporting year: LXBMP0002 was replaced by monitoring location LXBMP0005, following installation of the LOX sandbag berm.
LXBMP0003	Subarea for BMP Siting Analysis	BMP Subarea	Outfall 009	LOX east tributary - OLD	21.3	2011-2012 reporting year: LXBMP0003 was replaced by monitoring location LXBMP0006, following installation of the LOX sandbag berm.
LXBMP0004	Existing BMP Performance	BMP Subarea	Outfall 009	LOX southwest downstream of sandbag berm	11.7	2012-2013 reporting year: LXBMP0004 was discontinued and replaced by LXBMP0007 following the installation of the slope drains at the LOX sandbag berm.
LXBMP0005	Existing BMP Performance	BMP Subarea	Outfall 009	LOX southeast downstream of sandbag berm	11.7	2012-2013 reporting year: LXBMP0005 was discontinued and replaced by LXBMP0008 following installation of the slope drains at the LOX sandbag berm.
LXBMP0006 (LXSW0010)	Subarea for BMP Siting Analysis	BMP Subarea	Outfall 009	LOX east, runoff along dirt road	0.28	n/a
LXBMP0007	Existing BMP Performance	BMP Subarea	Outfall 009	LOX, inlet to western slope drain	11.7	n/a

Site Identifier (Co-location)	Subcategory	Prioritization Category	Watershed	Description	Approximate Upstream Drainage Area (ac)	Reason for Discontinuation
LXBMP0008	Existing BMP Performance	BMP Subarea	Outfall 009	LOX, inlet to central slope drain	11.7	n/a
LXBMP0009 (LXSW0009)	Existing BMP Performance	BMP Subarea	Outfall 009	LOX, inlet to eastern slope drain	11.7	n/a
LXSW0002	ISRA Performance	BMP Subarea	Outfall 009	CM-3 downstream (pre-filter fabric over weir boards) - OLD	16.8	2011-2012 reporting year: Discontinued LXSW0002 due to the low concentrations observed in results from the previous reporting year.
LXSW0002-A	ISRA Performance	BMP Subarea	Outfall 009	CM-3 downstream (post-filter fabric over weir boards)	16.8	*See description for LXSW0002.*
Outfall 008**	NPDES	NPDES	Outfall 008	NPDES Outfall 008	62.0	n/a
Outfall 009**	NPDES	NPDES	Outfall 009	NPDES Outfall 009	536	n/a

Notes

- Gray text indicates historic subarea monitoring locations that have been discontinued.
- (**) NPDES outfall monitoring data are included in this analysis for comparison and method testing purposes only. New stormwater controls are not being contemplated at these locations.



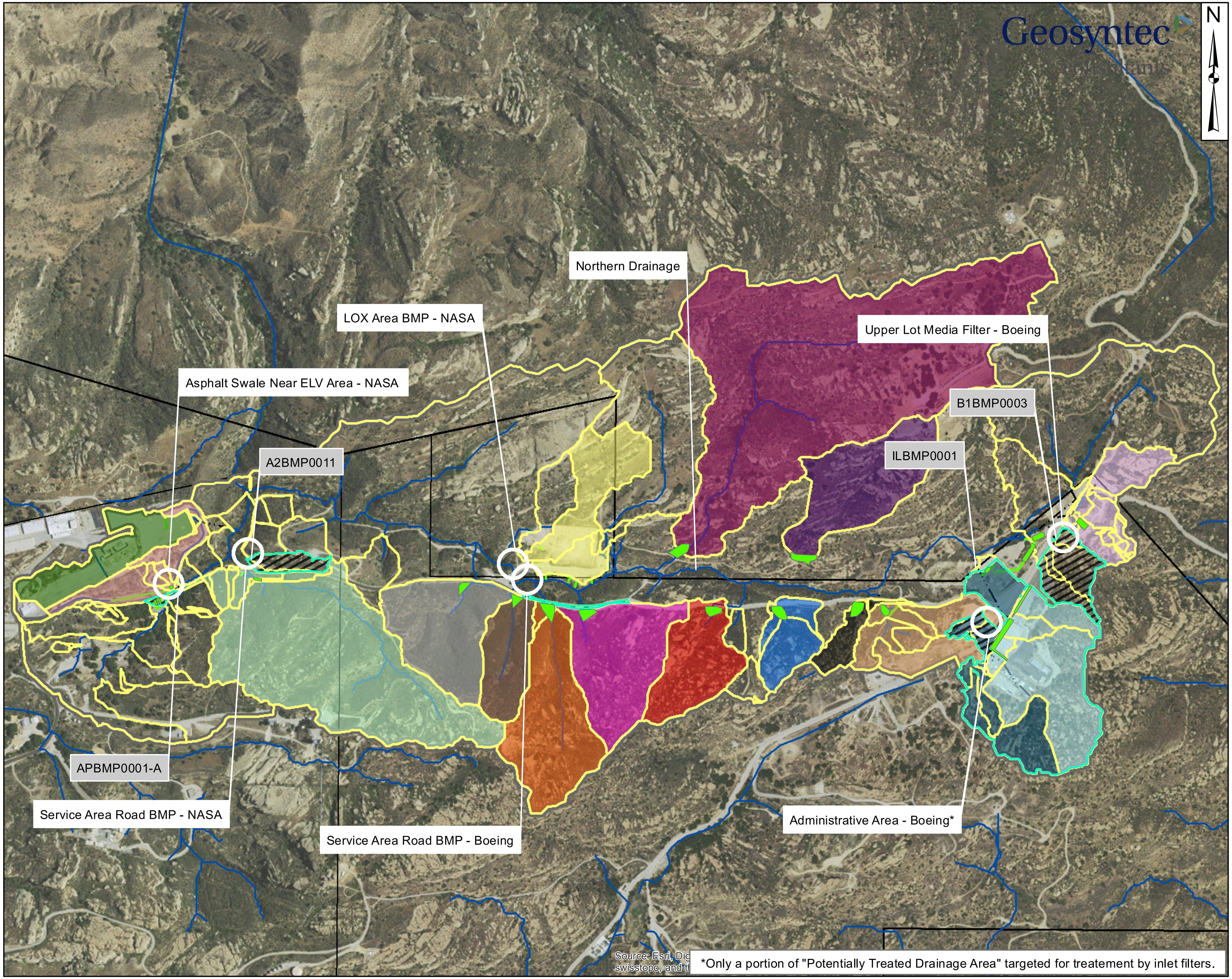
Legend

- Treatment BMPs
- Completed ISRA Area
- Watershed 009
- Untreated Drainage Area
- Drainage Area to Priority Location
- Potentially Treated Drainage Area
- Drainage
- Storm Drain

Treated Drainage Area

- B1 Media Filter
- Biofilter
- CM-1
- CM-2
- CM-3
- CM-4
- CM-5
- CM-6
- CM-8
- CM-9
- CM-10
- CM-11
- CM-12
- Detention Bioswales
- ELV Treatment BMP
- Helipad BMP
- LOX BMP

0 395 790 1,580 Feet



*Only a portion of "Potentially Treated Drainage Area" targeted for treatement by inlet filters.

Attachment 4

Treated Drainage Areas

Santa Susana Field Laboratory
Ventura County, CA

October 2016

Date: 10/26/2016, Path: Z:\GIS\Projects\Boeing\SSFL\2016 SB0363W\Ranking Memo\2016 Priority Sites-BMP Recommend_Working6.mxd, User: OLincoln

Attachment 5. Ranking Analysis Approach Methodology

Particulate Strength Calculation Approach

Particulate strength (PS) is computed as total COC concentration minus dissolved COC concentration divided by TSS concentration, or the estimated particulate COC mass per mass of suspended solids. Calculations of PS become complicated because some of the dissolved metal data are not available (e.g., for ISRA samples since this monitoring program does not include analyses for dissolved metals); therefore, procedures were established to make assumptions in lieu of missing information. These procedures also address situations where total, dissolved, or TSS results are not detected (ND, below the detection limit as reported by the analytical laboratory). Table 1 summarizes the procedures that were followed for the PS calculation analysis, given the data limitations described in Section 2 of the BMP Ranking Analysis Memo. It was not possible to calculate PS for sample events in which TSS or the total POC concentration was not available.

Table 1. Methods used in determining particulate strength.

Measurement Result			PS Calculation Approach
Total	**Dissolved**	**TSS**	
Det	Det	Det	Compute PS normally
Det	Det	ND	Compute PS with TSS detection limit
Det	ND	ND	Compute PS with TSS & dissolved DLs if dissolved DL is < 30% of the total result. Otherwise use average dissolved fraction from NPDES OF008 and OF009 data to computer PS.
ND	ND	ND	Report PS result as "ND"
ND	ND	Det	Report PS result as "ND"
ND	Det	Det	Report PS result as "ND"
Det	ND	Det	Assume DL for dissolved concentration to get PS if dissolved DL is < 30% of the total result. Otherwise use average dissolved fraction from NPDES OF008 and OF009 data.
ND	Det	ND	Report PS result as "ND"
ND	Null	ND	Report PS result as "ND"
ND	Null	Det	Report PS result as "ND"
Det	Null	Det	Use average dissolved fraction from NPDES OF008 or OF009 data
Det	Null	ND	Compute PS with TSS DL. Use average dissolved fraction from NPDES OF008 or OF009 data

Notes

- Det = Detected, a measured result was obtained
- Null = Not sampled, measurement not taken
- The 30% threshold for determination of the dissolved value to use in the PS calculations was selected based on best professional judgment.
- ND = non-detected measurement result – the POC was not detected. Detection limits in these cases are often used to determine the range of possible particulate strengths. In ‘PS Calculation Approach’ column, ND encompasses all situations where the particulate strength either reflects a non-detect in the concentration, or is non-determinate for other reasons. This distinction is used in all particulate strength columns throughout the rest of this report.

The following example calculation demonstrates the method for a theoretical sampling point (X) located in Outfall 009:

TSS_X = 100 mg/L

Total Pb_X = 10 µg/L

Dissolved Pb_X = Sample not collected, so value estimated based on Table 5 = 10 µg/L * 0.18 = 1.8 µg/L

Estimated PS_X = (10 µg/L – 1.8 µg/L) / 100 mg/L = 8.2 µg/L / 100 mg/L = 82 mg/kg

Subarea Ranking Analysis Approach

The two-tiered method for determining the potential BMP subarea weighting factor helps identify significant differences between sets having different numbers of "critical" observations ("m", defined as the sum of the number of results exceeding either the permit limit or the 95th percentile stormwater background[1]) and different numbers of total observations ("n", defined as the number of particulate strength results plus the number of concentration results). This allows a statistically-based weighting factor to be applied to each subarea for each POC to reflect the number of observations simultaneously with the number of critical observations. As an example, a location having 20 critical observations out of 20 total observations has more confidence compared to a location only having 3 critical observations out of 3 total observations. The larger number of total observations results in a greater confidence of the findings. Similarly, if only 1 out of 10 observations are critical, that subarea has less confidence in a critical determination compared to a subarea that has 8 out of 10 critical observations. The weighting factors for small sample sets used in this part of the analysis are summarized in Table 2.

Table 2. Weighting Factors for Small Sample Sets (WF, %) (divided by 100 for use in the ranking analyses)

Total Number of Observations (n)	**Total Number of Critical Values in Data Set (m)**													
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1	50													
2	50	75												
3	50	50	87											
4	31	50	69	94										
5	19	50	50	81	97									
6	11	34	50	66	89	98								
7	6	23	50	50	77	94	99							
8	4	14	36	50	64	86	98	99						
9	2	9	25	50	50	75	96	98	99					
10	1	5	17	38	50	63	83	95	99	99				
11	1	3	11	27	50	50	73	89	97	99	99			
12	0	2	7	19	39	50	63	81	93	98	99	99		
13	0	1	5	13	29	50	50	71	87	95	99	99	99	
14	0	1	3	9	21	40	50	61	79	91	97	99	99	99
15	0	0	2	6	15	30	50	50	70	85	94	98	99	99

[1] The 95th percentile threshold was recommended by the Panel based on best professional judgment as well as a review of relevant surface water regulations and guidance (WWE, 2011, attached as Appendix D).

Where the total number of observations was greater than 15[2] and the number of critical values in the dataset was greater than 14, the weighting factor (WF) was computed as the unadjusted value of the cumulative distribution function (CDF) of a binomial distribution with p = 0.5:

$$WF = \sum_{i=0}^{m} \binom{n}{i} p^i (1-p)^{n-i}$$

Where,

P = 0.5

$n = n_C + n_{PS}$, where

n_C = Number of concentration sample results

n_{PS} = Number of PS results

$m = m_C + m_{PS,}$, where

m_C = Number of concentrations sample results that exceed the Permit Limits

m_{PS} = Number of PS results that exceed the 95th percentile stormwater background PS results threshold

Comparing potential BMP subarea monitoring datasets with a combination of stormwater background and permit limit thresholds allows for the accounting of both the size of the dataset (number of samples) and the number of samples that are above a stormwater background threshold, resulting in a more robust and defensible weight for ranking potential BMP subareas based on need for treatment that can be reevaluated in the future as the available data sets grow.

Table 3 contains an example which demonstrates the multi-constituent score calculation method for a theoretical monitoring location. As shown in Table 3, the ranking analysis method calculates a single score for each POC for each potential BMP subarea and background subarea. The highest score across all metals at a single subarea is assumed representative of the multi-constituent “metals score” for each subarea. The highest score between TCDD TEQ and 2,3,7,8-TCDD at a single subarea is assumed representative of the multi-constituent “dioxin score” for each subarea. A multi-constituent score is then calculated as the average of the maximum metal and dioxin WF values. The TSS weighting factor and score are the same.

[2] This situation only occurs for Outfalls 008 and 009 which have several years of NPDES monitoring data available and are included here for method testing and results comparison purposes only (i.e., treatment controls are not being contemplated at these locations). The large sample sizes at these locations exceed the statistical capability of the methods used to determine the weighting factor. In future BMP subarea ranking analysis reports, this can be corrected by an adjustment that has been recommended by Dr. Pitt.

Table 3. Example Weighting Factor (WF) and Multi-Constituent Score Calculation

Calculation Step	Subarea X									
	Metals						Dioxins			
	TPb		TCu		TCd		TCDD		2,3,7,8-TCDD	TSS
	>PL	>95%B	>PL	>95%B	>PL	>95%B	>PL	>95%B	>95%B	>95%B
Sample 1	**Y**	N	N	N	N	N	N	N	N	N
Sample 2	N	N	N	N	N	N	N	N	**Y**	N
Sample 3	**Y**	N	**Y**	N	N	N	**Y**	N	N	N
Sample 4	**Y**	**Y**	N	N	N	N	--	--	N	**Y**
Sample 5	N	--	N	--	N	N	--	--	N	N
Sample 6	N	--	**Y**	--	N	N	--	--	--	N
# Y / # samples	3/6	1/4	2/6	0/4	0/6	0/6	1/3	0/3	1/5	1/6
(sum Y) / (sum n)	4/10		2/10		0/12		1/6		1/5	1/6
WF	0.38		0.05		0		0.11		0.19	0.11
Max WF	0.38						0.19			0.11
Multi Pollutant Score	0.29									0.11
Exceeds Both PL&B?	**Y**		N		N		N		NA	NA

Notes

>PL = greater than Permit Limit concentration, >95%B = greater than 95th percentile stormwater background particulate strength (or concentration for TSS), **Y** = yes, N = no, WF = weighting factor, -- = no data.

Attachment 6

Summary of Results by Subarea

Note: All median and maximum values in µg/L except TSS, which is in mg/L.

Location	Rank	COC	Concentration					Particulate Strength					Weight	Both Criteria Exceeded?
			Number of Samples	Number of NDs	Median	Maximum	N > PL	Number of PS	Number of NDs	Median PS	Maximum	N > 95th		
A1BMP0001	1	**Cadmium**	5	--	0.480	0.510	0	4	--	9.32	50.0	3	0.25	no
	2	**TCDD TEQ**	5	--	8.80e-10	5.62e-07	1	5	--	4.00e-08	5.62e-04	1	0.05	yes
	3	**2,3,7,8-TCDD**	5	5	<2.30e-06	<4.40e-06	0	5	5	<1.05e-04	<3.10e-03	1	0.01	no
	5	**Copper**	5	--	4.20	5.30	0	5	--	90.9	300	0	0	no
	5	**Lead**	5	2	0.280	2.50	0	5	2	>40.6	>213	0	0	no
	5	**Total Suspended Solids**	5	--	11.0	22.0	0	0	--	--	--	0	0	no
A1BMP0002	3.5	**2,3,7,8-TCDD**	8	8	<7.00e-07	<3.60e-06	0	8	8	<5.30e-04	<7.20e-04	0	0	no
	3.5	**Cadmium**	15	--	0.250	0.960	0	1	--	0.700	0.700	0	0	no
	3.5	**Copper**	16	--	4.40	20.0	2	16	--	154	>2,210	5	0	yes
	3.5	**Lead**	16	3	0.795	11.0	3	16	3	84.9	242	0	0	no
	3.5	**TCDD TEQ**	8	--	1.33e-08	2.43e-07	2	8	--	2.57e-06	>2.09e-05	0	0	no
	3.5	**Total Suspended Solids**	16	3	10.5	320	2	0	--	--	--	0	0	no
A1BMP0002-A	1	**Total Suspended Solids**	7	--	27.0	320	3	0	--	--	--	0	0.50	no
	2	**TCDD TEQ**	6	1	5.52e-08	1.81e-06	4	6	1	2.21e-07	3.85e-04	1	0.39	yes
	3	**Cadmium**	7	2	0.440	1.40	0	6	2	0.759	<34.0	4	0.13	no
	4	**Copper**	7	--	11.0	15.0	2	3	--	12.2	38.3	0	0.05	no
	5	**Lead**	7	3	0.690	15.0	2	7	3	14.0	<544	1	0.03	yes
	6	**2,3,7,8-TCDD**	6	6	<2.14e-06	<4.70e-06	0	6	6	<2.30e-04	<5.49e-03	1	0	no
A1BMP0004	1	**TCDD TEQ**	2	--	4.42e-07	8.83e-07	1	2	--	2.45e-05	4.91e-05	1	0.50	yes
	2	**Lead**	2	--	4.50	6.30	1	2	--	128	133	0	0.31	no
	4.5	**2,3,7,8-TCDD**	2	2	<4.30e-07	<4.30e-07	0	2	2	<1.67e-05	<1.67e-05	0	0	no
	4.5	**Cadmium**	2	2	<0.250	<0.250	0	2	2	<0.0	<0.0	0	0	no
	4.5	**Copper**	2	--	4.25	4.90	0	2	--	43.7	65.1	0	0	no
	4.5	**Total Suspended Solids**	2	--	30.5	43.0	0	0	--	--	--	0	0	no
A1SW0002	3.5	**2,3,7,8-TCDD**	0	--	--	--	0	0	--	--	--	0	0	no
	3.5	**Cadmium**	0	--	--	--	0	0	--	--	--	0	0	no
	3.5	**Copper**	0	--	--	--	0	0	--	--	--	0	0	no
	3.5	**Lead**	10	1	0.580	11.0	3	10	1	104	282	1	0	yes
	3.5	**TCDD TEQ**	0	--	--	--	0	0	--	--	--	0	0	no
	3.5	**Total Suspended Solids**	10	1	3.00	82.0	0	0	--	--	--	0	0	no
A1SW0003	3.5	**2,3,7,8-TCDD**	0	--	--	--	0	0	--	--	--	0	0	no
	3.5	**Cadmium**	0	--	--	--	0	0	--	--	--	0	0	no
	3.5	**Copper**	0	--	--	--	0	0	--	--	--	0	0	no
	3.5	**Lead**	10	2	0.285	7.00	1	10	2	160	236	0	0	no
	3.5	**TCDD TEQ**	0	--	--	--	0	0	--	--	--	0	0	no
	3.5	**Total Suspended Solids**	10	2	5.50	33.0	0	0	--	--	--	0	0	no
A1SW0005	1	**TCDD TEQ**	5	--	5.50e-09	4.46e-08	1	5	--	1.18e-06	>4.46e-05	1	0.05	yes
	2	**2,3,7,8-TCDD**	5	5	<6.50e-07	<3.80e-06	0	5	5	<1.30e-04	<9.50e-04	1	0.01	no
	4.5	**Cadmium**	10	2	0.130	0.430	0	1	--	2.86	2.86	0	0	no
	4.5	**Copper**	10	--	4.30	11.0	0	9	--	99.3	>1,730	2	0	no
	4.5	**Lead**	10	1	0.605	15.0	2	10	1	73.6	>251	0	0	no
	4.5	**Total Suspended Solids**	10	1	11.5	100	0	0	--	--	--	0	0	no

Location	Rank	COC	Concentration					Particulate Strength					Weight	Both Criteria Exceeded?
			Number of Samples	Number of NDs	Median	Maximum	N > PL	Number of PS	Number of NDs	Median PS	Maximum	N > 95th		
A1SW0006	1	**TCDD TEQ**	12	2	5.93e-09	6.61e-07	4	12	2	8.98e-07	3.48e-05	2	0.01	yes
	4	**2,3,7,8-TCDD**	12	12	<5.40e-07	<2.80e-06	0	12	12	<1.47e-04	<9.33e-04	2	0	no
	4	**Cadmium**	0	--	--	--	0	0	--	--	--	0	0	no
	4	**Copper**	0	--	--	--	0	0	--	--	--	0	0	no
	4	**Lead**	0	--	--	--	0	0	--	--	--	0	0	no
	4	**Total Suspended Solids**	12	2	3.50	19.0	0	0	--	--	--	0	0	no
A1SW0007	3.5	**2,3,7,8-TCDD**	12	12	<6.90e-07	<1.80e-05	0	12	12	<3.80e-04	<1.30e-03	3	0	no
	3.5	**Cadmium**	0	--	--	--	0	0	--	--	--	0	0	no
	3.5	**Copper**	0	--	--	--	0	0	--	--	--	0	0	no
	3.5	**Lead**	0	--	--	--	0	0	--	--	--	0	0	no
	3.5	**TCDD TEQ**	12	--	4.51e-09	1.38e-06	4	12	--	3.00e-06	6.91e-04	1	0	yes
	3.5	**Total Suspended Solids**	12	3	2.50	24.0	0	0	--	--	--	0	0	no
A1SW0009-A	1	**Lead**	1	--	9.10	9.10	1	1	--	629	629	1	0.75	yes
	2	**TCDD TEQ**	1	--	1.80e-07	1.80e-07	1	1	--	1.64e-05	1.64e-05	0	0.50	no
	4.5	**2,3,7,8-TCDD**	1	1	<2.60e-06	<2.60e-06	0	1	1	<2.36e-04	<2.36e-04	0	0	no
	4.5	**Cadmium**	1	1	<0.100	<0.100	0	0	--	--	--	0	0	no
	4.5	**Copper**	1	--	7.90	7.90	0	1	--	289	289	0	0	no
	4.5	**Total Suspended Solids**	1	--	11.0	11.0	0	0	--	--	--	0	0	no
A1SW0009-B	1	**TCDD TEQ**	5	--	1.84e-07	3.21e-06	5	5	--	2.91e-06	1.69e-04	1	0.63	yes
	2	**Lead**	6	--	12.1	36.0	4	6	--	120	761	1	0.39	yes
	3	**Total Suspended Solids**	6	--	33.5	450	1	0	--	--	--	0	0.11	no
	5	**2,3,7,8-TCDD**	5	5	<9.20e-07	<8.50e-06	0	5	5	<2.73e-05	<7.73e-05	0	0	no
	5	**Cadmium**	6	4	<0.200	0.390	0	0	--	--	--	0	0	no
	5	**Copper**	6	--	7.95	22.0	1	6	--	87.0	266	0	0	no
A1SW0009-C	1	**Total Suspended Solids**	5	--	10.0	180	1	0	--	--	--	0	0.19	no
	2	**TCDD TEQ**	5	1	4.43e-08	5.78e-07	3	5	1	3.16e-06	2.09e-05	0	0.17	no
	3	**Lead**	5	1	2.30	12.0	1	5	1	>139	<544	1	0.05	yes
	4	**Copper**	5	--	6.90	16.0	1	3	--	115	271	0	0.04	no
	5	**2,3,7,8-TCDD**	5	5	<3.04e-06	<1.13e-05	0	5	5	<3.04e-04	<4.54e-03	1	0.01	no
	6	**Cadmium**	5	5	<0.250	<0.500	0	5	5	<0.0	<1.39	0	0	no
A2BMP0002	1	**2,3,7,8-TCDD**	1	1	<3.40e-06	<3.40e-06	0	1	1	<1.13e-03	<1.13e-03	1	0.50	no
	4	**Cadmium**	1	1	<0.100	<0.100	0	1	1	<0.0	<0.0	0	0	no
	4	**Copper**	1	--	2.40	2.40	0	1	--	133	133	0	0	no
	4	**Lead**	1	--	0.290	0.290	0	1	--	>73.6	>73.6	0	0	no
	4	**TCDD TEQ**	1	--	1.10e-11	1.10e-11	0	1	--	3.67e-09	3.67e-09	0	0	no
	4	**Total Suspended Solids**	1	--	3.00	3.00	0	0	--	--	--	0	0	no
A2BMP0003	1	**Total Suspended Solids**	8	1	15.5	1,400	2	0	--	--	--	0	0.14	no
	2	**TCDD TEQ**	8	1	6.82e-08	9.64e-06	4	8	1	8.04e-07	8.67e-04	1	0.11	yes
	4.5	**2,3,7,8-TCDD**	8	8	<1.30e-06	<2.90e-06	0	8	8	<4.72e-05	<3.14e-04	0	0	no
	4.5	**Cadmium**	8	6	<0.200	1.00	0	8	6	<0.0	>0.643	0	0	no
	4.5	**Copper**	8	--	3.55	28.0	1	6	--	20.9	66.7	0	0	no
	4.5	**Lead**	8	--	1.38	68.0	2	8	--	63.1	>108	0	0	no

Location	Rank	COC	Concentration					Particulate Strength					Weight	Both Criteria Exceeded?
			Number of Samples	Number of NDs	Median	Maximum	N > PL	Number of PS	Number of NDs	Median PS	Maximum	N > 95th		
A2BMP0004	1	**TCDD TEQ**	3	--	5.71e-08	7.16e-07	2	3	--	1.84e-06	5.51e-06	0	0.34	no
	2	**Lead**	3	--	4.20	10.0	1	3	--	75.2	121	0	0.11	no
	4.5	**2,3,7,8-TCDD**	3	3	<1.40e-06	<2.10e-06	0	3	3	<4.52e-05	<1.31e-04	0	0	no
	4.5	**Cadmium**	3	2	<0.100	0.160	0	3	2	<0.0	>0.188	0	0	no
	4.5	**Copper**	3	--	6.70	7.80	0	3	--	47.7	161	0	0	no
	4.5	**Total Suspended Solids**	3	--	31.0	130	0	0	--	--	--	0	0	no
A2BMP0005	1	**TCDD TEQ**	4	--	3.30e-07	1.88e-05	4	4	--	4.86e-06	2.19e-04	1	0.64	yes
	2	**Lead**	4	--	4.45	11.0	1	4	--	60.1	119	0	0.04	no
	4.5	**2,3,7,8-TCDD**	4	4	<1.60e-06	<2.73e-06	0	4	4	<3.79e-05	<6.67e-05	0	0	no
	4.5	**Cadmium**	4	3	<0.250	<0.250	0	4	3	<0.0	>0.213	0	0	no
	4.5	**Copper**	4	--	4.90	8.70	0	4	--	38.0	50.0	0	0	no
	4.5	**Total Suspended Solids**	4	--	66.5	86.0	0	0	--	--	--	0	0	no
A2BMP0010	3.5	**2,3,7,8-TCDD**	1	1	<3.80e-07	<3.80e-07	0	1	1	<2.38e-05	<2.38e-05	0	0	no
	3.5	**Cadmium**	1	1	<0.250	<0.250	0	1	1	<0.0	<0.0	0	0	no
	3.5	**Copper**	1	--	4.60	4.60	0	1	--	137	137	0	0	no
	3.5	**Lead**	1	--	2.20	2.20	0	1	--	93.8	93.8	0	0	no
	3.5	**TCDD TEQ**	1	1	<1.00e-12	<1.00e-12	0	1	1	<6.25e-11	<6.25e-11	0	0	no
	3.5	**Total Suspended Solids**	1	--	16.0	16.0	0	0	--	--	--	0	0	no
A2BMP0011	1	**TCDD TEQ**	1	--	3.39e-06	3.39e-06	1	1	--	5.37e-05	5.37e-05	1	0.75	yes
	2	**Lead**	1	--	13.0	13.0	1	1	--	>198	>198	0	0.50	no
	4.5	**2,3,7,8-TCDD**	1	1	<2.70e-07	<2.70e-07	0	1	1	<4.29e-06	<4.29e-06	0	0	no
	4.5	**Cadmium**	1	1	<0.250	<0.250	0	1	1	<0.0	<0.0	0	0	no
	4.5	**Copper**	1	--	5.80	5.80	0	1	--	69.8	69.8	0	0	no
	4.5	**Total Suspended Solids**	1	--	63.0	63.0	0	0	--	--	--	0	0	no
A2SW0002	1	**TCDD TEQ**	16	--	7.20e-08	1.02e-05	10	16	--	6.94e-06	5.14e-04	3	0.19	yes
	4	**2,3,7,8-TCDD**	16	15	<1.10e-06	<4.00e-06	0	16	15	<2.22e-04	<6.20e-04	0	0	no
	4	**Cadmium**	0	--	--	--	0	0	--	--	--	0	0	no
	4	**Copper**	0	--	--	--	0	0	--	--	--	0	0	no
	4	**Lead**	16	4	1.50	39.0	4	16	4	158	>989	3	0	yes
	4	**Total Suspended Solids**	16	3	8.50	610	1	0	--	--	--	0	0	no
A2SW0002-A	1	**TCDD TEQ**	10	--	5.05e-08	4.83e-05	5	10	--	4.06e-06	6.36e-04	2	0.13	yes
	2	**Copper**	6	--	3.72	6.80	0	6	--	75.0	>450	2	0.02	no
	4.5	**2,3,7,8-TCDD**	10	9	<1.69e-06	<7.60e-06	0	10	9	<1.02e-04	<3.45e-04	0	0	no
	4.5	**Cadmium**	6	5	<0.128	<0.250	0	5	4	<0.0	>3.36	0	0	no
	4.5	**Lead**	10	--	3.15	14.0	2	10	--	163	304	2	0	yes
	4.5	**Total Suspended Solids**	10	3	11.0	76.0	0	0	--	--	--	0	0	no
APBMP0001	1	**Lead**	2	--	18.8	31.0	2	2	--	370	635	1	0.69	yes
	2	**TCDD TEQ**	2	--	5.23e-07	6.28e-07	2	2	--	9.77e-06	1.08e-05	0	0.50	no
	4.5	**2,3,7,8-TCDD**	2	2	<9.80e-07	<9.80e-07	0	2	2	<2.04e-05	<2.04e-05	0	0	no
	4.5	**Cadmium**	2	--	0.210	0.300	0	2	--	0.635	>0.954	0	0	no
	4.5	**Copper**	2	--	6.60	9.90	0	2	--	45.9	62.5	0	0	no
	4.5	**Total Suspended Solids**	2	--	53.0	58.0	0	0	--	--	--	0	0	no

Location	Rank	COC	Concentration					Particulate Strength					Weight	Both Criteria Exceeded?
			Number of Samples	Number of NDs	Median	Maximum	N > PL	Number of PS	Number of NDs	Median PS	Maximum	N > 95th		
APBMP0001-A	1.5	**Lead**	5	--	15.1	131	4	5	--	44.7	773	1	0.50	yes
	1.5	**Total Suspended Solids**	5	--	120	4,290	2	0	--	--	--	0	0.50	no
	3.5	**Copper**	5	--	16.0	86.0	3	5	--	60.0	1,070	1	0.38	yes
	3.5	**TCDD TEQ**	5	--	4.70e-08	1.08e-06	4	5	--	1.85e-07	1.40e-05	0	0.38	no
	5	**Cadmium**	5	2	0.129	2.81	0	5	2	>0.173	<13.6	1	0.01	no
	6	**2,3,7,8-TCDD**	5	5	<2.72e-06	<4.53e-06	0	5	5	<1.82e-05	<4.19e-05	0	0	no
APSW0014	1.5	**Lead**	2	--	5.75	7.29	1	2	--	79.5	91.3	0	0.31	no
	1.5	**TCDD TEQ**	2	--	2.80e-07	5.54e-07	1	2	--	7.95e-06	1.58e-05	0	0.31	no
	4.5	**2,3,7,8-TCDD**	2	2	<4.34e-06	<4.34e-06	0	2	2	<1.24e-04	<1.24e-04	0	0	no
	4.5	**Cadmium**	2	1	<0.703	0.703	0	0	--	--	--	0	0	no
	4.5	**Copper**	2	--	9.64	11.0	0	2	--	83.6	127	0	0	no
	4.5	**Total Suspended Solids**	2	--	58.5	82.0	0	0	--	--	--	0	0	no
B1BMP0001	1	**Total Suspended Solids**	3	--	270	650	3	0	--	--	--	0	0.87	no
	2	**Lead**	3	--	11.0	15.0	3	3	--	31.2	53.2	0	0.50	no
	3.5	**Copper**	3	--	16.0	27.0	2	3	--	22.8	49.6	0	0.34	no
	3.5	**TCDD TEQ**	3	--	4.83e-08	6.83e-07	2	3	--	1.79e-07	1.05e-06	0	0.34	no
	5.5	**2,3,7,8-TCDD**	3	3	<3.20e-06	<8.80e-06	0	3	3	<1.35e-05	<1.50e-05	0	0	no
	5.5	**Cadmium**	2	--	0.355	0.540	0	2	--	0.225	>0.305	0	0	no
B1BMP0003	1	**TCDD TEQ**	23	1	7.12e-07	1.35e-05	19	23	1	1.69e-05	5.63e-04	11	0.99	yes
	4	**2,3,7,8-TCDD**	23	23	<1.10e-06	<6.30e-06	0	23	23	<3.10e-05	<6.30e-03	1	0	no
	4	**Cadmium**	23	15	<0.250	<0.500	0	23	15	<0.0	<10.0	2	0	no
	4	**Copper**	23	--	7.30	21.0	6	22	--	102	688	2	0	yes
	4	**Lead**	23	1	2.70	8.90	6	23	1	>60.6	>177	0	0	no
	4	**Total Suspended Solids**	23	4	33.0	110	0	0	--	--	--	0	0	no
B1BMP0004	1	**TCDD TEQ**	21	--	4.05e-07	4.00e-04	20	21	--	2.52e-05	2.50e-02	8	0.99	yes
	4	**2,3,7,8-TCDD**	21	21	<1.10e-06	<1.00e-05	0	21	21	<4.15e-05	<7.44e-04	0	0	no
	4	**Cadmium**	21	14	<0.250	<0.500	0	20	14	<0.0	<15.6	2	0	no
	4	**Copper**	21	--	5.40	9.00	0	21	--	66.7	>170	0	0	no
	4	**Lead**	21	--	4.50	9.60	8	21	--	>129	495	1	0	yes
	4	**Total Suspended Solids**	21	2	27.0	170	1	0	--	--	--	0	0	no
B1BMP0005	1	**TCDD TEQ**	26	3	1.95e-07	2.60e-05	15	26	3	1.26e-05	>1.98e-03	10	0.44	yes
	4	**2,3,7,8-TCDD**	26	23	<2.10e-06	<1.00e-05	0	26	23	<5.88e-05	<1.78e-03	1	0	no
	4	**Cadmium**	26	20	<0.250	<0.250	0	22	17	<0.0	<10.0	1	0	no
	4	**Copper**	26	--	2.85	35.0	1	23	--	59.6	694	2	0	yes
	4	**Lead**	26	3	1.10	9.60	1	26	3	45.4	196	0	0	no
	4	**Total Suspended Solids**	26	2	16.0	170	1	0	--	--	--	0	0	no
B1BMP0007	1	**TCDD TEQ**	12	--	1.08e-07	1.24e-06	10	12	--	5.15e-06	3.75e-05	1	0.42	yes
	4	**2,3,7,8-TCDD**	12	12	<5.80e-07	<4.53e-06	0	12	12	<3.63e-05	<2.40e-04	0	0	no
	4	**Cadmium**	12	12	<0.250	<0.500	0	12	12	<0.0	<10.0	2	0	no
	4	**Copper**	12	--	4.65	9.10	0	11	--	71.4	119	0	0	no
	4	**Lead**	12	--	2.70	4.60	0	12	--	74.9	155	0	0	no
	4	**Total Suspended Solids**	12	2	30.5	43.0	0	0	--	--	--	0	0	no

Location	Rank	COC	Concentration					Particulate Strength					Weight	Both Criteria Exceeded?
			Number of Samples	Number of NDs	Median	Maximum	N > PL	Number of PS	Number of NDs	Median PS	Maximum	N > 95th		
B1BMP0008	1	**TCDD TEQ**	2	--	3.30e-07	5.43e-07	2	2	--	9.75e-06	1.23e-05	0	0.50	no
	4	**2,3,7,8-TCDD**	2	2	<4.10e-07	<4.10e-07	0	2	2	<2.40e-05	<2.40e-05	0	0	no
	4	**Cadmium**	2	2	<0.250	<0.250	0	2	2	<0.0	<0.0	0	0	no
	4	**Copper**	2	--	5.90	7.20	0	2	--	190	302	0	0	no
	4	**Lead**	2	--	3.40	4.60	0	2	--	116	>177	0	0	no
	4	**Total Suspended Solids**	2	--	42.3	75.0	0	0	--	--	--	0	0	no
B1SW0002	1.5	**Lead**	2	--	6.80	12.0	1	2	--	194	304	1	0.50	yes
	1.5	**TCDD TEQ**	2	1	<2.34e-05	2.34e-05	1	2	1	<2.13e-04	2.13e-04	1	0.50	yes
	3	**Copper**	2	--	6.65	10.0	0	2	--	184	332	1	0.31	no
	5	**2,3,7,8-TCDD**	2	2	<8.00e-06	<8.00e-06	0	2	2	<5.00e-04	<5.00e-04	0	0	no
	5	**Cadmium**	2	--	0.170	0.240	0	0	--	--	--	0	0	no
	5	**Total Suspended Solids**	2	--	57.0	110	0	0	--	--	--	0	0	no
B1SW0008	1	**TCDD TEQ**	2	--	8.28e-06	1.58e-05	2	2	--	1.40e-04	2.78e-04	1	0.69	yes
	2	**Total Suspended Solids**	2	--	168	280	1	0	--	--	--	0	0.50	no
	4.5	**2,3,7,8-TCDD**	2	2	<9.80e-07	<9.80e-07	0	2	2	<1.72e-05	<1.72e-05	0	0	no
	4.5	**Cadmium**	2	1	<0.220	<0.500	0	0	--	--	--	0	0	no
	4.5	**Copper**	0	--	--	--	0	0	--	--	--	0	0	no
	4.5	**Lead**	0	--	--	--	0	0	--	--	--	0	0	no
B1SW0014-A	1.5	**Lead**	1	--	6.90	6.90	1	1	--	65.6	65.6	0	0.50	no
	1.5	**TCDD TEQ**	1	--	2.64e-07	2.64e-07	1	1	--	3.30e-06	3.30e-06	0	0.50	no
	4.5	**2,3,7,8-TCDD**	1	1	<1.90e-06	<1.90e-06	0	1	1	<2.38e-05	<2.38e-05	0	0	no
	4.5	**Cadmium**	1	1	<0.100	<0.100	0	0	--	--	--	0	0	no
	4.5	**Copper**	1	--	5.90	5.90	0	1	--	29.7	29.7	0	0	no
	4.5	**Total Suspended Solids**	1	--	80.0	80.0	0	0	--	--	--	0	0	no
B1SW0014-B	1	**TCDD TEQ**	3	--	3.05e-07	5.89e-07	3	3	--	1.08e-05	2.18e-05	0	0.50	no
	2	**Lead**	4	--	2.70	6.70	1	4	--	60.5	71.8	0	0.04	no
	4.5	**2,3,7,8-TCDD**	3	3	<3.90e-06	<5.10e-06	0	3	3	<9.62e-05	<1.89e-04	0	0	no
	4.5	**Cadmium**	4	4	<0.100	<0.200	0	0	--	--	--	0	0	no
	4.5	**Copper**	4	--	3.75	4.10	0	4	--	42.1	54.2	0	0	no
	4.5	**Total Suspended Solids**	4	--	36.5	71.0	0	0	--	--	--	0	0	no
B1SW0014-C	1	**TCDD TEQ**	19	--	1.18e-07	3.73e-06	14	19	--	4.68e-06	3.73e-04	4	0.44	yes
	4	**2,3,7,8-TCDD**	19	19	<4.60e-07	<7.62e-06	0	19	19	<3.44e-05	<1.52e-03	1	0	no
	4	**Cadmium**	19	19	<0.250	<0.500	0	19	19	<0.0	<22.7	1	0	no
	4	**Copper**	19	--	3.20	6.60	0	16	--	60.0	408	1	0	no
	4	**Lead**	19	--	1.90	8.90	1	19	--	76.0	192	0	0	no
	4	**Total Suspended Solids**	19	--	15.0	77.0	0	0	--	--	--	0	0	no
BGBMP0001	1	**Copper**	4	--	2.45	3.60	0	3	--	100.0	314	1	0.06	no
	4	**2,3,7,8-TCDD**	4	4	<8.70e-07	<2.10e-06	0	4	4	<2.62e-04	<8.70e-04	0	0	no
	4	**Cadmium**	4	3	<0.100	0.160	0	4	3	<0.0	>3.49	0	0	no
	4	**Lead**	4	1	0.590	0.800	0	4	1	68.1	<152	0	0	no
	4	**TCDD TEQ**	4	2	<6.40e-12	7.90e-12	0	4	2	<9.14e-10	>7.90e-09	0	0	no
	4	**Total Suspended Solids**	4	1	5.50	8.00	0	0	--	--	--	0	0	no

Location	Rank	COC	Concentration					Particulate Strength					Weight	Both Criteria Exceeded?
			Number of Samples	Number of NDs	Median	Maximum	N > PL	Number of PS	Number of NDs	Median PS	Maximum	N > 95th		
BGBMP0002	1	**Total Suspended Solids**	4	--	20.5	750	1	0	--	--	--	0	0.31	no
	2	**Cadmium**	3	3	<0.100	<0.200	0	3	3	<0.0	<5.26	1	0.11	no
	3	**Copper**	4	--	1.60	19.0	1	3	--	23.9	38.2	0	0.06	no
	4.5	**Lead**	4	--	1.30	64.0	1	4	--	53.6	85.0	0	0.04	no
	4.5	**TCDD TEQ**	4	2	<6.00e-10	1.02e-07	1	4	2	<1.20e-07	1.36e-07	0	0.04	no
	6	**2,3,7,8-TCDD**	4	4	<1.80e-06	<3.40e-06	0	4	4	<1.55e-04	<1.92e-04	0	0	no
BGBMP0003	1.5	**2,3,7,8-TCDD**	5	5	<1.90e-06	<4.70e-06	0	5	5	<1.90e-04	<9.40e-04	1	0.01	no
	1.5	**TCDD TEQ**	5	3	<1.00e-12	3.32e-07	1	5	3	<2.00e-10	6.26e-06	0	0.01	no
	4.5	**Cadmium**	5	5	<0.100	<0.200	0	5	5	<0.0	<1.89	0	0	no
	4.5	**Copper**	5	--	3.00	4.70	0	4	--	86.4	125	0	0	no
	4.5	**Lead**	5	1	0.690	2.80	0	5	1	>49.1	<152	0	0	no
	4.5	**Total Suspended Solids**	5	2	5.00	53.0	0	0	--	--	--	0	0	no
BGBMP0004	1	**Total Suspended Solids**	3	--	17.0	240	1	0	--	--	--	0	0.50	no
	2.5	**Lead**	3	1	0.910	7.60	1	3	1	>30.8	38.8	0	0.11	no
	2.5	**TCDD TEQ**	3	--	1.00e-10	4.01e-08	1	3	--	5.88e-09	1.67e-07	0	0.11	no
	5	**2,3,7,8-TCDD**	3	3	<1.00e-06	<4.00e-06	0	3	3	<2.35e-04	<2.50e-04	0	0	no
	5	**Cadmium**	3	3	<0.100	<0.200	0	3	3	<0.0	<0.417	0	0	no
	5	**Copper**	3	--	2.40	6.60	0	2	--	32.7	47.1	0	0	no
BGBMP0005	3.5	**2,3,7,8-TCDD**	1	1	<3.90e-06	<3.90e-06	0	1	1	<3.55e-04	<3.55e-04	0	0	no
	3.5	**Cadmium**	1	1	<0.100	<0.100	0	1	1	<0.0	<0.0	0	0	no
	3.5	**Copper**	1	--	2.40	2.40	0	0	--	--	--	0	0	no
	3.5	**Lead**	1	--	0.840	0.840	0	0	--	--	--	0	0	no
	3.5	**TCDD TEQ**	1	--	2.80e-11	2.80e-11	0	1	--	2.55e-09	2.55e-09	0	0	no
	3.5	**Total Suspended Solids**	1	--	11.0	11.0	0	0	--	--	--	0	0	no
BGBMP0006	1	**Total Suspended Solids**	7	1	3.00	250	1	0	--	--	--	0	0.06	no
	2	**TCDD TEQ**	7	--	1.56e-08	2.45e-07	2	7	--	2.33e-06	>2.45e-04	1	0.03	yes
	3	**Lead**	7	1	1.50	17.0	1	7	1	78.6	>1,140	1	0.01	yes
	5	**2,3,7,8-TCDD**	7	7	<6.20e-07	<1.80e-06	0	7	7	<2.50e-05	<6.20e-04	0	0	no
	5	**Cadmium**	1	1	<0.100	<0.100	0	1	1	<0.0	<0.0	0	0	no
	5	**Copper**	1	--	2.90	2.90	0	1	--	5.56	5.56	0	0	no
BGBMP0007	1	**Lead**	7	--	1.00	16.0	1	7	--	76.1	312	1	0.01	yes
	4	**2,3,7,8-TCDD**	7	7	<8.10e-07	<5.40e-06	0	7	7	<1.83e-04	<3.17e-04	0	0	no
	4	**Cadmium**	6	6	<0.100	<0.100	0	2	2	<0.0	<0.0	0	0	no
	4	**Copper**	7	--	1.50	7.50	0	7	--	77.4	201	0	0	no
	4	**TCDD TEQ**	7	3	1.10e-11	9.64e-09	0	7	3	1.83e-09	3.54e-07	0	0	no
	4	**Total Suspended Solids**	7	--	7.00	39.0	0	0	--	--	--	0	0	no
EVBMP0001-A	1	**TCDD TEQ**	10	1	1.39e-07	2.11e-04	7	10	1	6.61e-06	3.51e-03	3	0.59	yes
	2	**Total Suspended Solids**	10	--	42.0	480	2	0	--	--	--	0	0.05	no
	3	**Lead**	10	1	3.65	41.0	4	10	1	99.3	320	1	0.02	yes
	5	**2,3,7,8-TCDD**	10	9	<2.40e-06	2.20e-05	0	10	9	<1.31e-04	<6.19e-04	0	0	no
	5	**Cadmium**	10	7	<0.250	0.410	0	10	7	<0.0	>0.646	0	0	no
	5	**Copper**	10	--	3.65	15.0	1	7	--	27.1	60.0	0	0	no

Location	Rank	COC	Concentration					Particulate Strength					Weight	Both Criteria Exceeded?
			Number of Samples	Number of NDs	Median	Maximum	N > PL	Number of PS	Number of NDs	Median PS	Maximum	N > 95th		
EVBMP0002	1	**TCDD TEQ**	6	--	4.40e-07	1.16e-06	6	6	--	4.24e-05	5.78e-04	3	0.93	yes
	2	**Lead**	6	--	3.35	26.0	1	5	--	284	1,090	3	0.27	yes
	3	**Copper**	6	--	4.60	13.0	0	5	--	121	600	2	0.03	no
	4	**Cadmium**	6	1	0.155	0.280	0	6	1	1.43	30.0	2	0.02	no
	5.5	**2,3,7,8-TCDD**	6	6	<2.40e-06	<4.00e-06	0	6	6	<1.46e-04	<2.00e-03	1	0	no
	5.5	**Total Suspended Solids**	6	--	12.0	120	0	0	--	--	--	0	0	no
EVBMP0002-A	1	**TCDD TEQ**	5	--	3.75e-08	6.95e-08	3	5	--	6.15e-07	6.95e-06	0	0.17	no
	2	**Lead**	5	--	3.80	4.80	0	5	--	194	344	1	0.01	no
	4.5	**2,3,7,8-TCDD**	5	5	<1.10e-06	<5.30e-06	0	5	5	<9.17e-05	<1.57e-04	0	0	no
	4.5	**Cadmium**	5	4	<0.100	0.130	0	5	4	<0.0	>0.863	0	0	no
	4.5	**Copper**	5	--	3.60	7.70	0	3	--	44.3	150	0	0	no
	4.5	**Total Suspended Solids**	5	--	12.0	61.0	0	0	--	--	--	0	0	no
EVBMP0002-B	1	**TCDD TEQ**	7	--	1.03e-07	2.84e-06	5	7	--	>9.21e-06	>2.84e-04	1	0.40	yes
	2	**Total Suspended Solids**	7	--	2.90	27.9	2	7	--	>180	>292	1	0.03	yes
	4.5	**Lead**	7	7	<7.90e-07	<9.16e-06	0	7	7	<4.47e-05	<2.38e-04	0	0	no
	4.5	**2,3,7,8-TCDD**	7	6	<0.128	0.425	0	7	6	<0.0	<10.0	1	0	no
	4.5	**Cadmium**	7	--	4.10	9.12	0	5	--	58.9	>150	0	0	no
	4.5	**Copper**	7	3	11.0	151	0	0	--	--	--	0	0	no
EVBMP0003	1	**TCDD TEQ**	18	--	2.26e-06	1.74e-05	17	18	--	3.16e-05	5.15e-04	9	1.00	yes
	2	**Lead**	18	--	9.15	55.0	13	18	--	227	664	7	0.80	yes
	4.5	**2,3,7,8-TCDD**	18	15	<3.20e-06	<7.40e-06	0	18	15	<1.19e-04	<3.83e-04	0	0	no
	4.5	**Cadmium**	9	2	0.180	0.730	0	9	2	>0.678	>2.33	0	0	no
	4.5	**Copper**	9	--	7.00	24.0	1	9	--	80.0	167	0	0	no
	4.5	**Total Suspended Solids**	18	--	36.0	890	3	0	--	--	--	0	0	no
EVBMP0003-A	1	**TCDD TEQ**	6	--	4.11e-07	9.93e-06	5	6	--	3.38e-05	5.22e-04	3	0.81	yes
	4	**2,3,7,8-TCDD**	6	6	<2.74e-06	<4.15e-06	0	6	6	<1.44e-04	<2.82e-04	0	0	no
	4	**Cadmium**	6	6	<0.128	<0.250	0	4	4	<0.0	<0.0	0	0	no
	4	**Copper**	6	--	4.75	9.00	0	6	--	52.5	154	0	0	no
	4	**Lead**	6	--	1.92	9.00	1	6	--	92.7	>181	0	0	no
	4	**Total Suspended Solids**	6	--	17.0	56.0	0	0	--	--	--	0	0	no
EVBMP0004	1	**Lead**	3	--	6.80	7.30	3	3	--	328	419	2	0.89	yes
	2	**TCDD TEQ**	3	--	1.52e-08	2.07e-06	1	3	--	7.59e-07	5.05e-05	1	0.34	yes
	4.5	**2,3,7,8-TCDD**	3	3	<4.30e-07	<5.70e-07	0	3	3	<2.15e-05	<3.80e-05	0	0	no
	4.5	**Cadmium**	3	3	<0.100	<0.100	0	3	3	<0.0	<0.0	0	0	no
	4.5	**Copper**	3	--	3.00	5.40	0	3	--	127	150	0	0	no
	4.5	**Total Suspended Solids**	3	--	20.0	41.0	0	0	--	--	--	0	0	no
EVBMP0005	1	**TCDD TEQ**	2	--	8.61e-07	1.25e-06	2	2	--	3.90e-05	>4.76e-05	1	0.69	yes
	4	**2,3,7,8-TCDD**	2	2	<6.00e-07	<6.00e-07	0	2	2	<6.00e-05	<6.00e-05	0	0	no
	4	**Cadmium**	2	1	<0.180	0.180	0	2	1	<1.95	1.95	0	0	no
	4	**Copper**	2	--	6.60	9.00	0	2	--	72.1	>110	0	0	no
	4	**Lead**	2	--	3.05	3.10	0	2	--	148	>250	0	0	no
	4	**Total Suspended Solids**	2	1	<41.0	41.0	0	0	--	--	--	0	0	no

Location	Rank	COC	Concentration					Particulate Strength					Weight	Both Criteria Exceeded?
			Number of Samples	Number of NDs	Median	Maximum	N > PL	Number of PS	Number of NDs	Median PS	Maximum	N > 95th		
EVBMP0006	2.5	**Copper**	1	--	15.0	15.0	1	1	--	33.5	33.5	0	0.50	no
	2.5	**Lead**	1	--	12.0	12.0	1	1	--	54.0	54.0	0	0.50	no
	2.5	**TCDD TEQ**	1	--	4.83e-06	4.83e-06	1	1	--	2.41e-05	2.41e-05	0	0.50	no
	2.5	**Total Suspended Solids**	1	--	200	200	1	0	--	--	--	0	0.50	no
	5.5	**2,3,7,8-TCDD**	1	1	<7.90e-07	<7.90e-07	0	1	1	<3.95e-06	<3.95e-06	0	0	no
	5.5	**Cadmium**	1	--	0.470	0.470	0	1	--	1.80	1.80	0	0	no
EVBMP0007	1	**TCDD TEQ**	6	--	3.55e-08	3.92e-06	4	6	--	1.10e-06	1.78e-04	2	0.50	yes
	2	**Copper**	6	--	7.29	17.2	1	5	--	122	253	0	0.01	no
	4.5	**2,3,7,8-TCDD**	6	6	<2.84e-06	<8.07e-06	0	6	6	<1.50e-04	<3.23e-04	0	0	no
	4.5	**Cadmium**	6	5	<0.128	0.251	0	5	5	<0.0	<0.0	0	0	no
	4.5	**Lead**	6	--	4.31	11.4	1	6	--	161	211	0	0	no
	4.5	**Total Suspended Solids**	6	--	23.5	66.0	0	0	--	--	--	0	0	no
EVBMP0008	3.5	**2,3,7,8-TCDD**	6	6	<2.15e-06	<5.22e-06	0	6	6	<1.11e-04	<1.37e-04	0	0	no
	3.5	**Cadmium**	6	5	<0.128	<0.250	0	5	4	<0.0	>0.138	0	0	no
	3.5	**Copper**	6	--	3.46	5.33	0	6	--	20.2	48.8	0	0	no
	3.5	**Lead**	6	--	2.12	3.67	0	6	--	42.0	133	0	0	no
	3.5	**TCDD TEQ**	6	--	8.77e-09	1.01e-07	1	6	--	2.41e-07	2.66e-06	0	0	no
	3.5	**Total Suspended Solids**	6	--	38.0	144	0	0	--	--	--	0	0	no
EVBMP0009	1	**TCDD TEQ**	5	--	2.15e-08	4.74e-08	2	5	--	1.13e-06	6.00e-06	0	0.05	no
	2	**Copper**	5	--	3.44	9.95	0	4	--	54.5	395	1	0.02	no
	4.5	**2,3,7,8-TCDD**	5	5	<1.28e-06	<5.64e-06	0	5	5	<1.16e-04	<2.97e-04	0	0	no
	4.5	**Cadmium**	5	5	<0.128	<0.128	0	4	4	<0.0	<0.0	0	0	no
	4.5	**Lead**	5	--	2.01	3.48	0	5	--	129	211	0	0	no
	4.5	**Total Suspended Solids**	5	--	18.0	47.0	0	0	--	--	--	0	0	no
EVBMP0010	1	**Total Suspended Solids**	1	--	174	174	1	0	--	--	--	0	0.50	no
	4	**2,3,7,8-TCDD**	1	1	<6.12e-06	<6.12e-06	0	1	1	<3.52e-05	<3.52e-05	0	0	no
	4	**Cadmium**	1	1	<0.128	<0.128	0	1	1	<0.0	<0.0	0	0	no
	4	**Copper**	1	--	0.916	0.916	0	1	--	>4.46	>4.46	0	0	no
	4	**Lead**	1	--	0.933	0.933	0	1	--	>4.85	>4.85	0	0	no
	4	**TCDD TEQ**	1	--	1.81e-08	1.81e-08	0	1	--	1.04e-07	1.04e-07	0	0	no
HZBMP0001	1	**Total Suspended Solids**	13	--	140	600	7	0	--	--	--	0	0.50	no
	4	**2,3,7,8-TCDD**	12	11	<2.10e-06	<3.10e-06	0	12	11	<6.13e-05	<9.70e-04	1	0	no
	4	**Cadmium**	6	4	<0.200	0.600	0	6	4	<0.0	>0.833	0	0	no
	4	**Copper**	13	--	5.70	15.0	1	13	--	33.3	1,160	1	0	yes
	4	**Lead**	13	1	2.10	19.0	2	13	1	24.9	<134	0	0	no
	4	**TCDD TEQ**	12	4	3.35e-09	1.17e-05	3	12	4	5.11e-08	1.96e-05	0	0	no
HZBMP0002	1	**2,3,7,8-TCDD**	4	4	<2.40e-06	<5.60e-06	0	4	4	<2.40e-03	<5.60e-03	3	0.36	no
	2	**Copper**	4	--	1.80	2.30	0	2	--	317	>600	1	0.11	no
	3	**Lead**	4	2	<0.650	0.900	0	4	2	<57.5	>380	1	0.04	no
	5	**Cadmium**	4	4	<0.100	<0.100	0	4	4	<0.0	<0.0	0	0	no
	5	**TCDD TEQ**	4	3	<1.00e-12	6.50e-12	0	4	3	<1.00e-09	6.50e-09	0	0	no
	5	**Total Suspended Solids**	4	2	<1.00	12.0	0	0	--	--	--	0	0	no

Location	Rank	COC	Concentration					Particulate Strength					Weight	Both Criteria Exceeded?
			Number of Samples	Number of NDs	Median	Maximum	N > PL	Number of PS	Number of NDs	Median PS	Maximum	N > 95th		
HZBMP0003	1	**Total Suspended Solids**	15	4	9.00	840	3	0	--	--	--	0	0.02	no
	2	**Cadmium**	7	6	<0.100	<0.250	0	7	6	<0.0	>14.7	2	0.01	no
	4.5	**2,3,7,8-TCDD**	15	15	<1.00e-06	<6.07e-06	0	15	15	<1.05e-04	<2.40e-03	2	0	no
	4.5	**Copper**	15	--	2.00	19.0	1	13	--	53.1	3,450	3	0	yes
	4.5	**Lead**	15	7	0.400	19.0	2	15	7	11.1	>341	1	0	yes
	4.5	**TCDD TEQ**	15	4	2.90e-11	4.00e-06	4	15	4	>4.50e-09	>4.00e-04	1	0	yes
HZSW0005	3.5	**2,3,7,8-TCDD**	1	1	<4.00e-07	<4.00e-07	0	1	1	<8.00e-05	<8.00e-05	0	0	no
	3.5	**Cadmium**	0	--	--	--	0	0	--	--	--	0	0	no
	3.5	**Copper**	0	--	--	--	0	0	--	--	--	0	0	no
	3.5	**Lead**	0	--	--	--	0	0	--	--	--	0	0	no
	3.5	**TCDD TEQ**	1	--	5.58e-09	5.58e-09	0	1	--	1.12e-06	1.12e-06	0	0	no
	3.5	**Total Suspended Solids**	1	--	5.00	5.00	0	0	--	--	--	0	0	no
HZSW0008	3.5	**2,3,7,8-TCDD**	1	1	<6.20e-07	<6.20e-07	0	1	1	<2.21e-05	<2.21e-05	0	0	no
	3.5	**Cadmium**	0	--	--	--	0	0	--	--	--	0	0	no
	3.5	**Copper**	0	--	--	--	0	0	--	--	--	0	0	no
	3.5	**Lead**	1	--	0.400	0.400	0	1	--	9.55	9.55	0	0	no
	3.5	**TCDD TEQ**	1	--	2.13e-09	2.13e-09	0	1	--	7.59e-08	7.59e-08	0	0	no
	3.5	**Total Suspended Solids**	1	--	28.0	28.0	0	0	--	--	--	0	0	no
HZSW0011	1	**Copper**	2	--	2.70	3.00	0	2	--	425	670	1	0.31	no
	4	**2,3,7,8-TCDD**	2	2	<5.20e-06	<5.20e-06	0	2	2	<8.67e-04	<8.67e-04	0	0	no
	4	**Cadmium**	0	--	--	--	0	0	--	--	--	0	0	no
	4	**Lead**	0	--	--	--	0	0	--	--	--	0	0	no
	4	**TCDD TEQ**	2	--	3.52e-09	7.02e-09	0	2	--	1.76e-06	3.51e-06	0	0	no
	4	**Total Suspended Solids**	2	--	4.00	6.00	0	0	--	--	--	0	0	no
HZSW0012	3.5	**2,3,7,8-TCDD**	0	--	--	--	0	0	--	--	--	0	0	no
	3.5	**Cadmium**	0	--	--	--	0	0	--	--	--	0	0	no
	3.5	**Copper**	0	--	--	--	0	0	--	--	--	0	0	no
	3.5	**Lead**	1	1	<0.200	<0.200	0	1	1	<19.1	<19.1	0	0	no
	3.5	**TCDD TEQ**	0	--	--	--	0	0	--	--	--	0	0	no
	3.5	**Total Suspended Solids**	1	--	7.00	7.00	0	0	--	--	--	0	0	no
HZSW0014	3.5	**2,3,7,8-TCDD**	0	--	--	--	0	0	--	--	--	0	0	no
	3.5	**Cadmium**	0	--	--	--	0	0	--	--	--	0	0	no
	3.5	**Copper**	3	--	6.40	7.90	0	3	--	40.9	136	0	0	no
	3.5	**Lead**	3	--	3.10	3.70	0	3	--	29.6	95.1	0	0	no
	3.5	**TCDD TEQ**	0	--	--	--	0	0	--	--	--	0	0	no
	3.5	**Total Suspended Solids**	3	--	61.0	70.0	0	0	--	--	--	0	0	no
HZSW0020	1.5	**Lead**	2	--	9.65	14.0	2	2	--	87.2	123	0	0.50	no
	1.5	**Total Suspended Solids**	2	--	72.5	76.0	1	0	--	--	--	0	0.50	no
	4.5	**2,3,7,8-TCDD**	2	2	<2.60e-06	<2.60e-06	0	2	2	<3.42e-05	<3.42e-05	0	0	no
	4.5	**Cadmium**	0	--	--	--	0	0	--	--	--	0	0	no
	4.5	**Copper**	0	--	--	--	0	0	--	--	--	0	0	no
	4.5	**TCDD TEQ**	2	--	4.53e-09	5.04e-09	0	2	--	6.23e-08	6.63e-08	0	0	no

Location	Rank	COC	Concentration					Particulate Strength					Weight	Both Criteria Exceeded?
			Number of Samples	Number of NDs	Median	Maximum	N > PL	Number of PS	Number of NDs	Median PS	Maximum	N > 95th		
ILBMP0001	1	**TCDD TEQ**	26	--	1.67e-07	3.38e-05	21	26	--	8.25e-06	6.78e-04	9	0.89	yes
	4	**2,3,7,8-TCDD**	26	25	<1.40e-06	<1.20e-05	0	26	25	<3.83e-05	<8.78e-04	1	0	no
	4	**Cadmium**	26	6	0.415	1.30	0	23	5	3.91	47.5	13	0	no
	4	**Copper**	26	--	12.0	35.0	10	23	--	122	725	3	0	yes
	4	**Lead**	26	--	4.90	19.0	13	26	--	110	710	4	0	yes
	4	**Total Suspended Solids**	26	--	34.5	330	3	0	--	--	--	0	0	no
ILBMP0002	1	**Lead**	16	--	12.5	82.0	13	15	--	333	1,020	9	0.99	yes
	2	**TCDD TEQ**	16	--	1.06e-06	2.40e-05	13	16	--	1.53e-05	7.22e-04	7	0.94	yes
	3	**Total Suspended Solids**	16	--	32.5	1,800	4	0	--	--	--	0	0.04	no
	5	**2,3,7,8-TCDD**	16	15	<9.60e-07	<6.99e-06	0	16	15	<3.41e-05	<2.75e-04	0	0	no
	5	**Cadmium**	16	10	<0.250	1.10	0	16	10	<0.0	3.48	0	0	no
	5	**Copper**	16	--	8.65	59.0	4	15	--	68.1	266	0	0	no
ILBMP0003	1	**2,3,7,8-TCDD**	4	4	<1.70e-06	<6.70e-06	0	4	4	<2.10e-04	<1.68e-03	1	0.04	no
	4	**Cadmium**	4	4	<0.100	<0.100	0	4	4	<0.0	<0.0	0	0	no
	4	**Copper**	4	--	3.90	4.80	0	3	--	100.0	267	0	0	no
	4	**Lead**	3	--	0.860	0.920	0	2	--	85.3	132	0	0	no
	4	**TCDD TEQ**	4	--	2.50e-09	2.69e-08	0	4	--	6.25e-07	8.95e-06	0	0	no
	4	**Total Suspended Solids**	4	--	4.00	10.0	0	0	--	--	--	0	0	no
ILBMP0004	1	**TCDD TEQ**	7	--	1.74e-06	1.24e-05	7	7	--	2.56e-05	5.63e-04	3	0.91	yes
	2	**Lead**	7	--	3.50	11.0	2	7	--	>70.4	349	1	0.03	yes
	3	**Copper**	7	--	10.0	19.0	1	7	--	107	327	1	0.01	yes
	5	**2,3,7,8-TCDD**	7	5	<4.40e-07	2.50e-06	0	7	5	<9.00e-06	1.14e-04	0	0	no
	5	**Cadmium**	7	3	0.270	1.20	0	7	3	>1.06	>31.7	1	0	no
	5	**Total Suspended Solids**	7	--	41.0	68.0	0	0	--	--	--	0	0	no
ILBMP0005	1	**TCDD TEQ**	8	1	7.83e-08	3.97e-07	5	8	1	5.22e-06	2.34e-05	0	0.11	no
	2	**Copper**	8	--	11.5	22.0	3	7	--	141	286	0	0.02	no
	4.5	**2,3,7,8-TCDD**	8	8	<3.70e-07	<7.30e-07	0	8	8	<2.47e-05	<2.28e-04	0	0	no
	4.5	**Cadmium**	8	7	<0.250	0.290	0	6	5	<0.0	>1.92	0	0	no
	4.5	**Lead**	8	1	2.00	3.00	0	8	1	102	191	0	0	no
	4.5	**Total Suspended Solids**	8	--	15.0	24.0	0	0	--	--	--	0	0	no
ILBMP0006	3.5	**2,3,7,8-TCDD**	1	1	<3.50e-07	<3.50e-07	0	1	1	<7.00e-05	<7.00e-05	0	0	no
	3.5	**Cadmium**	1	1	<0.250	<0.250	0	1	1	<0.0	<0.0	0	0	no
	3.5	**Copper**	1	--	1.70	1.70	0	1	--	80.0	80.0	0	0	no
	3.5	**Lead**	1	1	<0.500	<0.500	0	1	1	<76.1	<76.1	0	0	no
	3.5	**TCDD TEQ**	1	--	8.30e-09	8.30e-09	0	1	--	1.66e-06	1.66e-06	0	0	no
	3.5	**Total Suspended Solids**	1	--	5.00	5.00	0	0	--	--	--	0	0	no
ILBMP0007	1	**Copper**	9	--	16.0	26.0	6	6	--	318	1,590	3	0.70	yes
	4	**2,3,7,8-TCDD**	9	9	<3.50e-07	<8.10e-07	0	9	9	<3.18e-05	<1.98e-04	0	0	no
	4	**Cadmium**	9	9	<0.250	<0.500	0	5	5	<0.0	<33.3	1	0	no
	4	**Lead**	9	2	1.40	2.00	0	9	2	>100	<186	0	0	no
	4	**TCDD TEQ**	9	5	<1.00e-12	9.40e-08	2	9	5	<2.44e-10	1.65e-05	0	0	no
	4	**Total Suspended Solids**	9	--	10.0	27.0	0	0	--	--	--	0	0	no

Location	Rank	COC	Concentration					Particulate Strength					Weight	Both Criteria Exceeded?
			Number of Samples	Number of NDs	Median	Maximum	N > PL	Number of PS	Number of NDs	Median PS	Maximum	N > 95th		
ILBMP0008	1	**TCDD TEQ**	8	--	1.59e-06	2.62e-05	8	8	--	1.57e-05	1.31e-03	3	0.96	yes
	2	**Total Suspended Solids**	8	--	58.0	220	2	0	--	--	--	0	0.14	no
	3.5	**Cadmium**	8	--	0.805	6.80	1	8	--	4.92	16.1	4	0.11	yes
	3.5	**Lead**	8	--	5.55	25.0	5	8	--	105	>273	0	0.11	no
	5.5	**2,3,7,8-TCDD**	8	8	<5.30e-07	<1.40e-06	0	8	8	<6.36e-06	<3.31e-05	0	0	no
	5.5	**Copper**	8	--	12.5	48.0	2	8	--	112	182	0	0	no
ILSW0003	3.5	**2,3,7,8-TCDD**	0	--	--	--	0	0	--	--	--	0	0	no
	3.5	**Cadmium**	2	--	0.455	0.540	0	0	--	--	--	0	0	no
	3.5	**Copper**	0	--	--	--	0	0	--	--	--	0	0	no
	3.5	**Lead**	2	--	2.80	3.50	0	2	--	70.2	121	0	0	no
	3.5	**TCDD TEQ**	0	--	--	--	0	0	--	--	--	0	0	no
	3.5	**Total Suspended Solids**	2	--	52.5	83.0	0	0	--	--	--	0	0	no
ILSW0004-A	3.5	**2,3,7,8-TCDD**	0	--	--	--	0	0	--	--	--	0	0	no
	3.5	**Cadmium**	1	--	0.350	0.350	0	0	--	--	--	0	0	no
	3.5	**Copper**	0	--	--	--	0	0	--	--	--	0	0	no
	3.5	**Lead**	1	--	2.60	2.60	0	1	--	18.0	18.0	0	0	no
	3.5	**TCDD TEQ**	0	--	--	--	0	0	--	--	--	0	0	no
	3.5	**Total Suspended Solids**	1	--	110	110	0	0	--	--	--	0	0	no
ILSW0007	3.5	**2,3,7,8-TCDD**	0	--	--	--	0	0	--	--	--	0	0	no
	3.5	**Cadmium**	1	--	0.290	0.290	0	0	--	--	--	0	0	no
	3.5	**Copper**	0	--	--	--	0	0	--	--	--	0	0	no
	3.5	**Lead**	1	--	2.10	2.10	0	1	--	34.0	34.0	0	0	no
	3.5	**TCDD TEQ**	0	--	--	--	0	0	--	--	--	0	0	no
	3.5	**Total Suspended Solids**	1	--	47.0	47.0	0	0	--	--	--	0	0	no
ILSW0008	3.5	**2,3,7,8-TCDD**	0	--	--	--	0	0	--	--	--	0	0	no
	3.5	**Cadmium**	1	--	0.340	0.340	0	0	--	--	--	0	0	no
	3.5	**Copper**	0	--	--	--	0	0	--	--	--	0	0	no
	3.5	**Lead**	1	--	2.60	2.60	0	1	--	28.7	28.7	0	0	no
	3.5	**TCDD TEQ**	0	--	--	--	0	0	--	--	--	0	0	no
	3.5	**Total Suspended Solids**	1	--	69.0	69.0	0	0	--	--	--	0	0	no
LFSW0002-A	1	**TCDD TEQ**	3	--	8.38e-08	9.38e-06	2	3	--	1.27e-06	2.04e-04	1	0.50	yes
	2	**Lead**	3	--	3.70	6.70	1	3	--	58.6	61.2	0	0.11	no
	4.5	**2,3,7,8-TCDD**	3	3	<2.40e-06	<8.80e-06	0	3	3	<3.64e-05	<1.01e-04	0	0	no
	4.5	**Cadmium**	0	--	--	--	0	0	--	--	--	0	0	no
	4.5	**Copper**	3	--	4.30	7.30	0	3	--	33.8	37.6	0	0	no
	4.5	**Total Suspended Solids**	3	--	66.0	87.0	0	0	--	--	--	0	0	no
LPBMP0001	1	**TCDD TEQ**	2	--	2.17e-07	2.38e-07	2	2	--	2.96e-06	4.42e-06	0	0.50	no
	2.5	**Copper**	2	--	9.25	14.0	1	2	--	76.3	91.5	0	0.31	no
	2.5	**Lead**	2	--	9.75	15.0	1	2	--	93.8	112	0	0.31	no
	5	**2,3,7,8-TCDD**	2	2	<5.20e-07	<5.20e-07	0	2	2	<9.63e-06	<9.63e-06	0	0	no
	5	**Cadmium**	2	--	0.315	0.480	0	2	--	1.67	>2.92	0	0	no
	5	**Total Suspended Solids**	2	--	92.0	130	0	0	--	--	--	0	0	no

Location	Rank	COC	Concentration					Particulate Strength					Weight	Both Criteria Exceeded?
			Number of Samples	Number of NDs	Median	Maximum	N > PL	Number of PS	Number of NDs	Median PS	Maximum	N > 95th		
LPBMP0001-A	1	**TCDD TEQ**	6	--	4.88e-06	5.02e-05	6	6	--	1.79e-04	1.18e-03	4	0.98	yes
	2	**Copper**	6	--	11.1	21.0	3	4	--	62.9	242	0	0.17	no
	3	**Total Suspended Solids**	6	--	37.5	180	1	0	--	--	--	0	0.11	no
	4	**Lead**	6	--	2.55	32.0	2	6	--	114	172	0	0.02	no
	5.5	**2,3,7,8-TCDD**	6	6	<1.80e-06	<4.40e-06	0	6	6	<4.82e-05	<1.83e-04	0	0	no
	5.5	**Cadmium**	6	4	<0.100	0.350	0	5	4	<0.0	>1.39	0	0	no
LPBMP0002	1	**TCDD TEQ**	15	--	3.37e-07	1.32e-05	15	15	--	9.11e-06	7.70e-04	5	0.98	yes
	4	**2,3,7,8-TCDD**	15	14	<6.00e-07	<7.47e-06	0	15	14	<1.62e-05	<1.10e-04	0	0	no
	4	**Cadmium**	15	12	<0.250	0.750	0	14	11	<0.0	5.09	1	0	no
	4	**Copper**	15	--	10.0	32.0	4	13	--	82.1	221	0	0	no
	4	**Lead**	15	--	2.80	20.0	3	15	--	>71.9	>176	0	0	no
	4	**Total Suspended Solids**	15	--	32.0	280	1	0	--	--	--	0	0	no
LPBMP0003	1	**TCDD TEQ**	15	--	2.51e-07	7.94e-06	14	15	--	9.06e-06	7.45e-05	4	0.90	yes
	4	**2,3,7,8-TCDD**	15	15	<4.10e-07	<9.64e-06	0	15	15	<1.35e-05	<3.01e-04	0	0	no
	4	**Cadmium**	15	12	<0.250	<0.500	0	14	11	<0.0	<7.81	1	0	no
	4	**Copper**	15	--	11.0	15.0	2	15	--	93.0	262	0	0	no
	4	**Lead**	15	--	2.90	8.50	3	15	--	>72.1	>138	0	0	no
	4	**Total Suspended Solids**	15	--	26.0	240	1	0	--	--	--	0	0	no
LPBMP0004	3.5	**2,3,7,8-TCDD**	16	16	<5.80e-07	<5.84e-06	0	16	16	<3.19e-05	<2.10e-04	0	0	no
	3.5	**Cadmium**	16	16	<0.250	<0.500	0	15	15	<0.0	<2.27	0	0	no
	3.5	**Copper**	16	--	8.90	14.0	2	16	--	151	385	2	0	yes
	3.5	**Lead**	16	--	3.35	5.60	1	16	--	100	342	2	0	yes
	3.5	**TCDD TEQ**	16	2	2.46e-08	4.21e-06	7	16	2	7.32e-07	6.09e-04	1	0	yes
	3.5	**Total Suspended Solids**	16	--	23.5	110	0	0	--	--	--	0	0	no
LXBMP0002	1.5	**TCDD TEQ**	2	--	7.63e-08	1.07e-07	2	2	--	2.24e-06	4.12e-06	0	0.50	no
	1.5	**Total Suspended Solids**	2	--	156	300	1	0	--	--	--	0	0.50	no
	3.5	**Copper**	2	--	9.65	14.0	1	2	--	45.8	63.6	0	0.31	no
	3.5	**Lead**	2	--	3.82	6.90	1	2	--	31.6	40.9	0	0.31	no
	5.5	**2,3,7,8-TCDD**	2	2	<5.10e-06	<5.10e-06	0	2	2	<4.64e-04	<4.64e-04	0	0	no
	5.5	**Cadmium**	2	1	<0.120	0.120	0	2	1	<0.0610	>0.0610	0	0	no
LXBMP0003	1	**Total Suspended Solids**	6	--	78.5	1,000	2	0	--	--	--	0	0.34	no
	2	**TCDD TEQ**	6	3	<4.35e-08	1.23e-07	3	6	3	<1.23e-07	1.51e-05	0	0.07	no
	3	**Copper**	6	--	3.85	20.0	1	5	--	17.9	2,970	1	0.03	yes
	5	**2,3,7,8-TCDD**	6	6	<8.80e-07	<8.30e-06	0	6	6	<3.61e-05	<2.93e-04	0	0	no
	5	**Cadmium**	6	4	<0.100	0.440	0	6	4	<0.0	>6.10	1	0	no
	5	**Lead**	6	1	0.810	18.0	1	6	1	13.8	>63.4	0	0	no
LXBMP0004	1.5	**Lead**	5	--	8.80	14.0	5	5	--	44.3	102	0	0.50	no
	1.5	**Total Suspended Solids**	5	--	260	520	3	0	--	--	--	0	0.50	no
	3.5	**Copper**	5	--	11.0	15.0	1	5	--	40.6	86.9	0	0.01	no
	3.5	**TCDD TEQ**	5	--	4.50e-10	1.72e-07	1	5	--	3.81e-09	5.54e-07	0	0.01	no
	5.5	**2,3,7,8-TCDD**	5	5	<2.30e-06	<6.00e-06	0	5	5	<1.52e-05	<2.31e-05	0	0	no
	5.5	**Cadmium**	5	1	0.120	0.190	0	5	1	>0.0935	>0.218	0	0	no

Location	Rank	COC	Concentration					Particulate Strength					Weight	Both Criteria Exceeded?
			Number of Samples	Number of NDs	Median	Maximum	N > PL	Number of PS	Number of NDs	Median PS	Maximum	N > 95th		
LXBMP0005	1	**Total Suspended Solids**	5	--	54.0	180	2	0	--	--	--	0	0.50	no
	2	**TCDD TEQ**	5	--	2.50e-10	4.59e-06	2	5	--	4.05e-09	2.30e-04	1	0.17	yes
	3.5	**Copper**	5	--	8.40	12.0	0	5	--	59.3	435	1	0.01	no
	3.5	**Lead**	5	--	4.40	5.50	1	5	--	>31.5	>265	0	0.01	no
	5.5	**2,3,7,8-TCDD**	5	5	<1.50e-06	<7.30e-06	0	5	5	<4.05e-05	<9.00e-05	0	0	no
	5.5	**Cadmium**	5	3	<0.100	0.130	0	5	3	<0.0	>0.992	0	0	no
LXBMP0006	1	**Total Suspended Solids**	5	--	40.0	1,300	1	0	--	--	--	0	0.19	no
	2	**TCDD TEQ**	5	3	<1.00e-12	5.63e-08	2	5	3	<7.14e-10	1.25e-06	0	0.05	no
	3.5	**Copper**	5	--	4.66	26.0	1	5	--	45.0	207	0	0.01	no
	3.5	**Lead**	5	--	1.63	24.0	1	5	--	50.7	106	0	0.01	no
	5.5	**2,3,7,8-TCDD**	4	4	<1.06e-06	<3.88e-06	0	4	4	<3.67e-05	<8.82e-05	0	0	no
	5.5	**Cadmium**	5	4	<0.128	0.400	0	5	4	<0.0	>0.231	0	0	no
LXBMP0007	3.5	**2,3,7,8-TCDD**	1	1	<1.41e-06	<1.41e-06	0	1	1	<1.23e-05	<1.23e-05	0	0	no
	3.5	**Cadmium**	1	1	<0.128	<0.128	0	1	1	<0.0	<0.0	0	0	no
	3.5	**Copper**	1	--	9.84	9.84	0	1	--	69.8	69.8	0	0	no
	3.5	**Lead**	1	--	4.63	4.63	0	1	--	38.0	38.0	0	0	no
	3.5	**TCDD TEQ**	1	--	3.49e-09	3.49e-09	0	1	--	3.03e-08	3.03e-08	0	0	no
	3.5	**Total Suspended Solids**	1	--	115	115	0	0	--	--	--	0	0	no
LXBMP0009	1	**Total Suspended Solids**	4	--	41.0	174	1	0	--	--	--	0	0.31	no
	2	**Lead**	5	--	2.67	6.24	1	4	--	40.4	44.2	0	0.02	no
	4.5	**2,3,7,8-TCDD**	4	4	<3.89e-06	<4.17e-06	0	4	4	<5.45e-05	<1.74e-04	0	0	no
	4.5	**Cadmium**	5	5	<0.128	<0.250	0	4	4	<0.0	<0.0	0	0	no
	4.5	**Copper**	5	--	6.56	12.2	0	4	--	72.9	104	0	0	no
	4.5	**TCDD TEQ**	4	--	2.70e-09	3.71e-09	0	4	--	8.68e-08	1.34e-07	0	0	no
LXSW0002	1	**Total Suspended Solids**	9	2	4.00	190	1	0	--	--	--	0	0.02	no
	4	**2,3,7,8-TCDD**	8	8	<1.20e-06	<8.80e-06	0	8	8	<4.25e-04	<1.20e-03	2	0	no
	4	**Cadmium**	8	8	<0.100	<0.100	0	0	--	--	--	0	0	no
	4	**Copper**	9	--	1.80	13.0	0	9	--	242	1,740	3	0	no
	4	**Lead**	9	--	0.340	27.0	1	9	--	95.1	>213	0	0	no
	4	**TCDD TEQ**	9	3	1.21e-09	1.86e-05	2	9	3	3.02e-07	9.78e-05	1	0	yes
Outfall 008	1	**Total Suspended Solids**	23	1	68.0	1,300	11	0	--	--	--	0	0.50	no
	4	**2,3,7,8-TCDD**	32	32	<9.52e-07	<4.70e-06	0	21	21	<1.50e-05	<1.49e-04	0	0	no
	4	**Cadmium**	32	14	0.0280	1.50	0	12	8	<0.0	>5.29	1	0	no
	4	**Copper**	33	1	5.20	18.0	2	22	--	42.4	183	0	0	no
	4	**Lead**	33	--	3.70	120	13	22	--	46.4	92.5	0	0	no
	4	**TCDD TEQ**	33	5	1.33e-09	2.20e-06	6	22	4	1.41e-08	2.34e-07	0	0	no
Outfall 009	3.5	**2,3,7,8-TCDD**	72	69	<8.95e-07	3.43e-05	0	49	47	<9.00e-05	<1.70e-03	1	0	no
	3.5	**Cadmium**	77	44	<0.250	9.20	1	36	25	<0.0	>33.0	2	0	yes
	3.5	**Copper**	77	--	4.10	39.0	3	49	--	>84.6	950	4	0	yes
	3.5	**Lead**	77	6	1.70	260	19	53	3	102	>1,000	6	0	yes
	3.5	**TCDD TEQ**	77	8	9.37e-09	3.67e-04	31	54	5	8.71e-07	2.10e-04	6	0	yes
	3.5	**Total Suspended Solids**	54	18	6.00	4,000	3	0	--	--	--	0	0	no

Appendix G: 2015/2016 BMP Performance Analysis

Prepared for

The Boeing Company
Santa Susana Site
5800 Woolsey Canyon Road
Canoga Park, California, 91304-1148

Appendix G: Best Management Practice (BMP) Performance Analysis

2015/2016 Reporting Year

Prepared by

The Surface Water Expert Panel

and

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SB0363W
October 2016

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Acronyms

ANOVA	Analysis of Variance
BMP	Best Management Practice
CM	Culvert Modification
COC	Constituent of Concern
COV	Coefficient of Variation
DNQ	Detected not Quantified
ELV	Expendable Launch Vehicle
ENTS	Engineered Natural Treatment Systems
GIS	Geographic Information System
HDPE	High Density Polyethylene
ISRA	Interim Source Removal Action
μg/kg	micrograms per kilogram
μg/L	micrograms per liter
mg/L	milligram per liter
NASA	National Aeronautics and Space Administration
ND	Non-Detect
NPDES	National Pollutant Discharge Elimination System
POR	Period of Record
SSFL	Santa Susana Field Laboratory
SWMM	Storm Water Management Model
TCDD	Tetrachlorodibenzo-*p*-dioxin
TEQ	Toxic Equivalence
TSS	Total Suspended Solids

1 Introduction

The purpose of this memorandum is to evaluate the performance of existing treatment Best Management Practices (BMPs) in the Outfall 009 watershed of the Boeing Santa Susana Field Laboratory (Site). This is an update to the BMP performance analysis that is conducted annually, consistent with the 2010 Engineered Natural Treatment Systems (ENTS) and Expert Panel Work Plan for SSFL Outfalls 008 and 009 (Outfall 008/009 BMP Work Plan). This memorandum incorporates 2015/2016 reporting year data into a dataset that began in December 2009. The National Pollutant Discharge Elimination System (NPDES) constituents of concern (COCs) addressed in this analysis include total suspended solids (TSS), total lead, total copper[1], and dioxins (TCDD TEQ, DNQ excluded, BAFs included). 2015/2016 data were collected to assess effectiveness of culvert modification (CM) installations, the Lower Lot biofilter, the ELV Treatment BMP, a vegetated channel section of the northern drainage upstream of the biofilter outlet, and the newly constructed B1436 detention bioswales[2]. Figure 1 in the Annual Report shows a Site map with drainages, drainage areas, outfall locations, and surface water boundaries.

The quantity of monitoring data collected during the 2015/2016 reporting year increased slightly from the previous 2014/2015 reporting year, but data for 2015/2016 was still fairly limited due to the lower than average total precipitation and storm events. Long-term average annual rainfall at SSFL from the 1958/1959 reporting year through the 2015/2016 reporting year was 16.8 inches[3], compared to 11.97 inches in the 2015/2016 reporting year[4]. Thirteen rain events (where a "rain event" is defined as greater than 0.1 inches of rainfall in a 24-hour period and preceded by at least 72 hours of dry weather) occurred in the 2015/2016 period, with nine of these storms producing observable flow at one or more BMP monitoring sites[5]. This is compared with 11, 14, 10, 9, 5, and 9 total rain events in prior reporting years 2009/2010, 2010/2011, 2011/2012, 2012/2013, 2013/2014, and 2014/2015, respectively. There were no samples collected in the Outfall 008 watershed during the 2015/2016 reporting year due to lack of observed flows. As a result, BMP performance monitoring sites in the Outfall 008 watershed are not discussed in this memorandum. Data from the Interim Source Removal Action (ISRA) locations are also not discussed in this memorandum because ISRA Phase III activities for watershed 009 were completed by the end of 2013.

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[1] Copper is not included as a pollutant of concern for the Outfall 009 watershed in the 2015 Expert Panel Work Plan. However, data for total copper are still presented in the paired line plots.

[2] Construction was completed in December of 2014. The 2015/2016 reporting year was the first year where a paired influent/effluent data sample was collected.

[3] Data from the Simi Hills – Rocketdyne Lab gauge (Ventura County Watershed Protection District site 249) was used to determine annual rainfall from 1958/1959 through 2000/2001. However, rainfall data was not available at this gauge from 1977/1978 through 1984/1985. Data from the Area 4 gauge (which was moved to Area 1 on January 1, 2013) was used to determine annual rainfall from 2001/2002 through 2015/2016. This results in a period of record (POR) of 50 years.

[4] A water year is typically defined as October 1 through September 30. However, due to the reporting timeline for the Annual Report, reporting years have been defined as June 1 through May 31.

[5] Monitoring occurs when rain events result in observable flow.

2 Overview of BMPs

Paired influent and effluent sampling data for each BMP for the same storm event were compared. Split samples were also periodically collected and used for lab comparison purposes; however, only the primary samples were used in the analysis. For each of the six CM sites discussed here[6], the number of paired samples ranges from 10 to 22 pairs for TSS, 11 to 21 pairs for dioxins, three to 22 pairs for copper, and 10 to 22 pairs for lead for all years combined. Six new CM paired samples were collected during this reporting year. Performance data for the lower lot biofilter (construction of which was completed in 2013) were collected from three locations within the system (influent, effluent, and a mid-point sample at the sedimentation basin outlet before the media filter inlet) during eight storm events in the 2015/2016 sampling year. As a result, there are 15 sample pairs associated with this location to date, including one 2013/2014 biofilter effluent sample reflecting a blend of filtered underdrain flows and overflows that bypassed the filter media.

The ELV Treatment BMP, implemented during the 2013/2014 reporting year, includes paired data taken during one event in the 2013/2014 reporting year, two events in 2014/2015, and three events in 2015/2016. These data are shown in the paired line plots and statistical analyses in the following sections, though it should be noted that it is possible that the media bed for this system may still have been flushing fines during the first sampling event in 2013/2014 since this was the first rain event it experienced. During this event, the ELV Treatment BMP was also heavily loaded by sediments eroded from the denuded ELV channel prior to implementation of recent erosion control improvements.

The B1436 detention bioswales, which were constructed in December 2014, were sampled for the first time during the 2015/2016 reporting year[7]. Samples were collected at three locations at the southern detention bioswale, which includes two influent locations (results from both locations were area-weighted to determine the influent concentrations) and the effluent. Performance data were collected during eight events at the southern detention bioswale during this reporting year. However, the effluent was not sampled during one of these events. Samples were also collected at both the influent and effluent locations of the northern detention bioswale during one event during the 2015/2016 reporting year. The effluent location was sampled for a total of seven events, but only one data pair was collected during this past reporting year.

Samples were also collected at the vegetated channel in the upper Northern Drainage above the biofilter outlet during the 2015/2016 reporting year. Samples were collected downstream of the vegetated channel in previous reporting years (2012/2013, 2013/2014, and 2014/2015). However, the most recent reporting year was the first year that samples were also collected at the B-1 culvert outfall.

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[6] Includes CM-1, CM-3, CM-8, CM-9, CM-11, and B-1. However, CM-3 was excluded from this analysis due to post-storm dry weather flows observed at the outlet between February 2010 and March 2011 when no flows were observed entering the culvert, suggesting subsurface inflows were contributing to effluent samples, thus limiting the meaningfulness of an influent-effluent comparison.

[7] The effluent of the northern detention bioswale (ILBMP0007) was sampled in the 2014/2015 reporting year (May 2015). However, a paired influent sample was not collected during this event.

Data were collected at this site during three rain events during the 2015/2016 rain year, but paired data at both the B-1 culvert outfall and downstream of the vegetated channel were only collected during two of these events.

With respect to sampling at the CM sites, influent grab samples are collected from flowing surface water upstream of the maximum extent of ponding at each CM as observed before that date.[8] All sampled CMs include a media filter and a slipline HDPE lining through existing galvanized corrugated metal culvert pipes with the exception of B-1, which is a media bed with no slipline element. CM effluent grab samples are collected at the culvert outlets on the downstream side of the road, where the culvert pipes discharge to the Northern Drainage, with the exception of CM-9 and B-1, where effluent samples were collected from the underdrain outlets beginning in October 2011, rather than the culvert outlet. Flows from the culvert outlets may represent treated runoff (via sedimentation and media filtration) and partially treated runoff (flowing through or over the weir boards). At CM-3, the slipline HDPE pipes were inserted from both the influent and effluent sides and could not be sealed at the point where they meet, and subsurface flows through the road embankment are known to have entered the pipe during rain events from February 2010 through March 2011[9] because water was observed discharging from the HDPE pipe outlet when no water was flowing into the inlet. Therefore, CM-3 performance as designed cannot be reliably assessed due to this bypassing of the media filter.

Monitoring sites at CM-1 (influent-east; see additional discussion in Section 1, below), CM-3, CM-8, and CM-11 receive runoff from drainage areas that do not include any known historic industrial activities, although the CM-3 drainage area does include a clean soil borrow area at the top of the watershed. Therefore, influent sample results at these four CM locations (not including CM-1 influent-west) are of relatively good quality and considered reflective of "background" stormwater concentrations, making it difficult to achieve additional COC reduction through these CMs. These "background" CM locations were therefore statistically evaluated separately from the other CM locations. Sampling at these background CM locations was discontinued following the 2010/2011 reporting year.

The BMPs discussed in this memo and their respective drainage areas are shown in Table 1. While these areas are discussed specifically with respect to performance monitoring data, there are other areas of the SSFL site which are also addressed by BMPs, including CMs, asphalt removal, erosion control, and treatment control BMPs.

[8] When the extent of ponding increased at the CM-1 and CM-3 culvert basins on December 22, 2010 during a heavy rainfall, the influent sample locations were moved upstream a sufficient distance to remain above the maximum ponded water footprint.

[9] Sampling at this site was discontinued after the 2010/2011 reporting year, so no observations have been made since March 2011.

Table 1. BMP Sites and Drainage Areas

BMP	Drainage Area (acres)	Approximate Impervious Cover (%)
CM-1	52.8 (pre-ELV improvements) 42.4 (post-ELV improvements)	6.5 22
CM-3	16.8	30
CM-8	2.6	36
CM-9	10.2	48
CM-11	5.7	26
B-1 Media Filter	8.6	53
ELV Treatment BMP	15.6 (Helipad plug in place) 6.6 (Helipad plug removed)	26 37
Lower Lot Biofilter	29.9[1]	53
Vegetated Channel	50.6	29
Detention Bioswale	18.2	50

[1] A percentage of the 24-inch stormdrain drainage area is diverted to the lower lot biofilter for treatment. As a result, the percent of runoff volume captured and treated from the smaller (approximately 11.7 acre) lower lot drainage area is greater than the percent of long-term runoff volume captured and treated from the larger (approximately 18.2 acre) 24-inch stormdrain drainage area. The average impervious cover of the smaller lower lot drainage area of 11.7 acres is 60%.

3 Paired Line Plots

The log-scale line plots presented in this section illustrate the changes in measured concentrations between influent and effluent sample pairs at each treatment BMP. Paired data were obtained from CM locations B-1, CM-1, CM-8, CM-9, and CM-11, the ELV Treatment BMP, the lower parking lot biofilter, the vegetated channel in the upper Northern Drainage above the biofilter outlet, and the detention bioswales. Data are presented by constituent of concern (COC) in Figure 1 through **Figure** 47, where paired data are represented by two points (influent and effluent) connected by a line, and single sample results (where both an influent and effluent sample was not collected) are shown by single points without any connected line. Points and lines are shaded based on the sampling year during which they were collected, where black lines and points represent data from the 2015/2016 reporting year and data from all previous reporting years are shown as gray. In addition, different symbology is used for different influent and effluent sample collection locations (symbology is defined in each graph). Additionally, non-detect results are displayed as the detection limit. The detection limit may vary slightly from year to year, but the typical detection limit is also shown as a black dotted line. The statistical analysis of the datasets is presented in Section 2.

In addition to evaluating BMP performance, the monitoring data have also been used in the site selection evaluations for consideration for enhancements to selected CMs for improved performance in areas where the effluent remains problematic. This was the case at CM-9 based on previous year results, and upgradient improvements were added in 2013. Other examples of improvements include asphalt removal and filter fabric installation. For these sites, separate graphs are shown for sample results that occurred before and after the improvements were made. At the B-1 media filter site, media washout was observed during initial sampling dates in the 2011/2012 reporting year. Results collected during this period were removed from the analysis. It should be noted that the ISRA program in watershed 009 was completed by 9/30/2013.

Monitoring data were first collected at the new ELV Treatment BMP during the 2013/2014 reporting year; since that was the first rain event that the system experienced, it is possible that the monitoring data reflect media fines being flushed out of the system. In addition, during the February/March 2014 storm event, a plug in the storm drain under Helipad Road resulted in high flows from Helipad Road being routed to the ELV sump and treatment system. Additionally, inadequate erosion controls along the earthen ELV channel resulted in sediment filling the sump, and a power outage resulted in the sump pump turning off. The influent-effluent pollutant concentration reduction performance of the ELV Treatment BMP is not expected to be affected by these conditions; however, the fraction of runoff volume captured from the ELV drainage area during each storm is expected to be reduced due to these factors. Although no overflow events as described previously were observed during the 2014/2015 reporting year, this plug was not removed for any storm events. The plug was not in place during the 2015/2016 reporting year. However, samples collected at this location during the most recent reporting year reflect runoff from the small drainage area on the backside of the berm, instead of the main helipad area.

The B1436 detention bioswales were constructed in December of 2014, that provided pretreatment and detention of upper area paved area flows that resulted in increased treatment capacity at the lower lot biofilter. It is estimated that the average volume pumped to the biofilter has increased from approximately 52,000 gallons per inch of rainfall to approximately 82,000 gallons per inch of rainfall since the detention bioswales were constructed. Similarly, the estimated percent of total annual runoff volume captured and treated (from both the 24-inch drain and the lower lot drainage areas) has increased from 22% to 44% on average since the detention bioswales were constructed.

Several CM locations (CM-1, CM-9, and the B-1 media filter) and the southern detention bioswale have multiple influent drainage areas:

- CM-1 receives runoff from an eastern tributary that is considered to reflect background concentrations as well as a western tributary comprising paved road and ELV hillside runoff (ELV hillside runoff is only reflected in samples collected prior to November 2013);
- CM-9 receives runoff from the Area I Landfill and former Building 1324 parking lot (demolished Summer/Fall 2011), as well as the paved road to the east; and
- B-1 receives runoff from the north, comprised of paved road runoff, and the south, comprised of the upper B-1 ISRA areas, the sedimentation basin, and paved road runoff.
- The southern detention bioswale receives runoff discharged from the rock crib swale and the paved area adjacent to the detention bioswales (contractor laydown area).

The selection of the influent location used in the paired analysis was evaluated on a case by case basis, with similar sample dates taking precedence (between influent and effluent); in instances when two influent samples were available for the same effluent-sampling storm event, an impervious area-weighted average (used as an estimate of proportioned flowrate from each influent stream) was used to represent a single influent value. With regards to the line plots, the BMP effects on events having influent concentrations above the Permit Limit is the most important performance criterion since those below the Permit Limit are already of acceptable quality and are generally considered to be at levels unlikely to be further reduced using typical stormwater controls, especially considering the conditions that have been experienced to date in terms of precipitation and watershed erosion. As with most stormwater quality controls, the water quality improvements are largest when the influent concentrations are highest.

These charts are included for general visual assessment purposes only; the statistical tests in later sections are used to make quantitative evaluations on BMP performance. It should be noted that these samples are all grab samples, and therefore highly variable in terms of water quality results, and may represent collection times that vary throughout the storm event hydrograph. Therefore, relatively large numbers of samples are needed to represent the varying conditions with reasonable statistical confidence and power.

The following five effluent samples were collected during overflow/bypass conditions based on available field notes. These conditions are noted on the plots with red markers and indicate decreased performance. No other sampling dates were noted as having overflows in the available field notes, so whether or not this occurred for other dates cannot be determined. In addition, observations of weir board overflows were collected starting in the 2011/2012 reporting year. It is unknown which prior samples, if any, were collected during overflow conditions. Sampling notes, which now more carefully track this information, have not noted any samples collected under overflow conditions since the 2011/2012 observations listed below.

CM-9, effluent underdrain (A1SW0009) samples:

- 10/5/2011 (max intensity = 0.18 in/hr; duration = 9 hours; total depth = 0.90 inches)
- 3/17/2012 (max intensity = 0.31 in/hr; duration = 29 hours; total depth = 1.51 inches)
- 3/25/2012 (max intensity = 0.51 in/hr; duration = 21 hours; total depth = 2.12 inches)

CM-1, effluent culvert outlet (A1SW0002) samples:

- 3/17/2012 (max intensity = 0.31 in/hr; duration = 29 hours; total depth = 1.51 inches)
- 3/25/2012 (max intensity = 0.51 in/hr; duration = 21 hours; total depth = 2.12 inches)

Table 2 summarizes rainfall events in which data were collected for the 2009-2016 reporting years (‘non sample collection events’ represent precipitation events where samples were not collected). Not all BMPs had influent and effluent flows during each rain event.

Table 2. Sample Collection Event Rainfall Data Summary (gray cells indicate dates that did not have data pairs sampled)

Date(s)	Average Intensity (in/hr)	Max Intensity (in/hr)	Event Total (in)	Event Duration (hrs)	Cumulative Rainfall for Sampled Events (in)
10/13/2009 - 10/14/2009	0.05	0.24	2.48	35	2.48
12/7/2009 - 12/13/2009	0.02	0.25	3.43	57	5.91
1/17/2010 – 1/22/2010	0.05	0.52	6.88	123	12.79
2/5/2010 – 2/6/2010	0.04	0.20	1.84	43	14.63
2/9/2010	0.01	0.17	0.20	3	14.83
2/19/2010	0.01	0.05	0.14	8	14.97
2/24/2010	0.01	0.03	0.12	12	15.09
2/27/2010	0.06	0.34	1.52	17	16.61
3/6/2010	0.02	0.13	0.38	11	16.99
4/4/2010 - 4/5/2010	0.03	0.23	0.86	13	17.85
4/11/2010 - 4/12/2010	0.03	0.22	0.65	11	18.50
Non sample collection event total[1]			*0.89*		
Total for 2009/2010 reporting year			**19.39**		
10/5/2010 - 10/6/2010	0.049	0.18	0.93	20	0.93
10/16/2010 - 10/25/2010	0.003	0.22	0.69	216	1.62
11/17/2010 - 11/21/2010	0.011	0.23	0.97	89	2.59
12/5/2010	0.018	0.09	0.41	10	3.0
12/17/2010 – 12/22/2010	0.054	0.37	7.22	131	10.22
12/25/2010 - 12/26/2010	0.030	0.22	0.57	9	10.79
12/29/2010	0.043	0.10	0.43	7	11.22
1/2/2011 - 1/3/2011	0.014	0.12	0.38	17	11.60
2/15/2011 – 2/20/2011	0.019	0.45	2.33	121	13.93
2/25/2011 - 2/26/2011	0.030	0.22	1.50	20	15.43
3/2/2011 - 3/3/2011	0.007	0.03	0.13	8	15.56
3/6/2011 - 3/7/2011	0.006	0.02	0.12	10	15.68
3/18/2011 - 3/27/2011	0.030	--	6.00	197	21.68
5/15/2011 - 5/18/2011	0.009	0.08	0.67	76	22.35
Non sample collection event total[1]			*1.04*		
Total for 2010/2011 reporting year			**23.39**		
10/5/2011	0.090	0.18	0.90	9	0.90
11/4/2011 - 11/6/2011	0.041	0.23	0.58	59	1.48
11/11/2011 - 11/12/2011	0.035	0.26	0.76	22	2.24
11/19/2011 - 11/21/2011	0.031	0.29	0.78	35	3.02
12/12/2011 - 12/17/2011	0.006	0.21	0.80	137	3.82
1/21/2012 – 1/23/2012	0.017	0.15	1.06	62	4.88
2/27/2012	--	--	0.00	--	4.88
3/16/2012 - 3/18/2012	0.052	0.31	1.51	29	6.39
3/25/2012 – 3/26/2012	0.079	0.51	2.12	21	8.51
4/10/2012 – 4/13/2012	0.034	0.36	2.37	64	10.88

Date(s)	Average Intensity (in/hr)	Max Intensity (in/hr)	Event Total (in)	Event Duration (hrs)	Cumulative Rainfall for Sampled Events (in)
4/23/2012 - 4/26/2012	0.003	0.09	0.26	80	11.14
Non sample collection event total[1]			*0.19*		
Total for 2011/2012 reporting year			**11.33**		
11/14/2012 – 11/18/2012	0.010	0.36	0.99	99	0.99
11/28/2012 – 12/4/2012	0.011	0.12	1.49	139	2.48
12/12/2012 – 12/18/2012	0.005	0.07	0.68	129	3.16
12/22/2012 – 12/26/2012	0.013	0.18	1.13	87	4.29
1/23/2013 – 1/27/2013	0.020	0.18	1.78	89	6.07
2/8/2013 – 2/9/2013	0.008	0.07	0.12	15	6.19
2/19/2013	0.025	0.09	0.25	10	6.44
3/7/2013 – 3/8/2013	0.041	0.23	0.87	7	7.31
5/5/2013 - 5/6/2013	0.040	0.16	0.48	7	7.79
Non sample collection event total[1]			*0.31*		
Total for 2012/2013 reporting year			**8.10**		
11/20/2013 – 11/21/2013	0.013	0.12	0.47	17	0.47
12/7/2013	0.070	0.09	0.28	4	0.75
2/6/2014 – 2/7/2014	0.015	0.15	0.28	16	1.03
2/26/2014 – 3/2/2014	0.052	0.47	4.62	89	5.65
4/1/2014 – 4/2/2014	0.008	0.14	0.22	28	5.87
Non sample collection event total[1]			*0.20*		
Total for 2013/2014 reporting year			**6.07**		
10/31/2014 – 11/1/2014	0.045	0.33	0.36	8	0.36
11/30/2014 – 12/4/2014	0.033	0.40	3.20	97	3.56
12/11/2014 – 12/12/2014	N/A[2]	N/A[2]	2.62	N/A[2]	6.18
12/15/2014 – 12/17/2014	0.025	0.33	0.91	36	7.09
1/10/2015 – 1/11/2015	0.071	0.23	1.56	22	8.65
1/26/2015 – 1/27/2015	0.015	0.06	0.25	17	8.90
2/22/2015 – 2/23/2015	0.008	0.06	0.21	26	9.11
3/1/2015 – 3/3/2015	0.024	0.22	1.44	60	10.55
5/14/2015 – 5/15/2015	0.017	0.30	0.41	24	10.96
Non sample collection event total[1]			*0.26*		
Total for 2014/2015 reporting year			**11.22**		
7/18/2015 – 7/19/2015	0.027	0.32	0.83	31	0.83
9/14/2015 – 9/15/2015	0.050	0.39	1.10	22	1.93
10/5/2015 – 10/6/2015	0.025	0.32	0.45	18	2.38
12/13/2015	0.055	0.06	0.11	2	2.49
12/19/2015 – 12/22/2015	0.008	0.08	0.52	65	3.01
1/5/2016 – 1/10/2016	0.030	0.60	3.87	129	6.88
1/18/2016 – 1/20/2016	0.005	0.02	0.20	40	7.08

Date(s)	Average Intensity (in/hr)	Max Intensity (in/hr)	Event Total (in)	Event Duration (hrs)	Cumulative Rainfall for Sampled Events (in)
1/31/2016	0.108	0.27	0.86	8	7.94
2/17/2016 – 2/18/2016	0.027	0.10	0.57	21	8.51
3/5/2016 – 3/7/2016	0.029	0.29	1.57	54	10.08
3/11/2016	0.088	0.34	0.44	5	10.52
4/7/2016 – 4/9/2016	0.010	0.10	0.52	52	11.04
5/6/2016	0.128	0.22	0.77	6	11.81
Non sample collection event total[1]			*0.16*		
Total for 2015/2016 reporting year			**11.97**		

[1] Rainfall was measured, but not considered a rain event per the NPDES definition.

[2] Area I weather station malfunctioned during rain event, rainfall totals from Station 436 used but hourly rainfall not available.

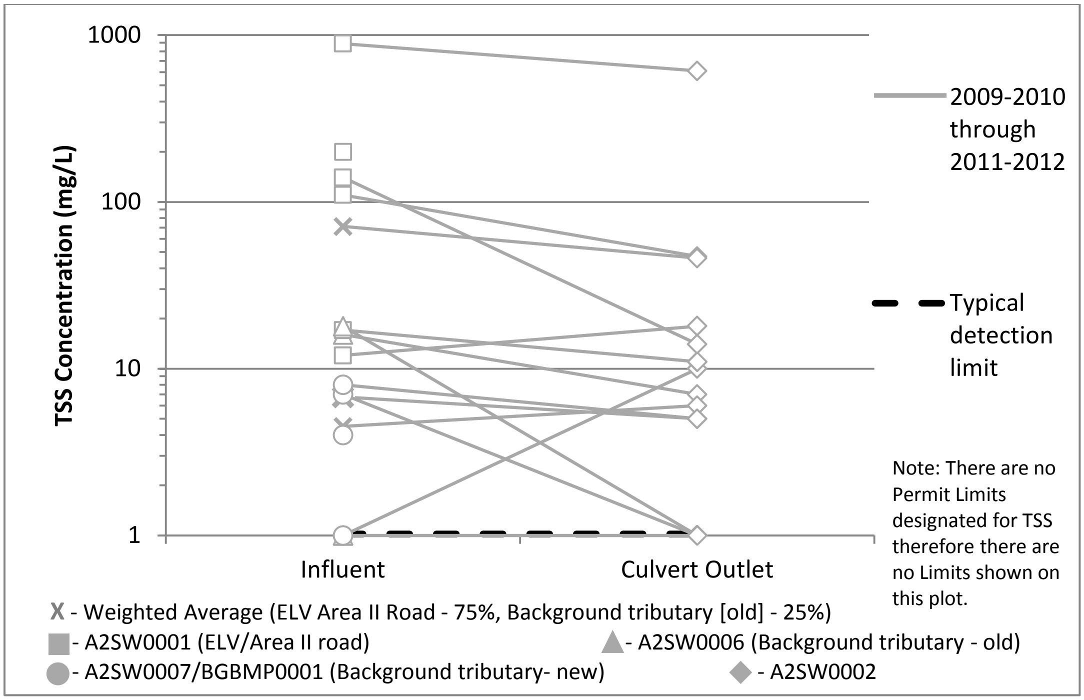

Figure 1. TSS at CM-1, pre filter fabric installation (filter fabric installed on 1/20/2012)

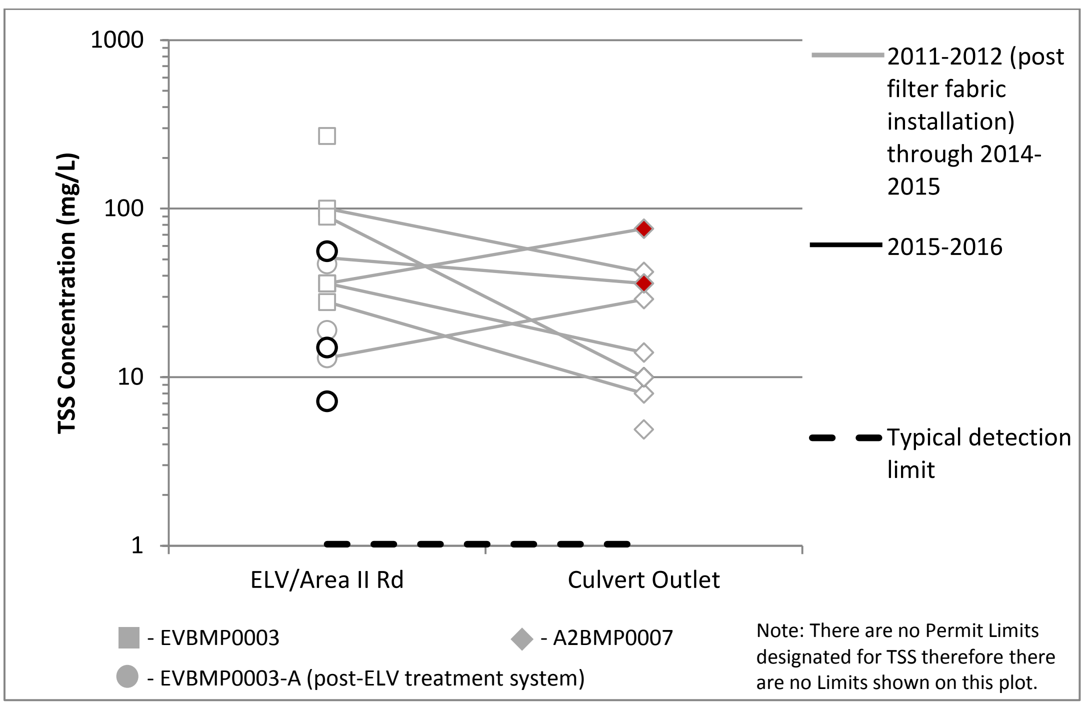

Figure 2. TSS at CM-1, post filter fabric installation (filter fabric installed on 1/20/2012)

Note: Bold markers and bold solid lines represent 2015-2016 samples; red markers indicate samples collected during weir board overflow

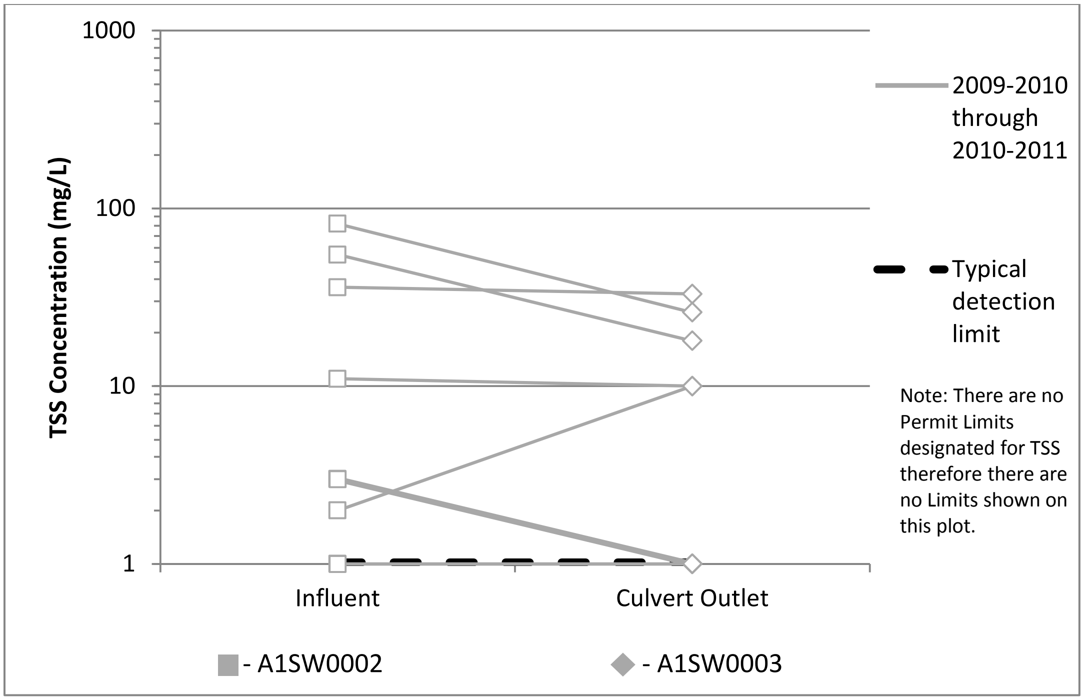

Figure 3. TSS at CM-8

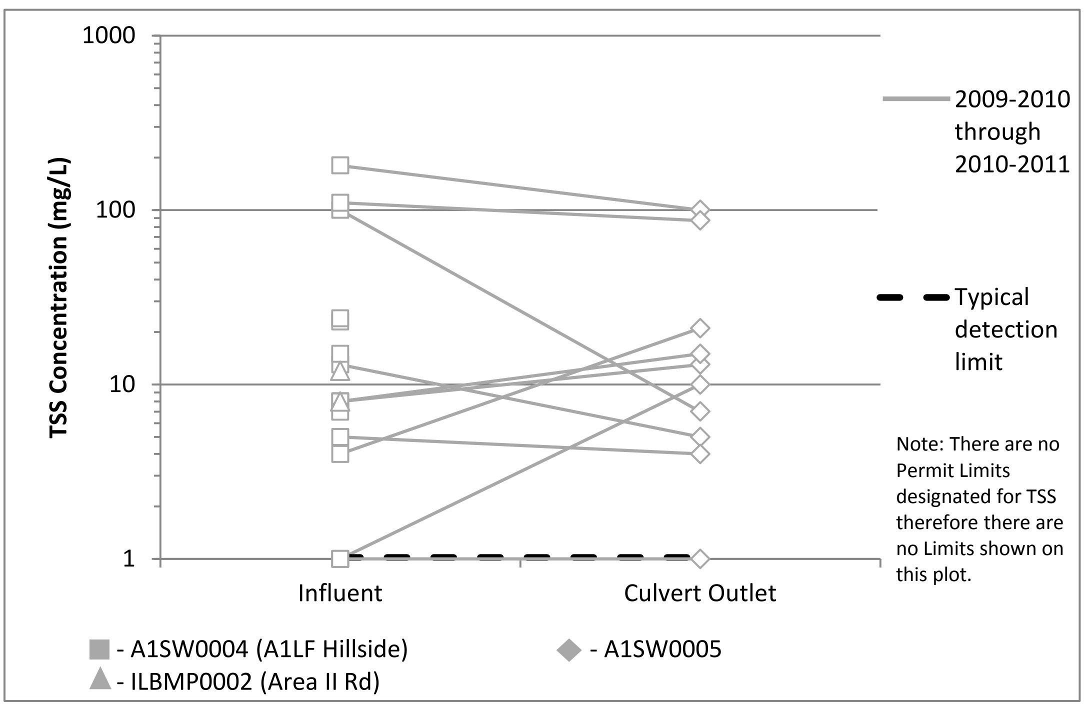

Figure 4. TSS at CM-9, pre improvements (removal of A1LF asphalt [9/1/2011] and addition of CM weir board filter fabric [1/20/2012])

Note: Bold markers and bold solid lines represent 2015-2016 samples; red markers indicate samples collected during weir board overflow

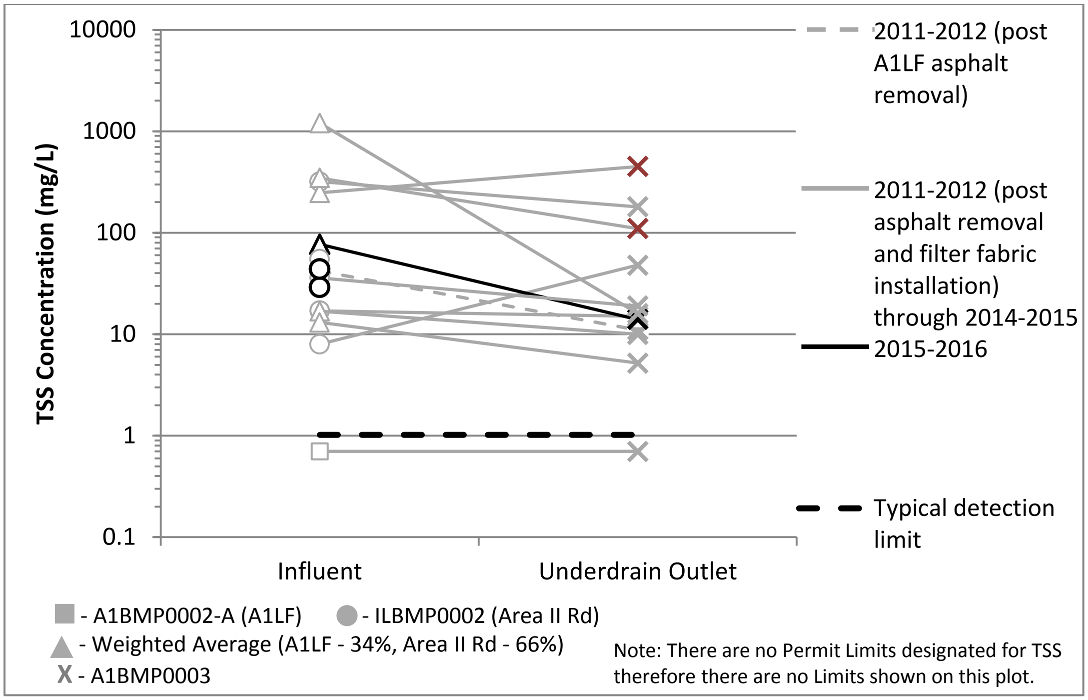

Figure 5. TSS at CM-9, post improvements (removal of A1LF asphalt [9/1/2011] and addition of CM weir board filter fabric [1/20/2012])

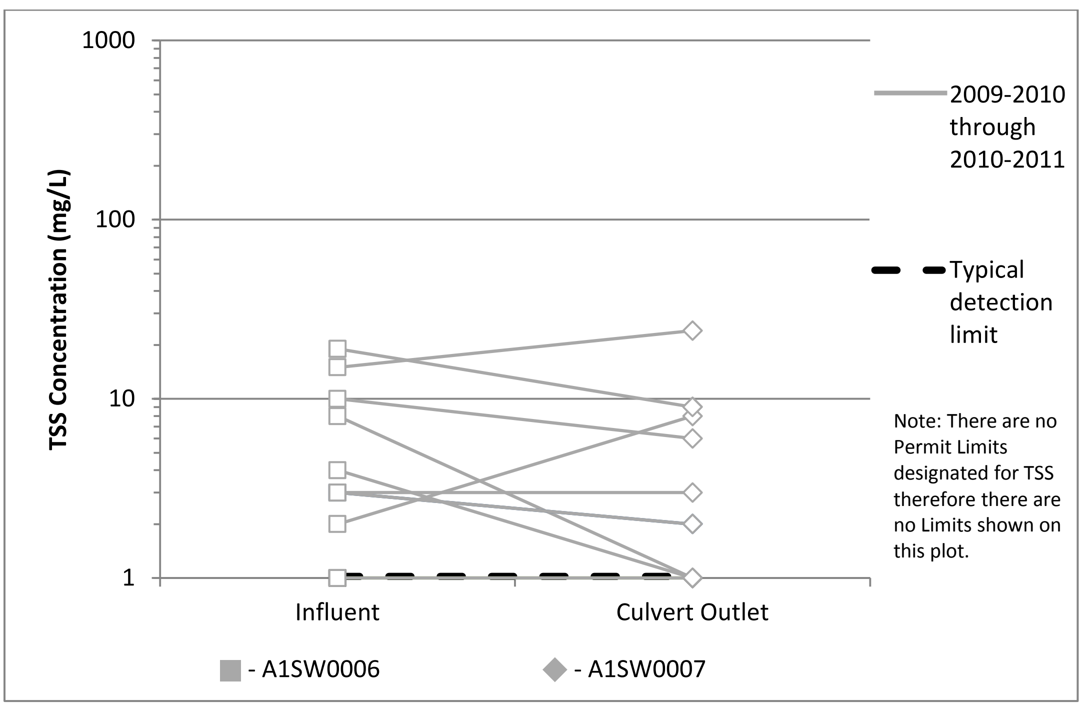

Figure 6. TSS at CM-11

Note: Bold markers and bold solid lines represent 2015-2016 samples; red markers indicate samples collected during weir board overflow

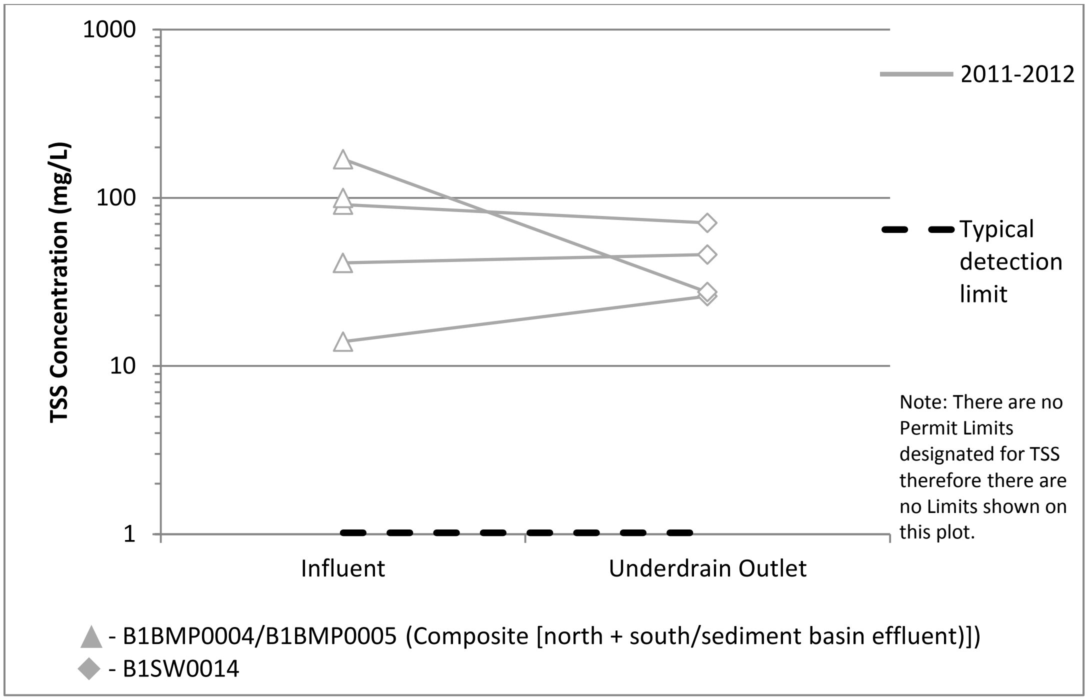

Figure 7. TSS at B-1 Media Filter (CM), pre curb cuts (curb cuts installed on 11/2/2012)

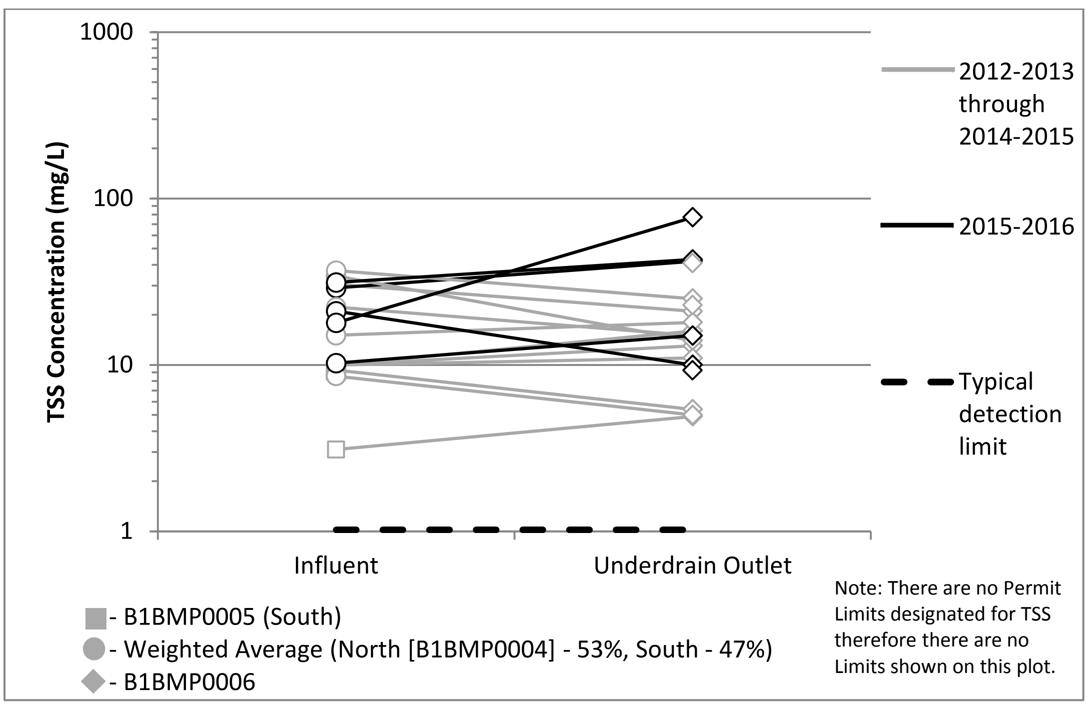

Figure 8. TSS at B-1 Media Filter (CM), post curb cuts (curb cuts installed on 11/2/2012)

Note: Bold markers and bold solid lines represent 2015-2016 samples; red markers indicate samples collected during weir board overflow

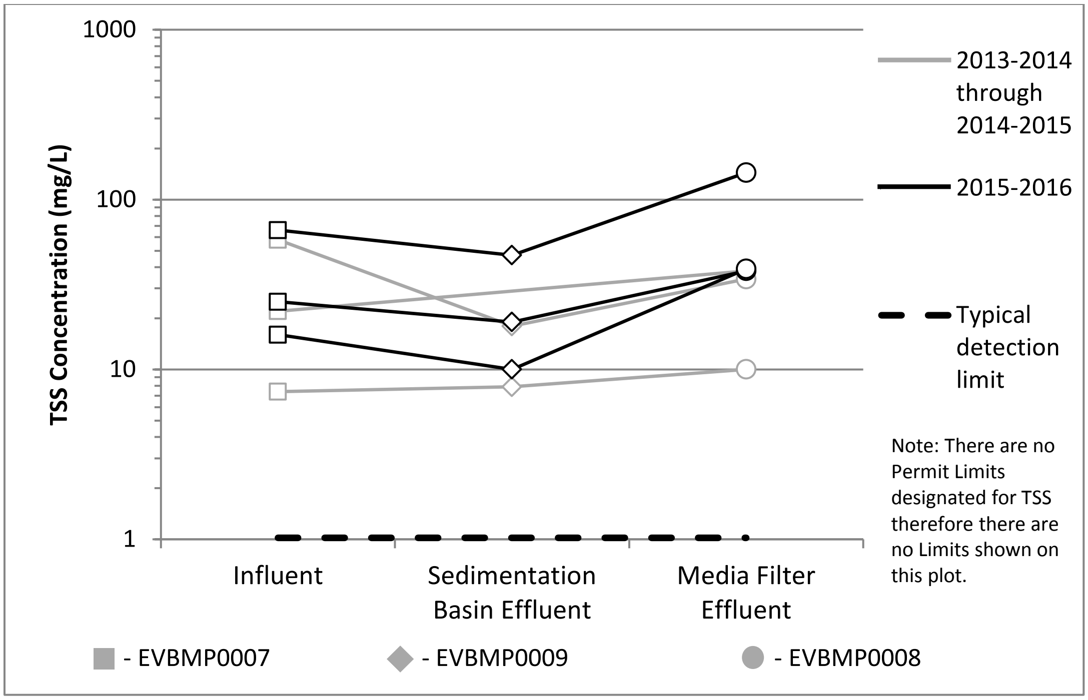

Figure 9. TSS at ELV Treatment BMP

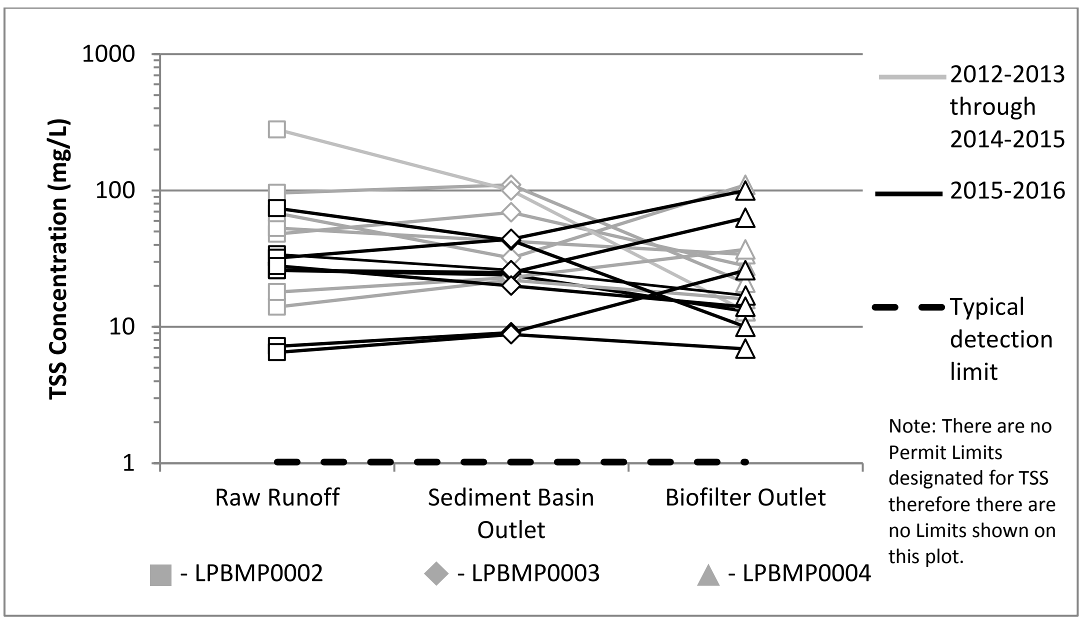

Figure 10. TSS at Lower Lot Biofilter[10]

Note: Bold markers and bold solid lines represent 2015-2016 samples; red markers indicate samples collected during weir board overflow

[10] A sample was not taken at the biofilter inlet (post-sedimentation basin) during the 2013/2014 sampling year due to the sample location being submerged and inaccessible. The biofilter outlet sample from the 2013/2014 reporting year reflects a mix of filtered underdrain flow and unfiltered overflow.

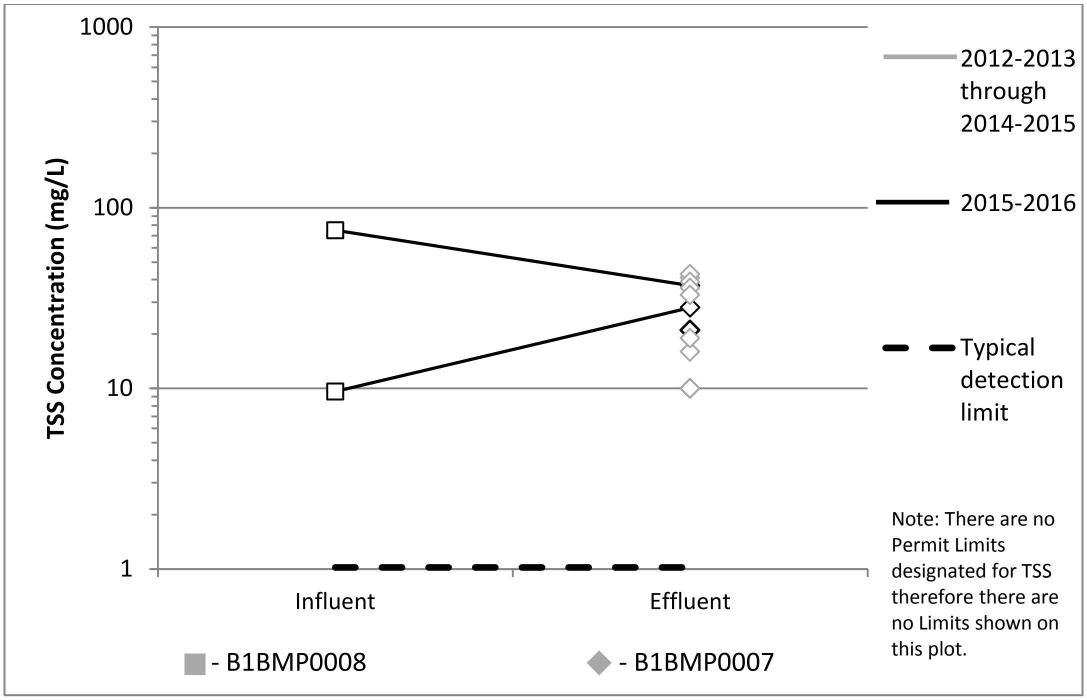

Figure 11. TSS at Vegetated Channel

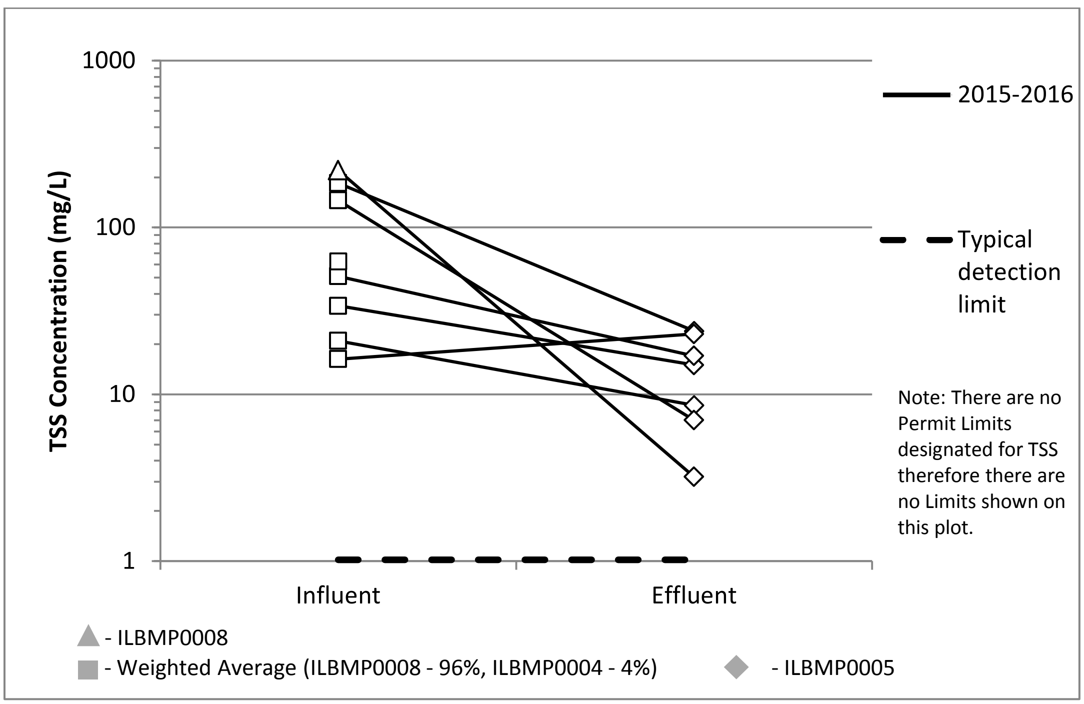

Figure 12. TSS at Southern Detention Bioswale

Note: Bold markers and bold solid lines represent 2015-2016 samples; red markers indicate samples collected during weir board overflow

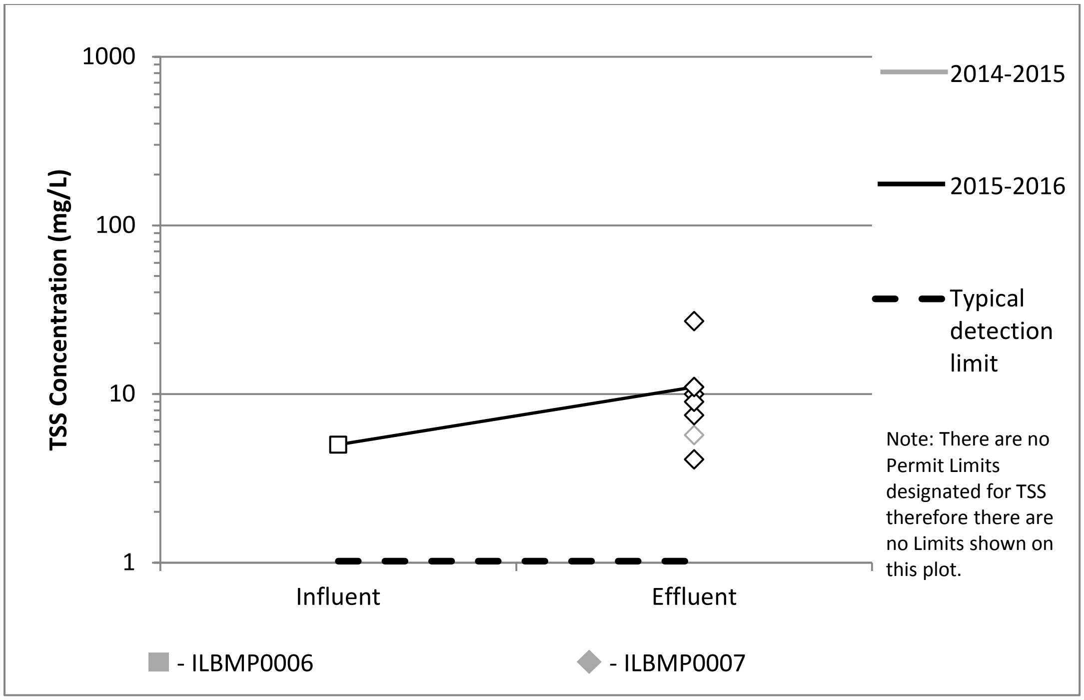

Figure 13. TSS at Northern Detention Bioswale

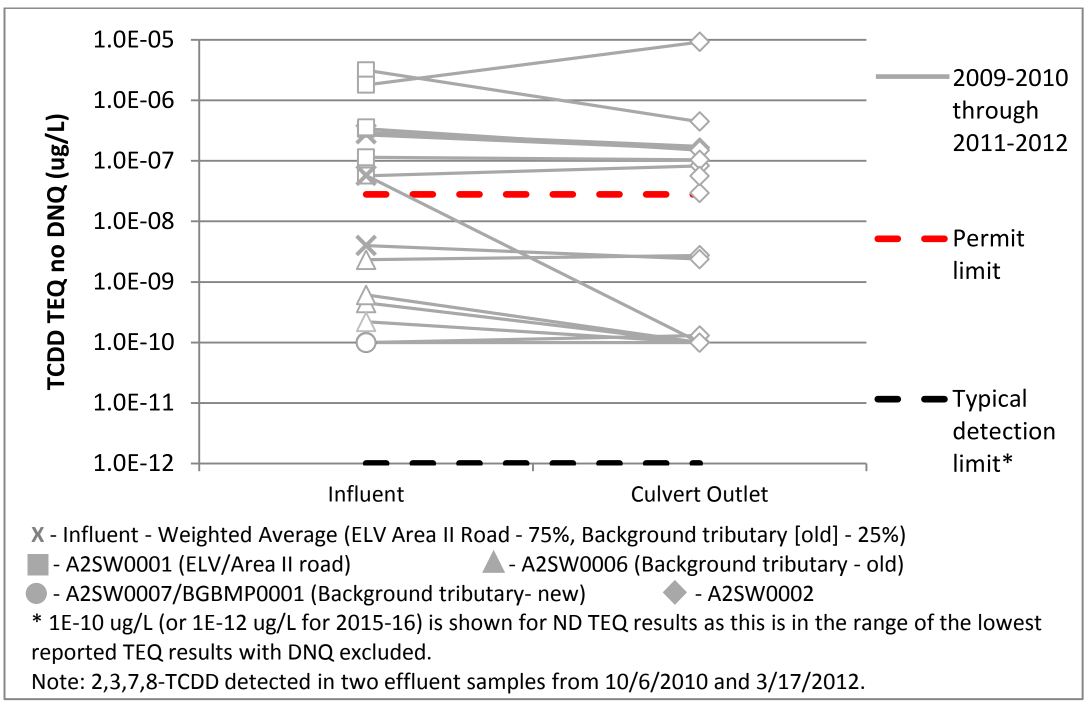

Figure 14. Dioxins at CM-1, pre filter fabric installation (filter fabric installed on 1/20/2012)

Note: Bold markers and bold solid lines represent 2015-2016 samples; red markers indicate samples collected during weir board overflow

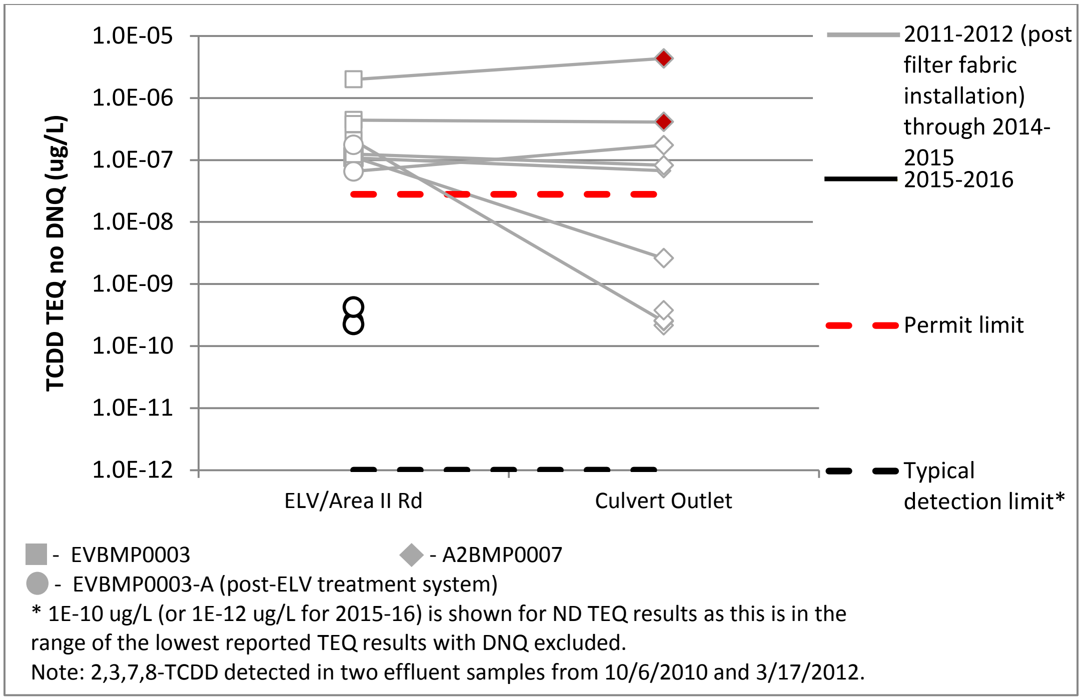

Figure 15. Dioxins at CM-1, post filter fabric installation (filter fabric installed on 1/20/2012)

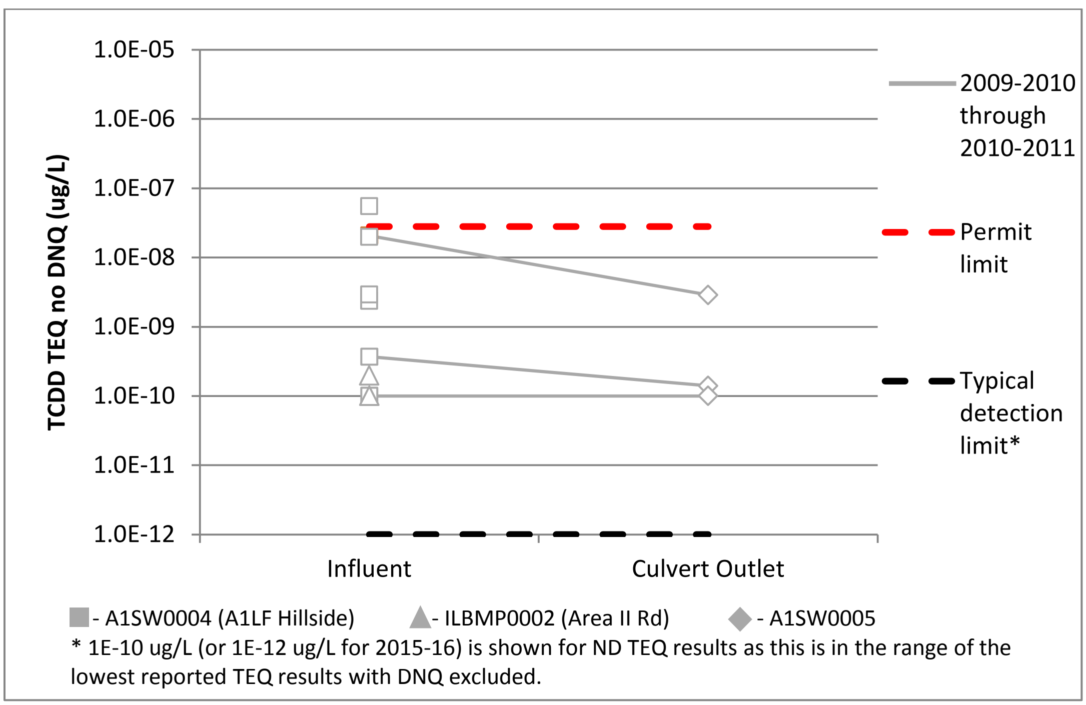

Figure 16. Dioxins at CM-9, pre improvements (removal of A1LF asphalt [9/1/2011] and addition of CM weir board filter fabric [1/20/2012])

Note: Bold markers and bold solid lines represent 2015-2016 samples; red markers indicate samples collected during weir board overflow

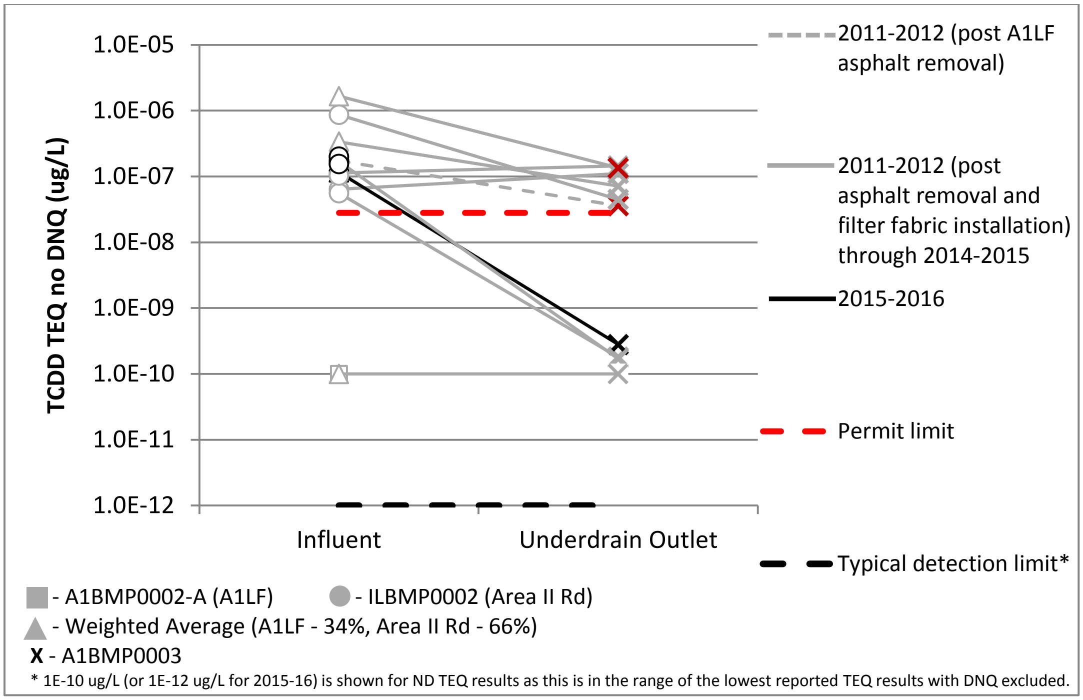

Figure 17. Dioxins at CM-9, post improvements (removal of A1LF asphalt [9/1/2011] and addition of CM weir board filter fabric [1/20/2012])

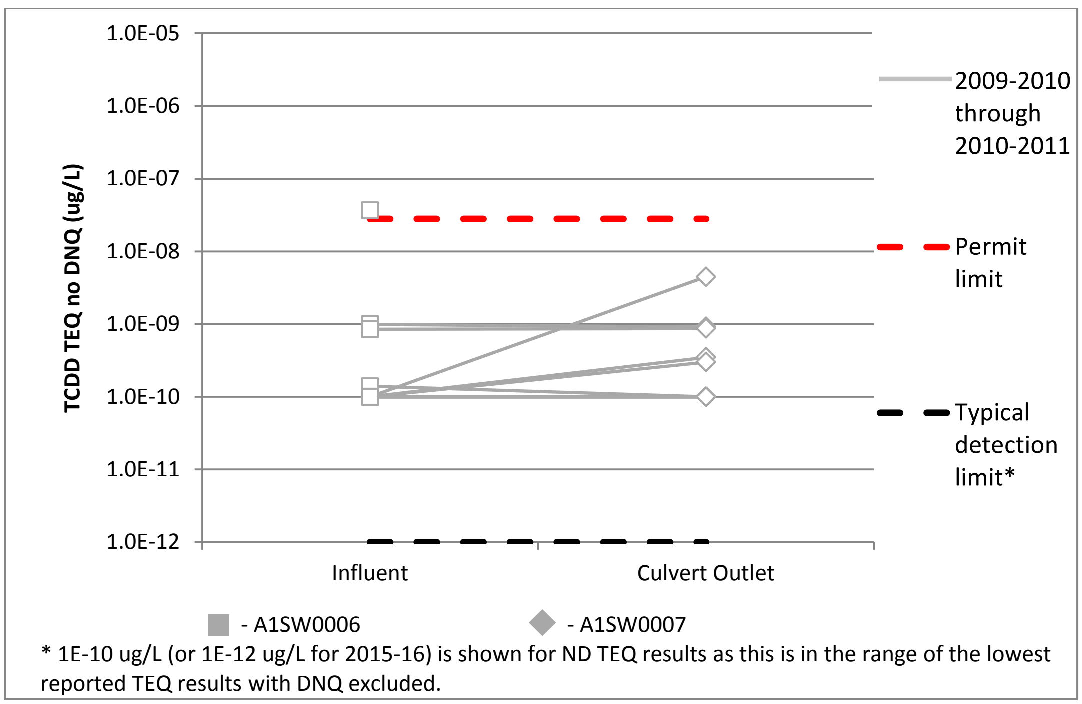

Figure 18. Dioxins at CM-11

Note: Bold markers and bold solid lines represent 2015-2016 samples; red markers indicate samples collected during weir board overflow

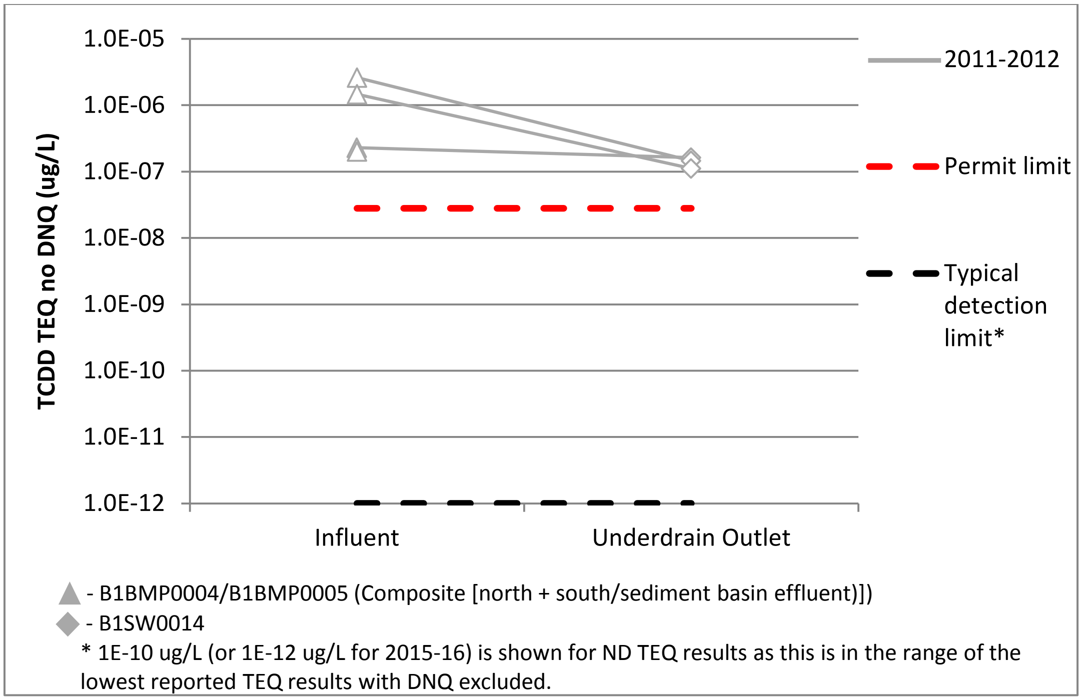

Figure 19. Dioxins at B-1 Media Filter (CM), pre curb cuts (curb cuts installed on 11/2/2012)

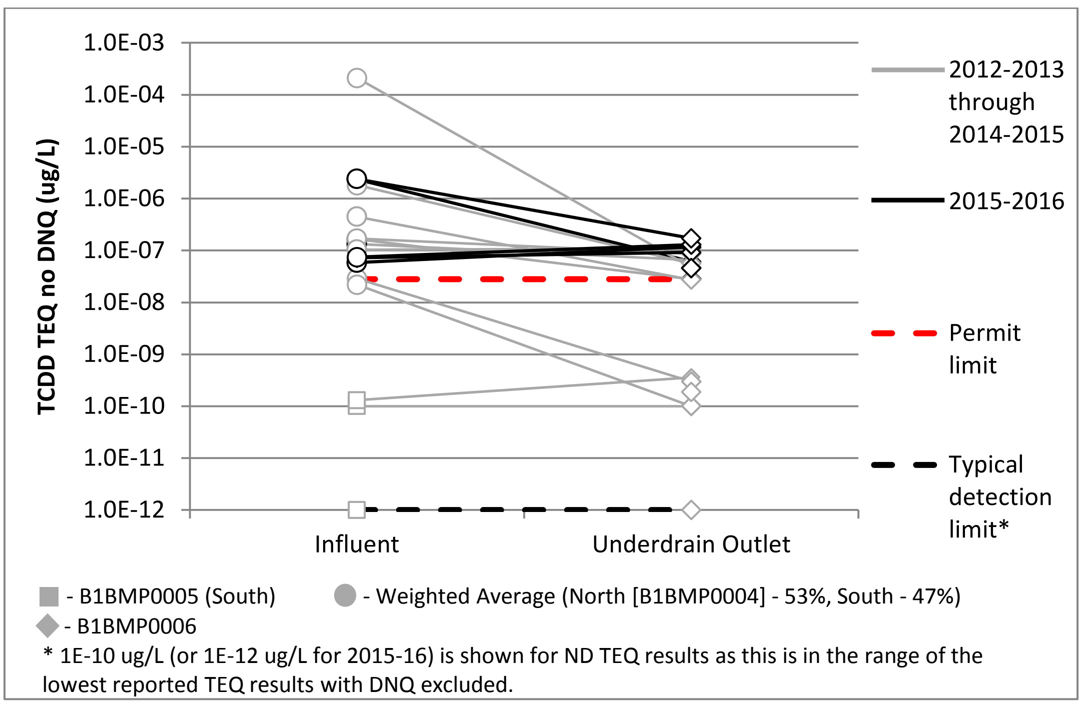

Figure 20. Dioxins at B-1 Media Filter (CM), post curb cuts (curb cuts installed on 11/2/2012)

Note: Bold markers and bold solid lines represent 2015-2016 samples; red markers indicate samples collected during weir board overflow

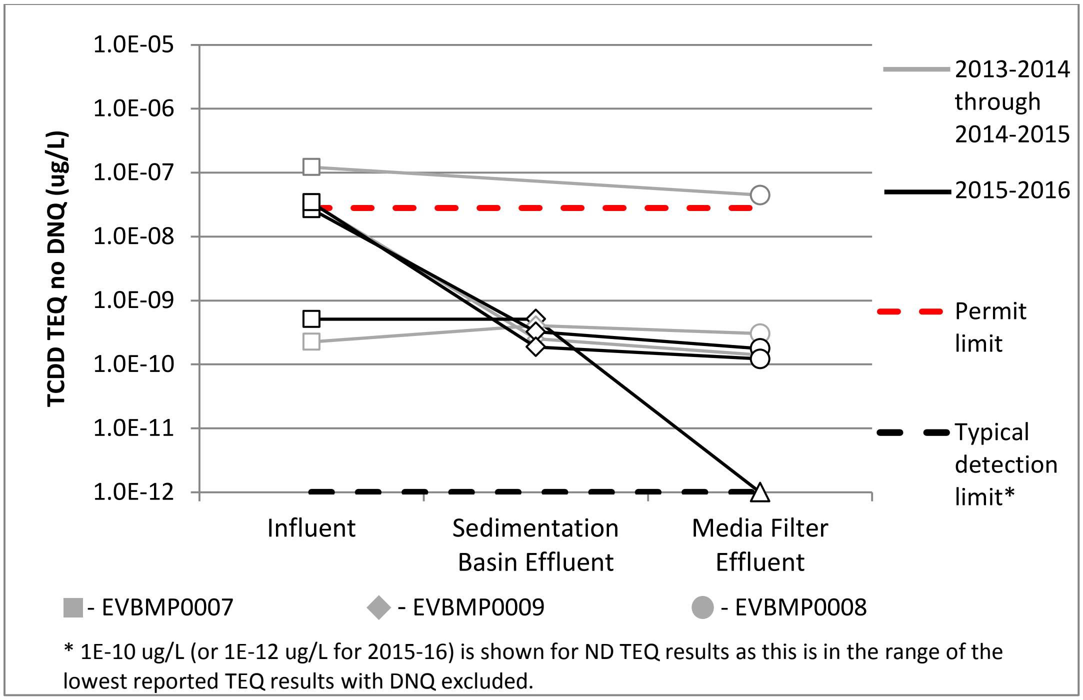

Figure 21. Dioxins at ELV Treatment BMP

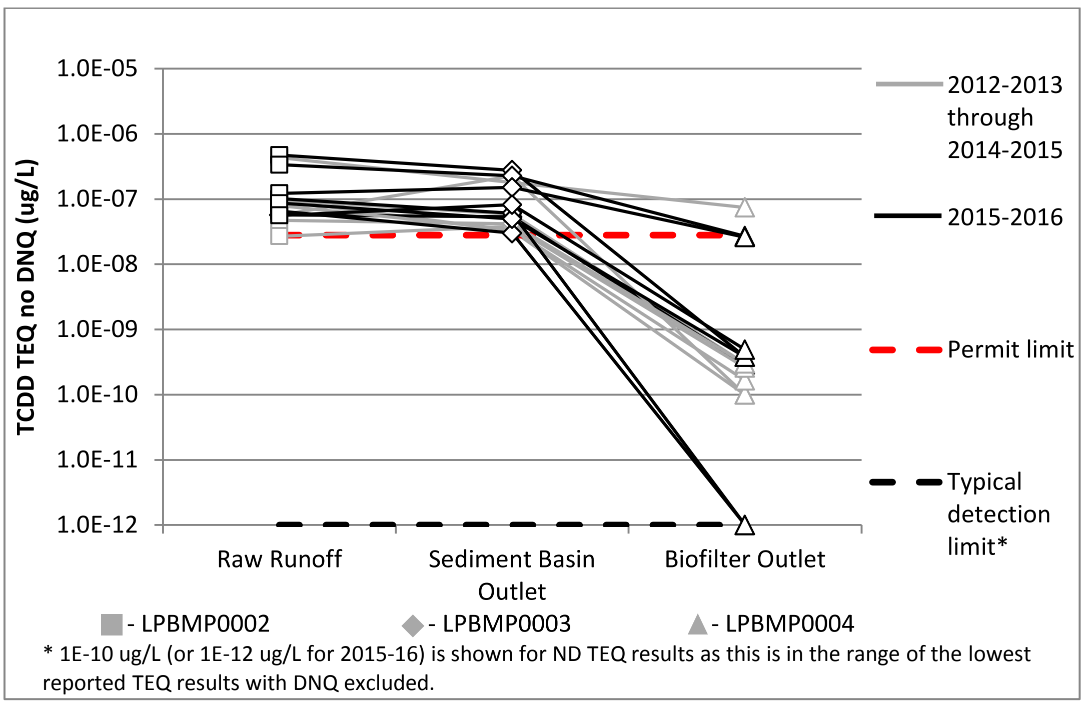

Figure 22. Dioxins at Lower Lot Biofilter

Note: Bold markers and bold solid lines represent 2015-2016 samples; red markers indicate samples collected during weir board overflow

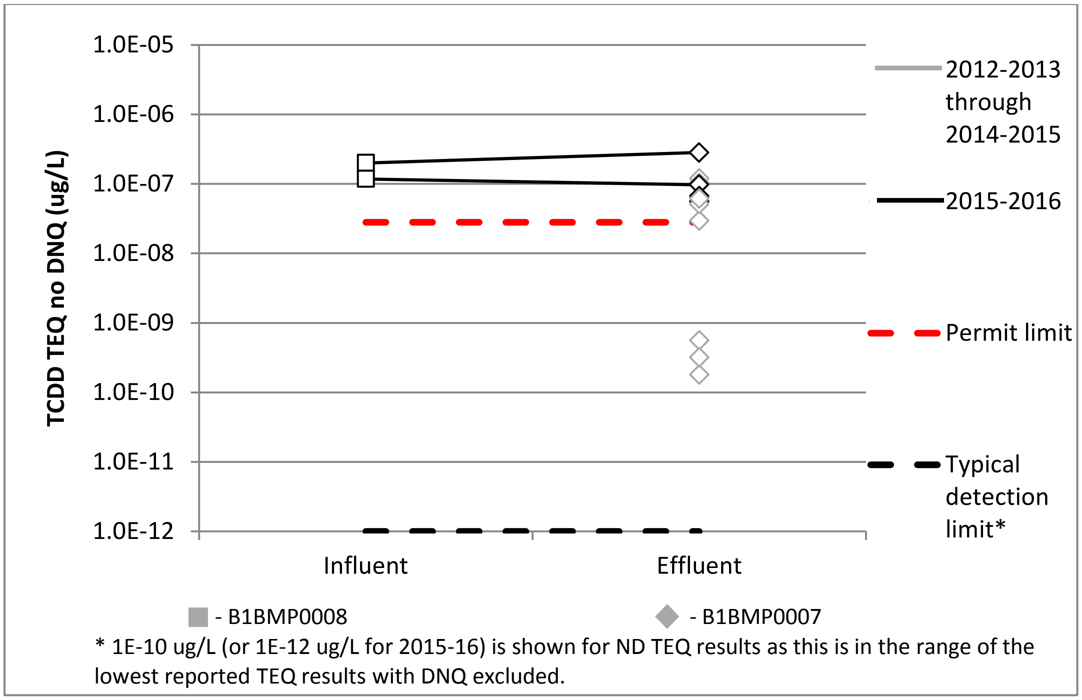

Figure 23. Dioxins at Vegetated Channel

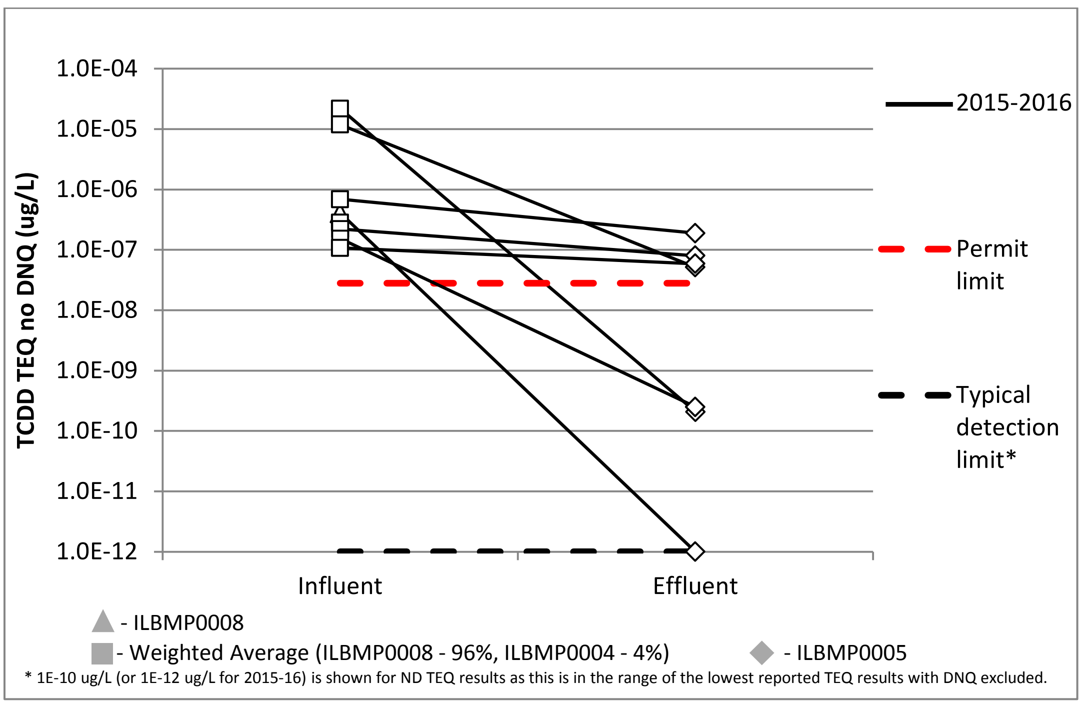

Figure 24. Dioxins at Southern Detention Bioswale

Note: Bold markers and bold solid lines represent 2015-2016 samples; red markers indicate samples collected during weir board overflow

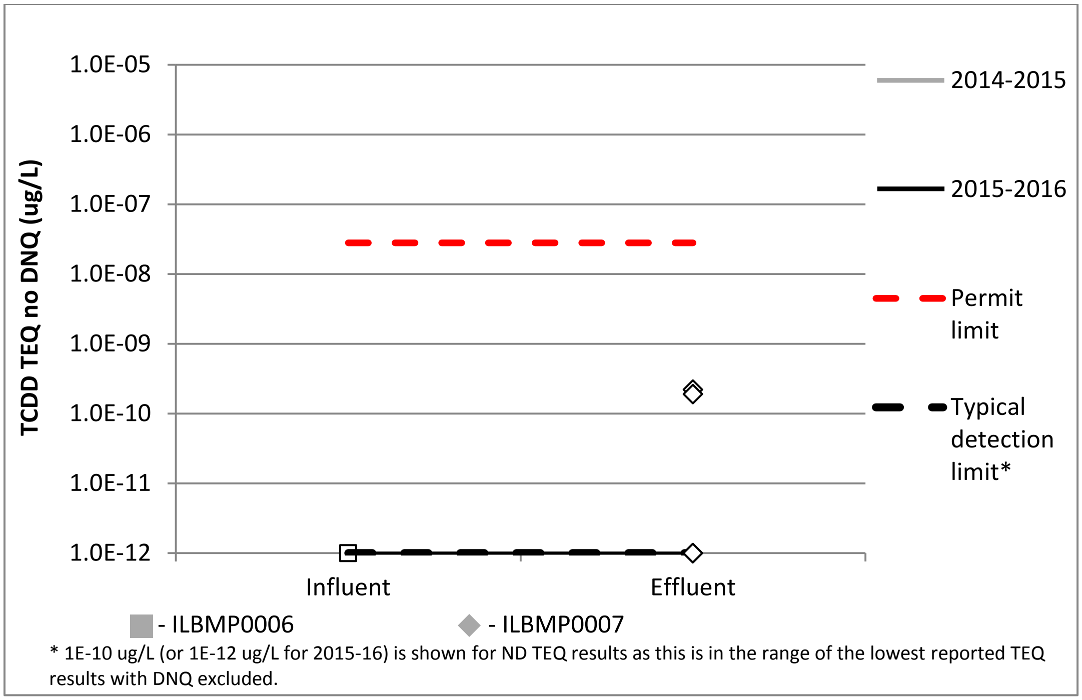

Figure 25. Dioxins at Northern Detention Bioswale

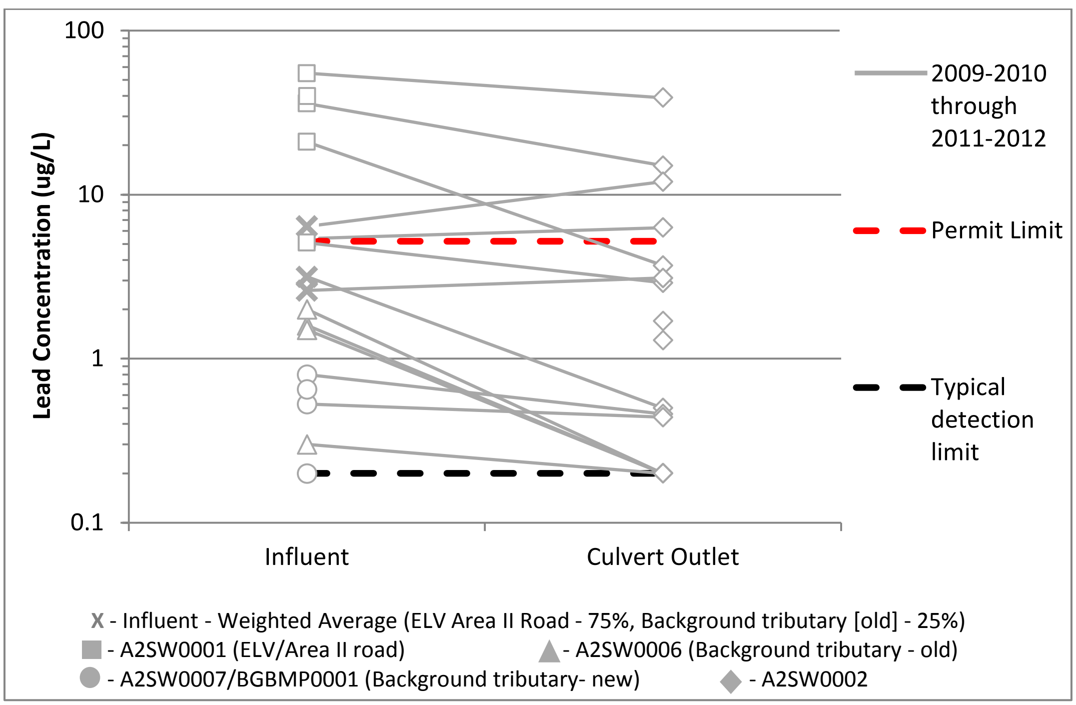

Figure 26. Lead at CM-1, pre filter fabric installation (filter fabric installed on 1/20/2012)

Note: Bold markers and bold solid lines represent 2015-2016 samples; red markers indicate samples collected during weir board overflow

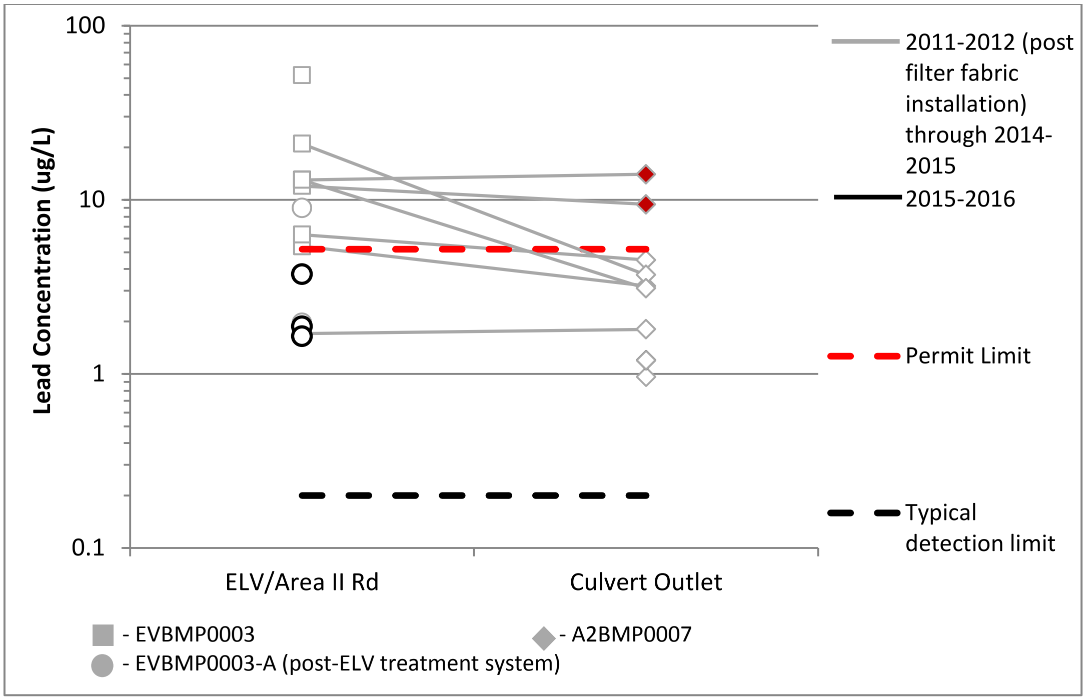

Figure 27. Lead at CM-1, post filter fabric installation (filter fabric installed on 1/20/2012)

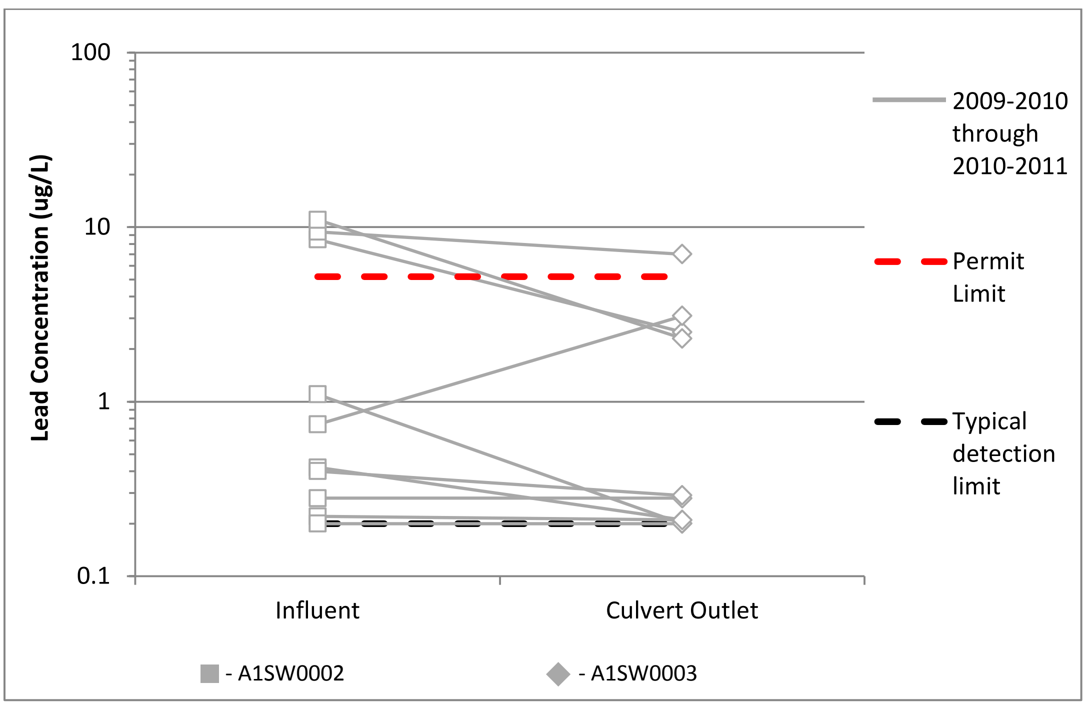

Figure 28. Lead at CM-8

Note: Bold markers and bold solid lines represent 2015-2016 samples; red markers indicate samples collected during weir board overflow

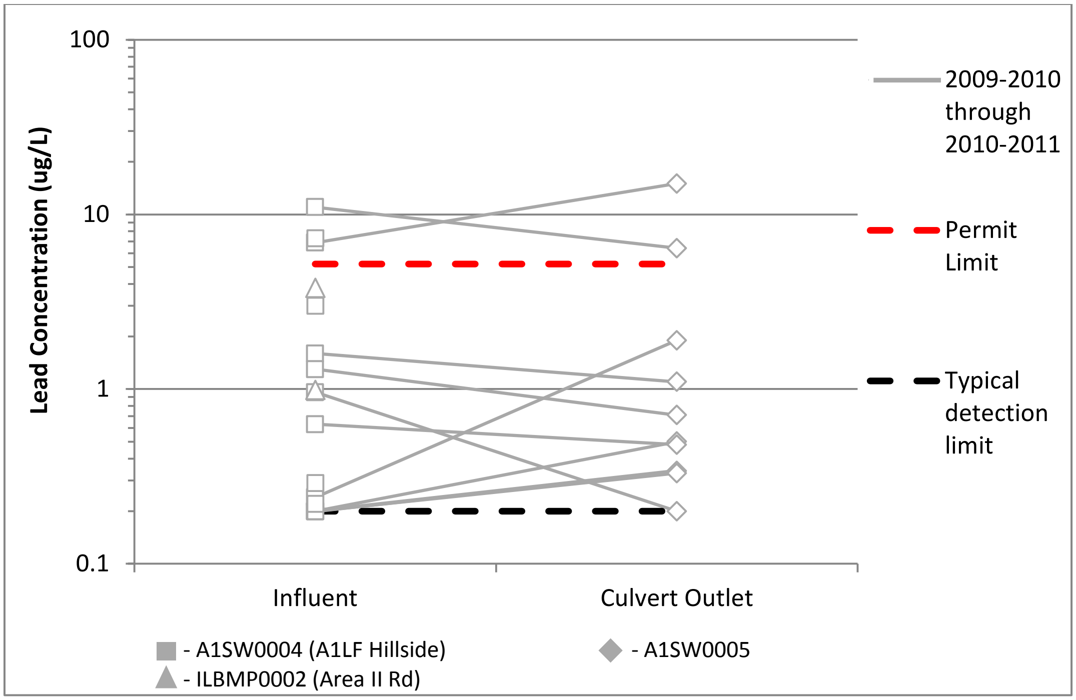

Figure 29. Lead at CM-9, pre improvements (removal of A1LF asphalt [9/1/2011] and addition of CM weir board filter fabric [1/20/2012])

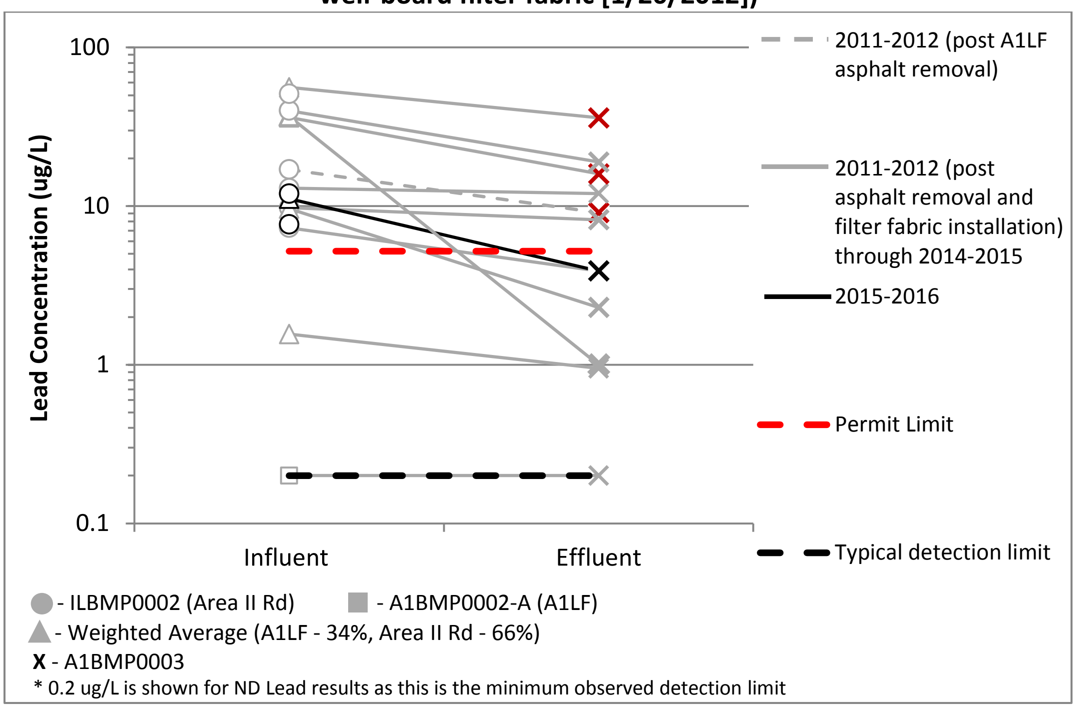

Figure 30. Lead at CM-9, post improvements (removal of A1LF asphalt [9/1/2011] and addition of CM weir board filter fabric [1/20/2012])

Note: Bold markers and bold solid lines represent 2015-2016 samples; red markers indicate samples collected during weir board overflow

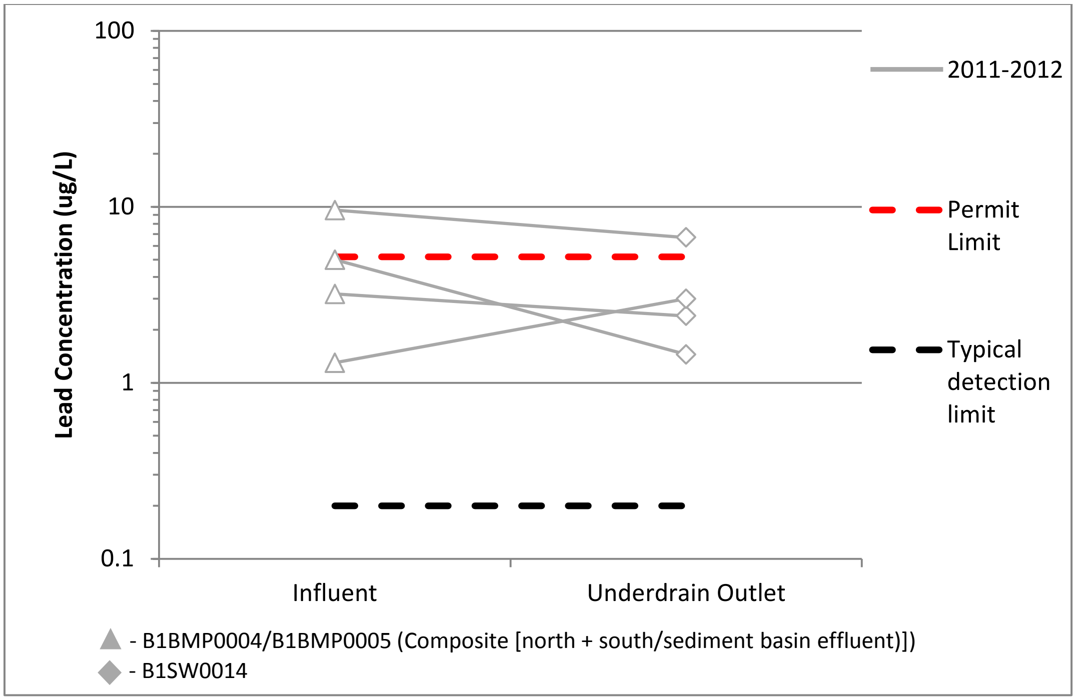

Figure 31. Lead at B-1 Media Filter (CM), pre curb cuts (curb cuts installed on 11/2/2012)

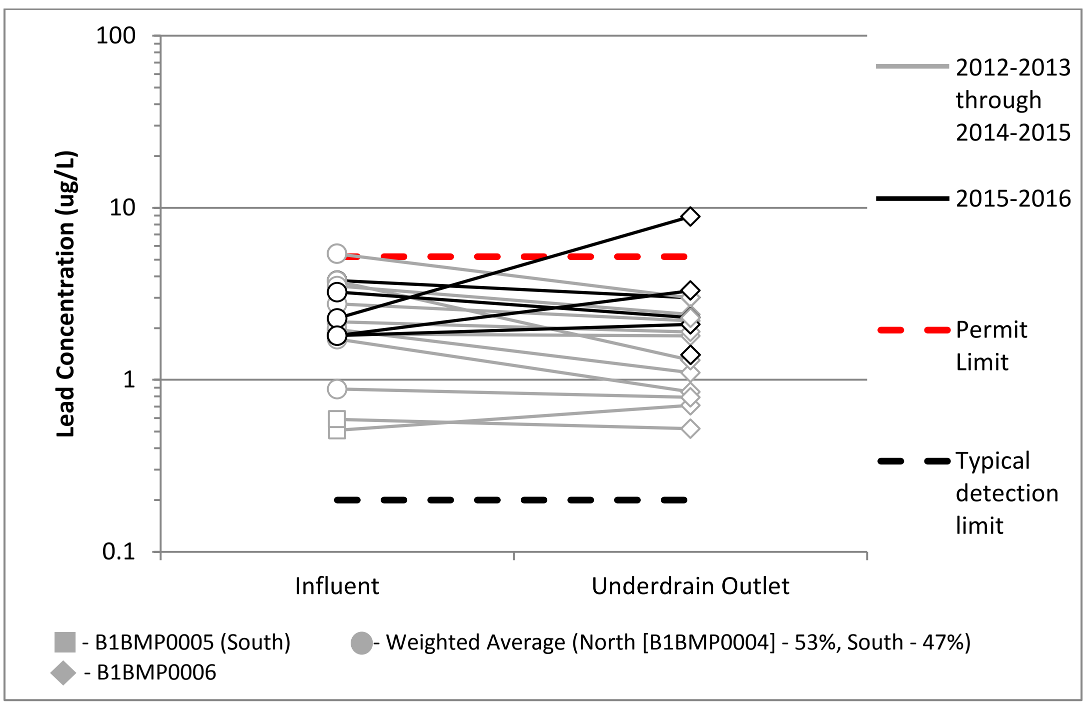

Figure 32. Lead at B-1 Media Filter (CM), post curb cuts (curb cuts installed on 11/2/2012)

Note: Bold markers and bold solid lines represent 2015-2016 samples; red markers indicate samples collected during weir board overflow.

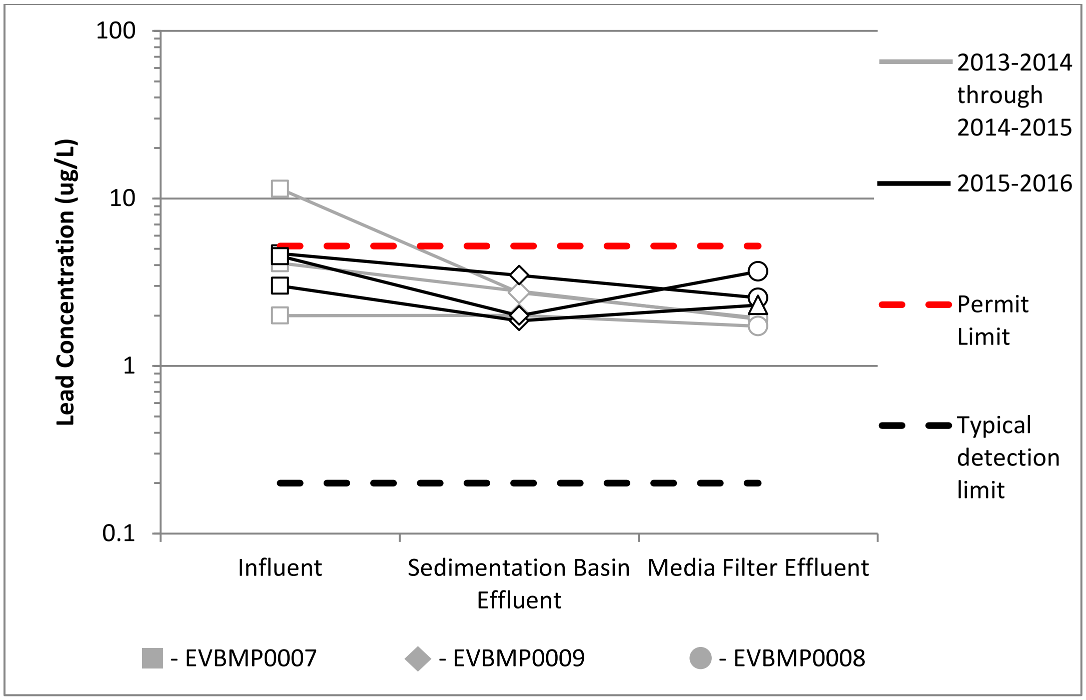

Figure 33. Lead at ELV Treatment BMP

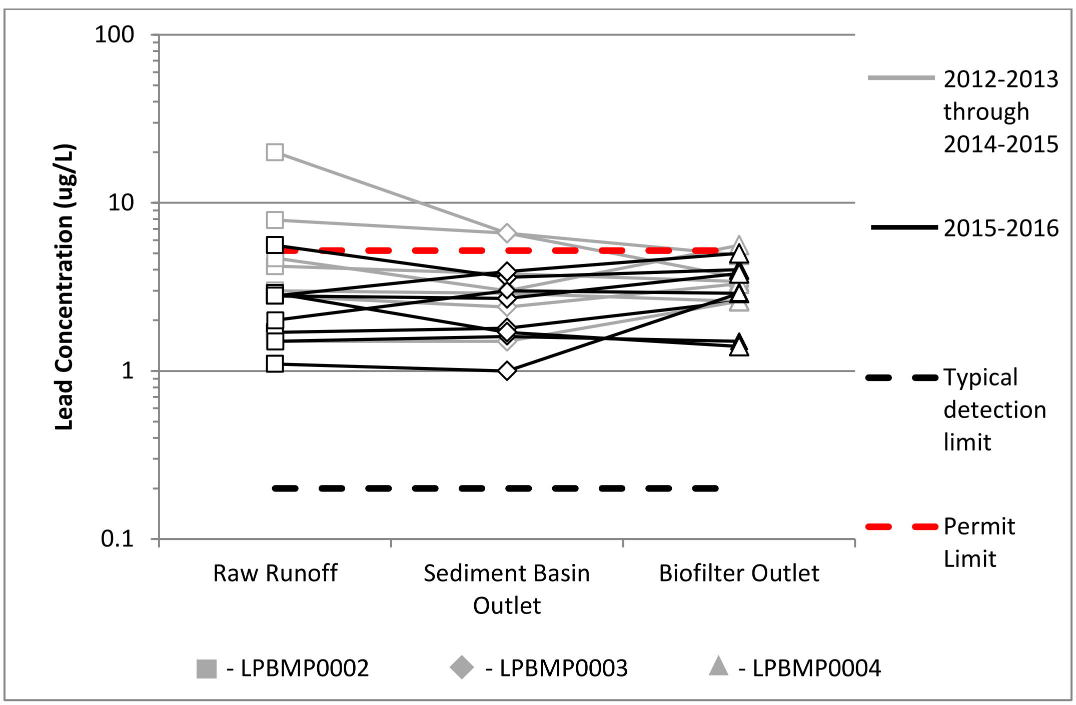

Figure 34. Lead at Lower Lot Biofilter

Note: Bold markers and bold solid lines represent 2015-2016 samples; red markers indicate samples collected during weir board overflow

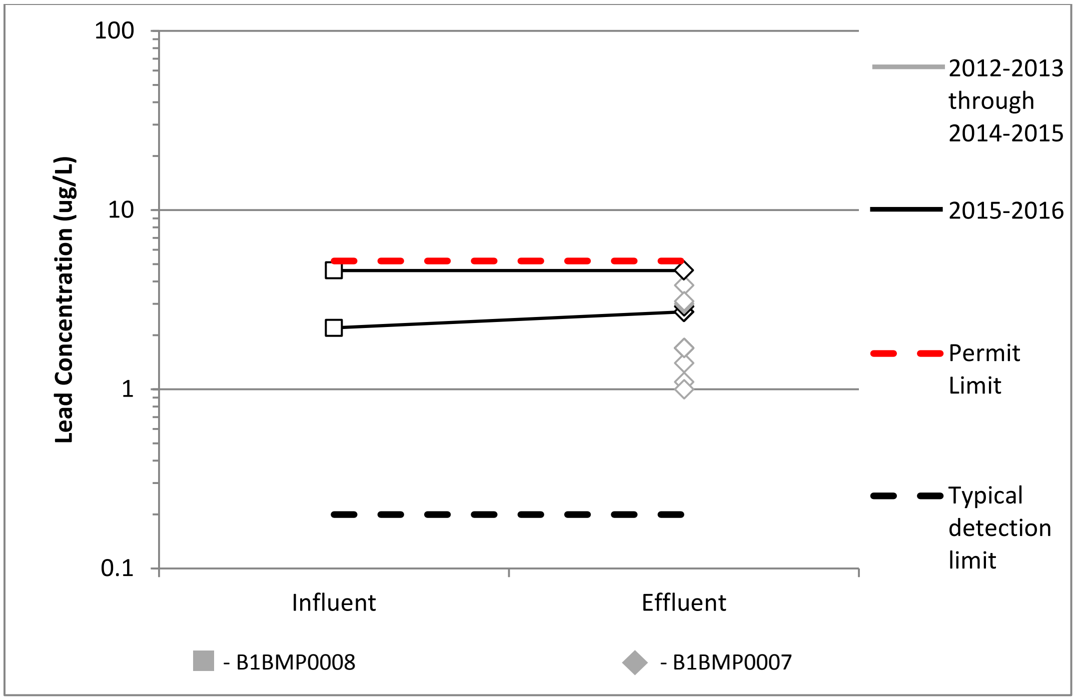

Figure 35. Lead at Vegetated Channel

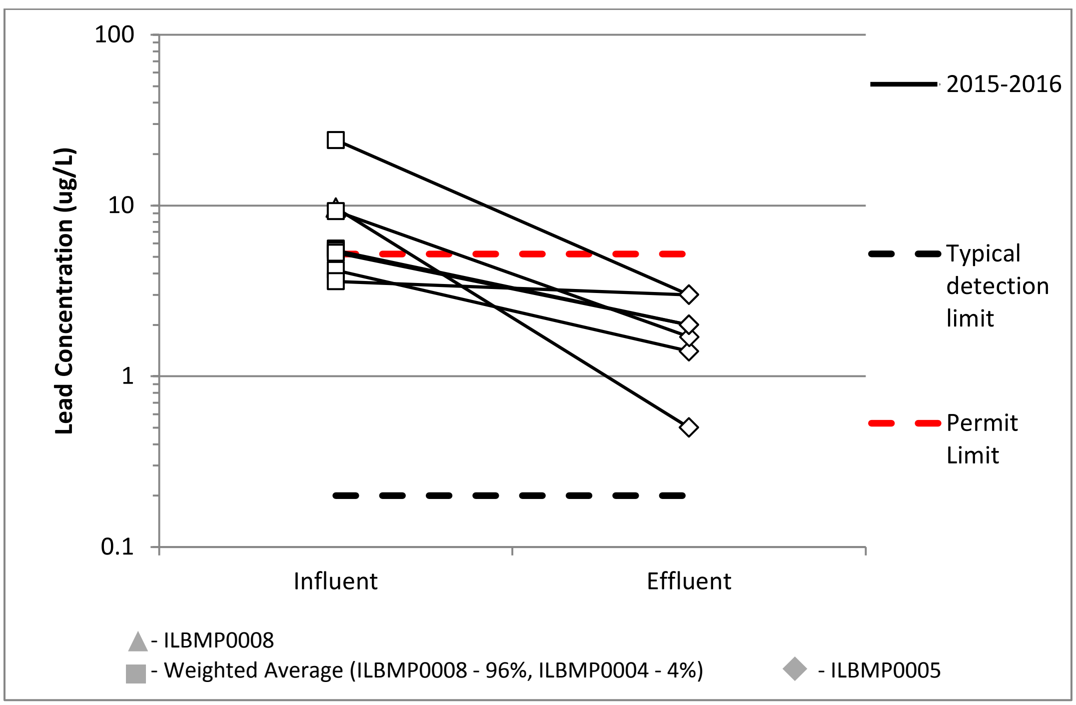

Figure 36. Lead at Southern Detention Bioswale

Note: Bold markers and bold solid lines represent 2015-2016 samples; red markers indicate samples collected during weir board overflow

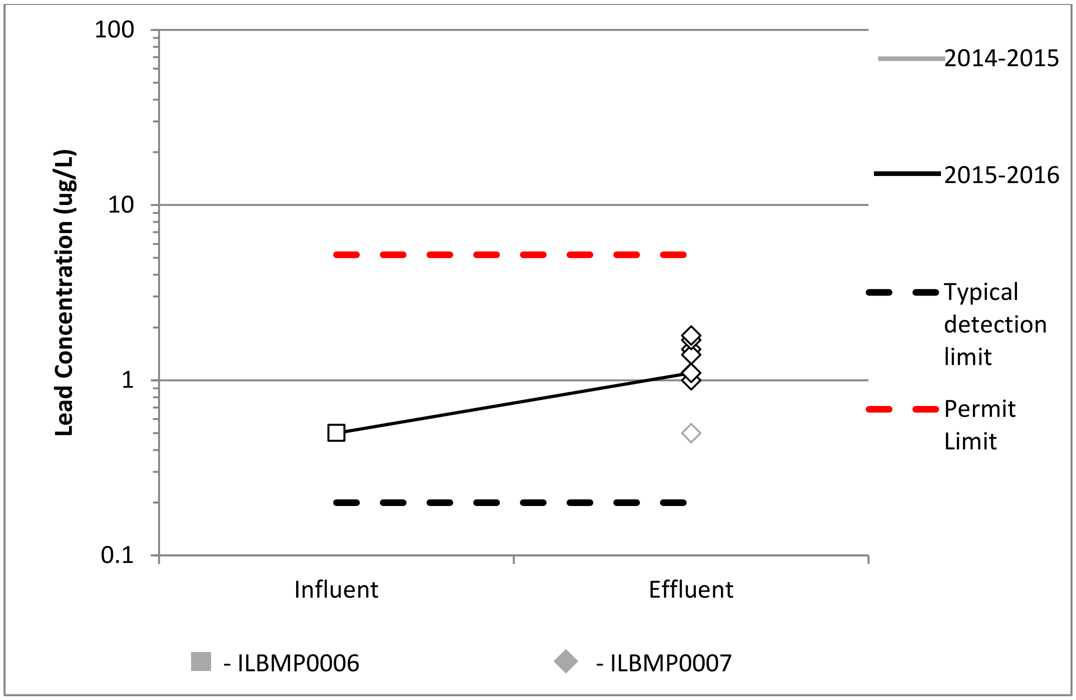

Figure 37. Lead at Northern Detention Bioswale

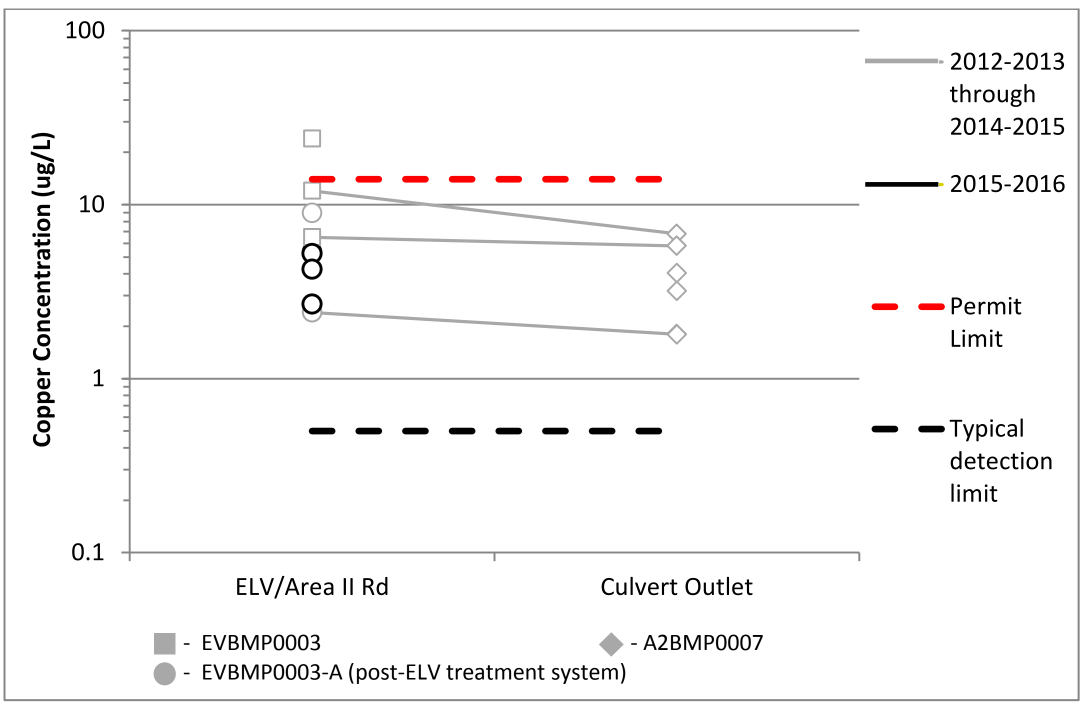

Figure 38. Copper at CM-1, post filter fabric installation (filter fabric installed on 1/20/2012)

Note: Bold markers and bold solid lines represent 2015-2016 samples; red markers indicate samples collected during weir board overflow

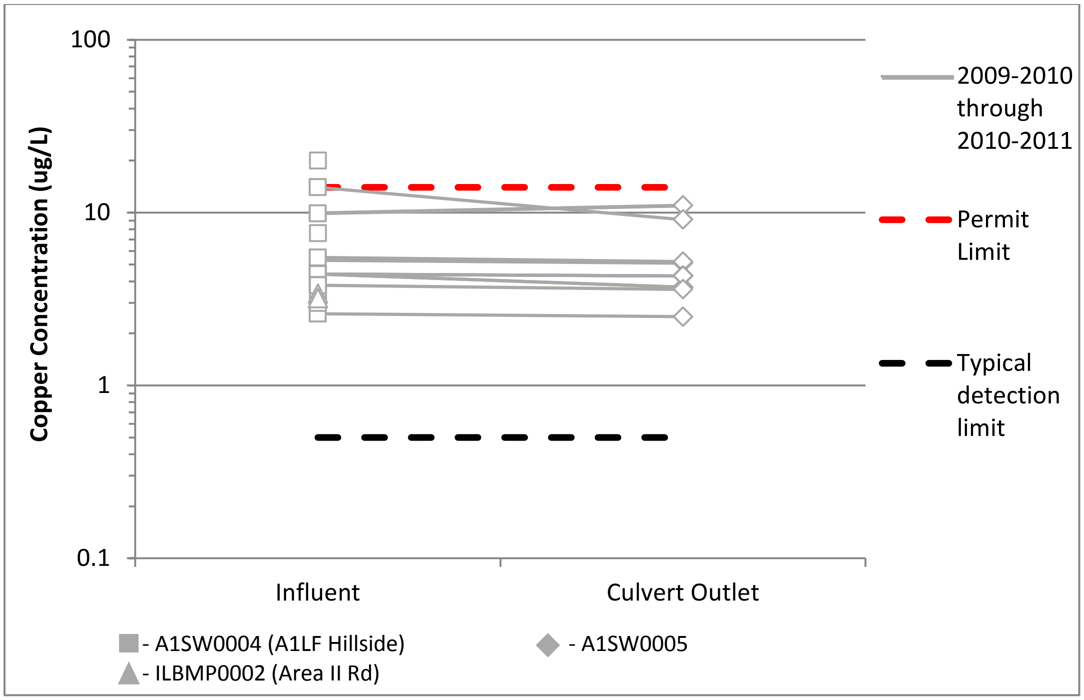

Figure 39. Copper at CM-9, pre improvements (removal of A1LF asphalt and addition of CM weir board filter fabric)

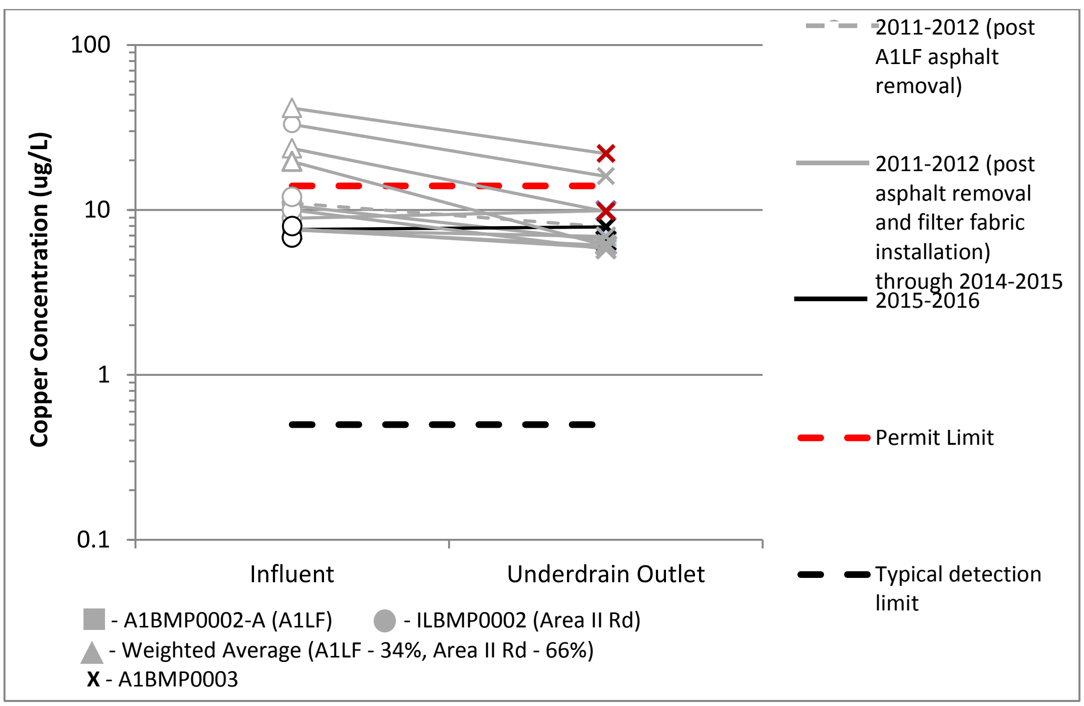

Figure 40. Copper at CM-9, post improvements (removal of A1LF asphalt [9/1/2011] and addition of CM weir board filter fabric [1/20/2012])

Note: Bold markers and bold solid lines represent 2015-2016 samples; red markers indicate samples collected during weir board overflow

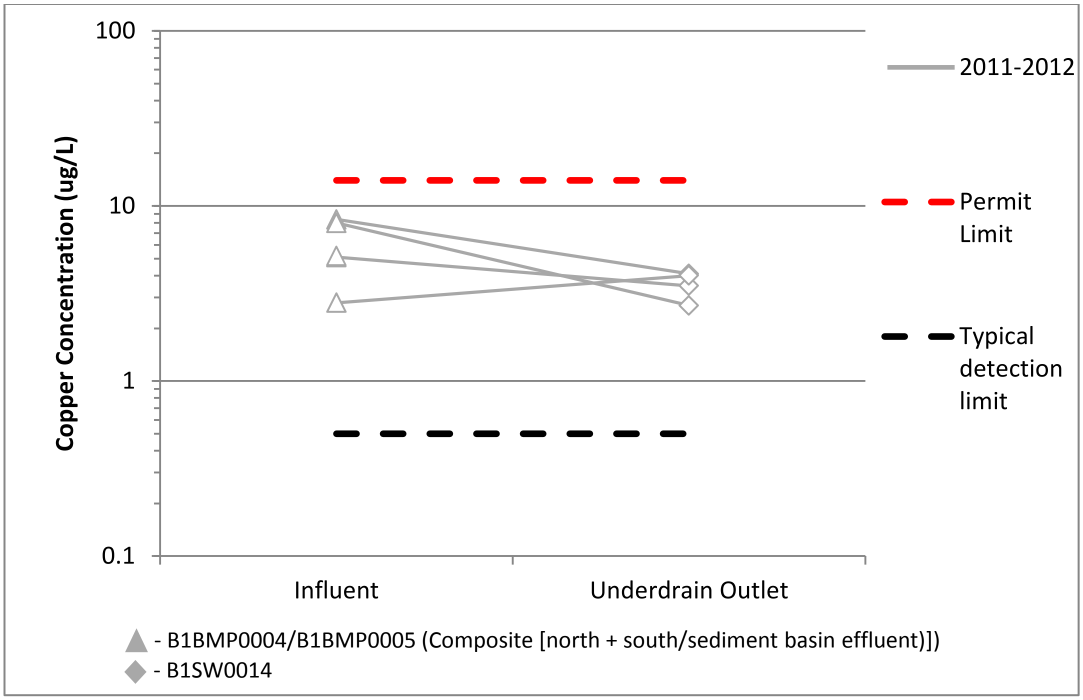

Figure 41. Copper at B-1 Media Filter (CM), pre curb cuts (curb cuts installed on 11/2/2012)

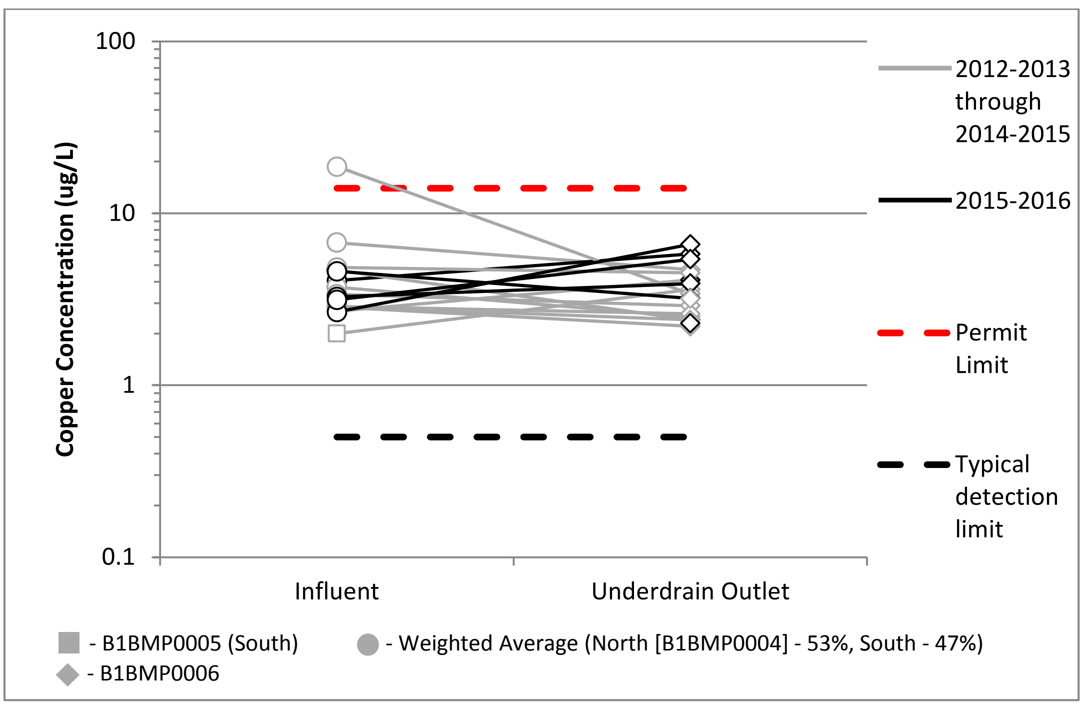

Figure 42. Copper at B-1 Media Filter (CM), post curb cuts (curb cuts installed on 11/2/2012)

Note: Bold markers and bold solid lines represent 2015-2016 samples; red markers indicate samples collected during weir board overflow

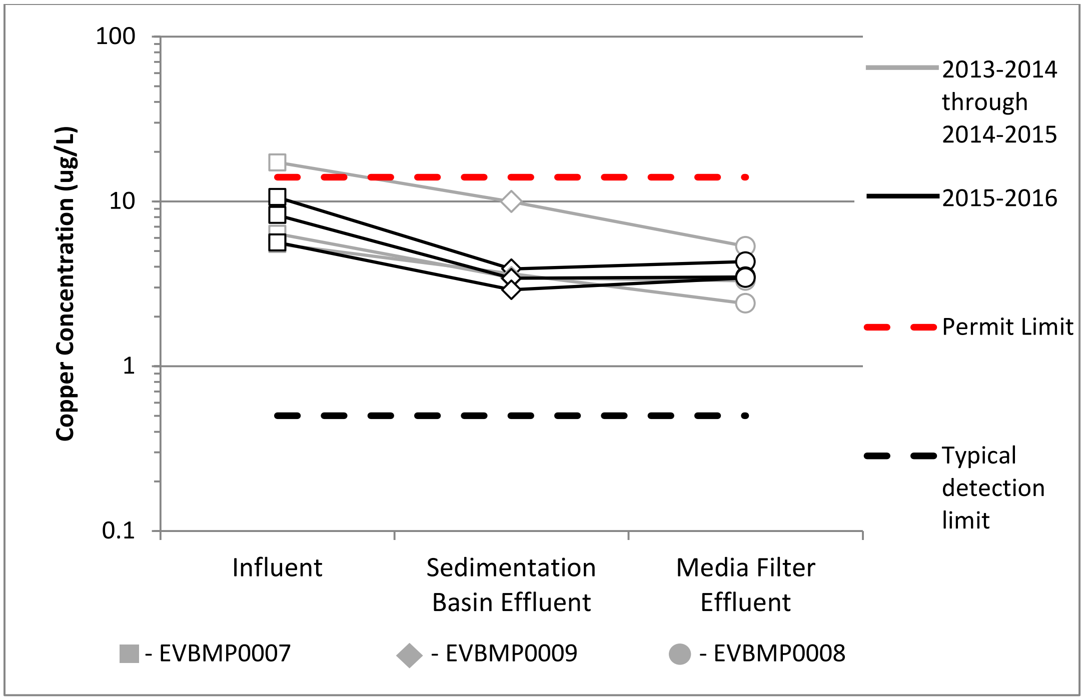

Figure 43. Copper at ELV Treatment BMP

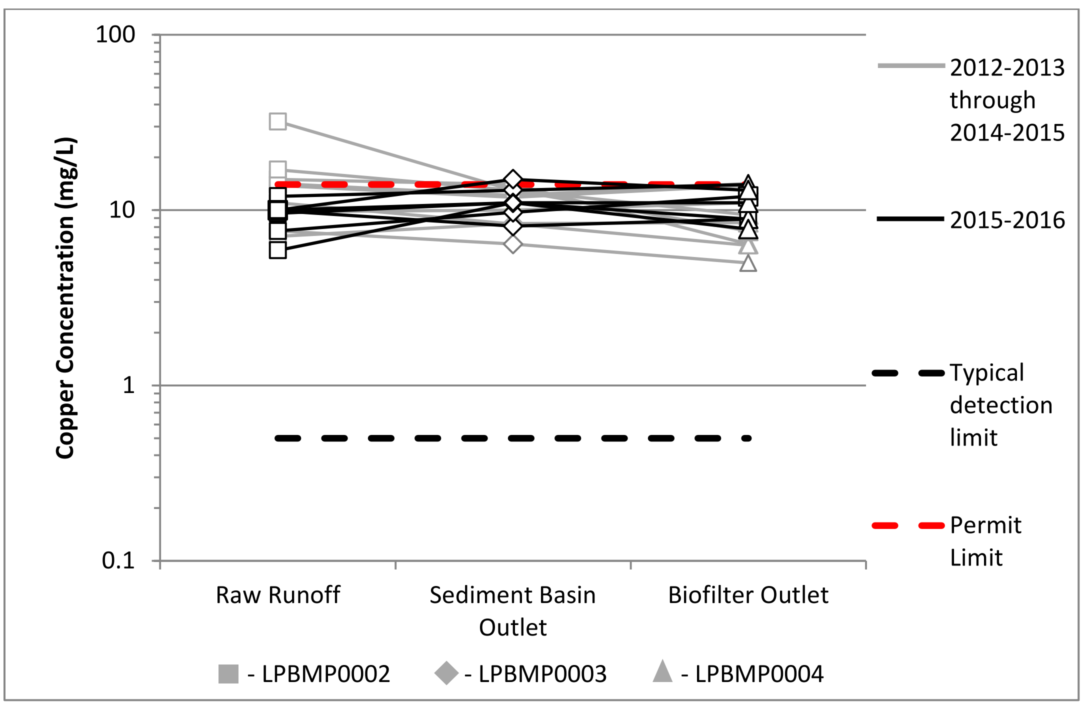

Figure 44. Copper at Lower Lot Biofilter

Note: Bold markers and bold solid lines represent 2015-2016 samples; red markers indicate samples collected during weir board overflow

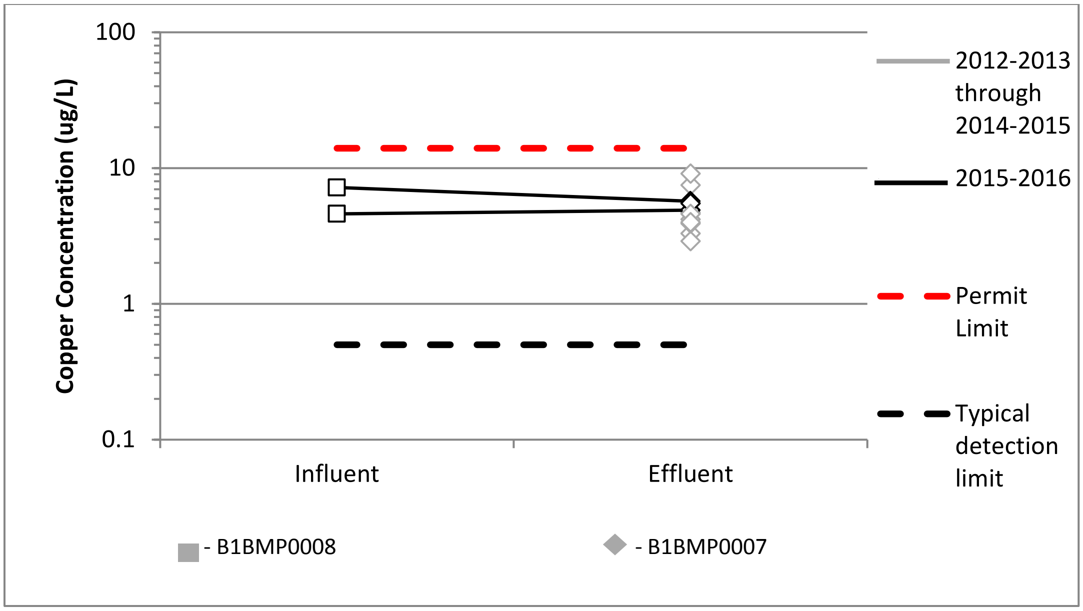

Figure 45. Copper at Vegetated Channel

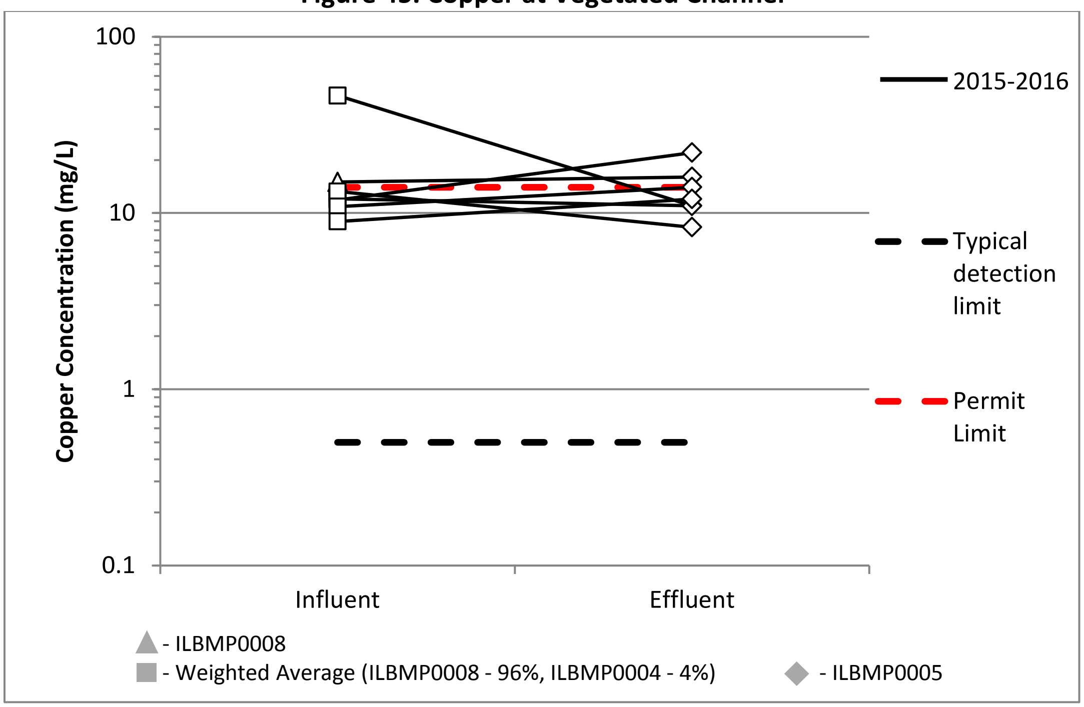

Figure 46. Copper at Southern Detention Bioswale[11]

Note: Bold markers and bold solid lines represent 2015-2016 samples; red markers indicate samples collected during weir board overflow

[11] The permit limit does not apply to this location. No exceedances in permit limits for copper occurred at watershed 009 locations during the 2015/2016 reporting year.

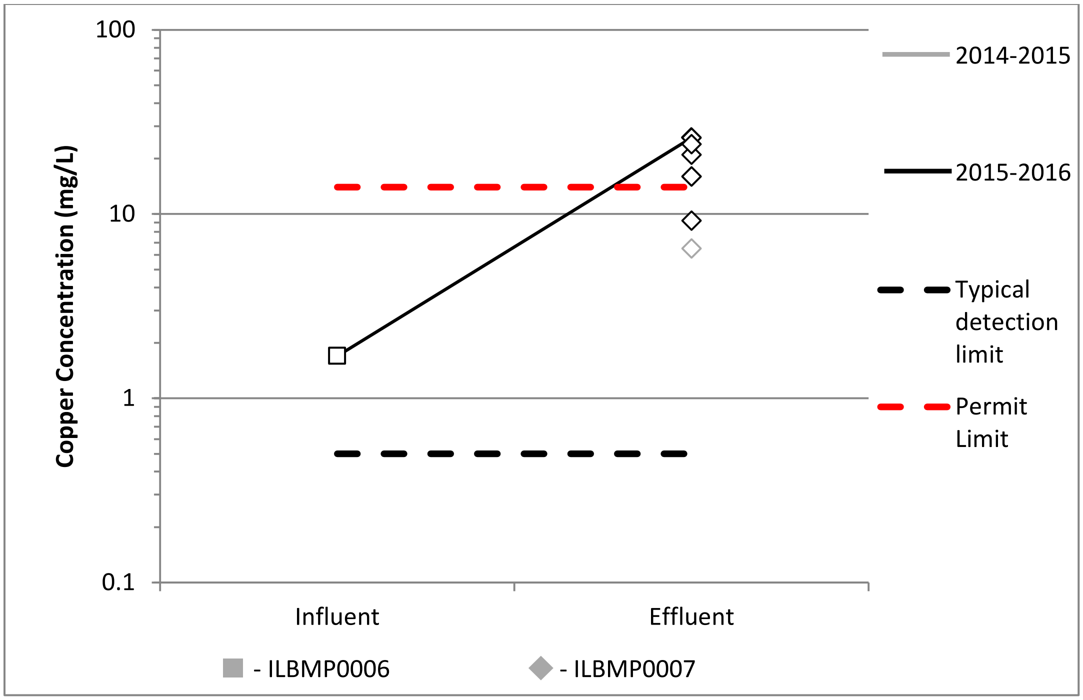

Figure 47. Copper at Northern Detention Bioswale[11]

Note: Bold markers and bold solid lines represent 2015-2016 samples; red markers indicate samples collected during weir board overflow

4 Statistical Analysis

Statistical summaries of the Site cumulative paired data over the 2009-2016 sampling period using the non-parametric one-tailed sign test are shown for the paired datasets in Table 3 through Table 12. This test is used to evaluate statistical differences between paired data points, or in this case, between influent and effluent stormwater samples. The null hypothesis is that the number of data pairs showing an increase from influent to effluent concentrations equals the number of data pairs showing a decrease in concentration from the influent to effluent samples. If the p-value is less than 0.05, the null hypothesis is rejected. Rejection of the null hypothesis results in a statistically significant difference in the number of data pairs that show an increase in concentration from the influent to effluent and data pairs with a decrease in concentration from influent to effluent. For this analysis, data pairs that were taken during observed bypass/overflow events were removed (specific locations, events, and rainfall characteristics were listed previously in Section 1).

4.1 Culvert Modification Areas

At the six monitored CMs (B-1, CM-1, CM-3, CM-8, CM-9, and CM-11), the total number of combined influent and effluent data pairs ranged from 62 (for dioxins) to 79 (for TSS)[12]. Table 3 and Table 4 summarize the paired data statistics for these locations. CM-8, CM-11, and select CM-1 paired statistics are presented separately since the influent flows to these sites come largely from unimpaired/background sites, and therefore significant reduction of the COC concentrations (which are already generally very low) in those flows by CMs is unlikely. No data were collected from these background sites in the 2015/2016 reporting year. Data from the CM-3 background site were excluded since post-storm dry weather flows were observed at the outlet between February 2010 and March 2011 when no flows were observed entering the culvert, suggesting subsurface inflows were contributing to effluent samples. Therefore, this CM cannot be reliably assessed based on the effluent sample results. At the B-1 media filter site, media washout was observed during initial sampling dates in the 2011/2012 reporting year. Since this was a malfunction that was subsequently corrected, results from these sample dates were removed from the analysis. As noted in the paired plots, the CM-1 effluent sample collected on 2/28/2014 represented a blend of underdrain flow and seepage through the upstream weir boards.

In the non-background CM sites, for TSS, 31 out of 52 (60%) of influent concentrations were greater than their paired effluent concentrations, with an average decrease of 55%. For lead, 37 out of 52 (71%) influent concentrations were greater than their paired effluent concentrations, with an average decrease of 42%. For dioxins, 30 out of 45 (67%) influent concentrations were greater than effluent concentrations with an average decrease of 95%; however, it should be noted that this removal average is heavily influenced by one data pair taken during the 2010/2011 reporting year prior to the upgrade at CM-1, and another data pair at B-1 media filter in the 2014/2015 reporting year with a very high influent concentration. If these pairs are removed from the analysis, the average removal is 84% for dioxins. These results show that the influent concentrations are significantly greater than the effluent

[12] Because copper is not included as a pollutant of concern in the Expert Panel Work Plan for watershed 009, which was submitted to the Regional Board in September 2015, results for copper are not included herein.

concentrations for dioxins and lead (p-value ≤ 0.05). The majority of influent concentrations were also greater than their paired effluent concentrations for TSS at the non-background CM sites. However, results were not statistically significant (p-value = 0.059).

Concentration decreases from influent to effluent were seen for TSS (statistically significant at p-value = 0.004) and lead (statistically significant at p-value = <0.001) at background sites (42% and 54%, respectively), as shown in Table 4, though again it should be noted that no data were collected from these sites in the most recent sampling year. There was a statistically insignificant increase from influent to effluent for dioxins for the background sites (p-value = 0.5); however, as noted earlier, the influent concentrations at these sites are very low (none of the dioxins samples at these sites, either influent or effluent, were above Permit Limits), so further reductions would be difficult to achieve.

Table 3. CM-1 ("background" samples excluded), CM-9, and B-1 Non-Background Statistical Analysis

	TSS (mg/L)		Dioxin (µg/L)[2]		Lead (µg/L)	
	Influent	Effluent	Influent	Effluent	Influent	Effluent
Minimum	0.70	0.70	1.0E-10	1.0E-10	0.20	0.20
Maximum	1,206	610	2.1E-04	9.3E-06	55	39
Average	82	37	5.2E-06	2.7E-07	7.5	4.4
Median	17	15	1.1E-07	6.1E-08	3.2	2.4
Standard Deviation	204	86	3.1E-05	1.4E-06	11	6.4
Coefficient of Variation (COV)	2.5	2.3	6.0	5.0	1.5	1.5
Total pairs of observations	52		45		52	
Number of influent samples having larger concentrations than effluent samples	31		30		37	
Number of effluent samples having larger concentrations than influent samples	19		10		14	
Number of samples having equal influent and effluent concentrations	2		5		1	
p-value by paired nonparametric sign test[1]	0.059		0.0011		<0.001	
Average percent change (- sign indicating higher effluent results)	55%		95%		42%[3]	

[1] One-tail sign test used to evaluate data. P values of ≤ 0.05 are considered statistically significant.

[2] Average change in dioxins is heavily influenced by one pair at CM-1 that was taken during the 2010/2011 reporting year (prior to improvements at that CM) and one pair at the B-1 media filter from the 2014/2015 reporting year that had a very high influent concentration. Exclusion of this pair results in an average change of 84% (p = 0.00083). Without this sample, the average influent and effluent concentrations are 4.3E-07 and 7.0E-08 respectively, and the influent and effluent COVs are 1.8 and 1.2 respectively.

[3] Average percent change was calculated using the average influent and effluent concentrations before rounding, resulting in a value slightly different than what is calculated using influent and effluent results shown in the table.

Table 4. CM-1[1], CM-8 and CM-11 Background Statistical Analysis[2]

	TSS (mg/L)		Dioxin (µg/L)		Lead (µg/L)	
	Influent	Effluent	Influent	Effluent	Influent	Effluent
Minimum	1.0	1.0	1.0E-10	1.0E-10	0.20	0.20
Maximum	82	33	2.3E-09	4.5E-09	11	7.0
Average	12	6.9	3.9E-10	6.3E-10	2.4	1.1
Median	3.0	2.0	1.0E-10	1.0E-10	0.77	0.25
Standard Deviation	19	8.6	5.6E-10	1.2E-09	3.5	1.8
Coefficient of Variation (COV)	1.6	1.3	1.4	1.8	1.4	1.6
Total pairs of observations	27		17		16	
Number of influent samples having larger concentrations than effluent samples	17		5		13	
Number of effluent samples having larger concentrations than influent samples	4		6		1	
Number of samples having equal influent and effluent concentrations	6		6		2	
p-value by paired nonparametric sign test[3]	0.0036		0.50		<0.001	
Average percent change (- sign indicating higher effluent results)	42%		-64%		54%	

[1] Only CM-1 samples that were taken from east/background tributary influent sites are included in this analysis
[2] As noted earlier in this memorandum, the CM-3 performance cannot be reliably assessed based on the effluent sample results. For this reason, the CM-3 paired data were excluded from the statistical analysis presented in this table.
[3] One-tail sign test used to evaluate data. P values of ≤ 0.05 are considered statistically significant.

4.2 Lower Lot Biofilter Treatment Train

Figure 48. A photo of the biofilter taken on 12/2/2014

Construction of the lower lot biofilter, located in the Outfall 009 watershed, was completed in 2013. To date, samples were taken at this location during 15 rain events that occurred after the construction was completed, with samples collected at three locations within the biofilter treatment train (influent, post-sedimentation basin, and post-biofilter) for one rain event during 2012/2013, two locations (influent and post-biofilter) for a single rain event in the 2013/2014 sampling year, and three locations within the treatment train (influent, post-sedimentation basin, and post-biofilter) for five rain events during the 2014/2015 sampling year and eight events during the most recent sampling year. The post-biofilter samples collected in early 2014 represents a blend of filtered underdrain water and overflow. A sample was not taken at the biofilter inlet (post-sedimentation basin) during the 2013/2014 sampling year due to the sample location being submerged and inaccessible. During one event in the 2014/2015 reporting year, unusually turbid water was observed in the biofilter; this may have been due to sediment-laden run-on from the Building 1436 detention bioswale construction area (Figure 38).

Table 5, Table 6, and Table 7 summarize the paired sampling data for the biofilter. The pairs in Table 5 (runoff to sedimentation basin outlet) and Table 6 (sedimentation basin to biofilter outlet) were collected during the 2012/2013, 2014/2015, and 2015/2016 reporting years.

For TSS, there were an equal number of influent runoff samples having larger concentrations than their paired sedimentation basin outlet samples and sedimentation basin outlet samples with larger concentrations than their influent samples[13]. However, the majority of sample pairs from the sedimentation basin outlet to the biofilter outlet showed a decrease in TSS concentration, and more than half of paired samples showed a net reduction in TSS concentration across the system (influent runoff to the biofilter outlet) across all years. The majority of data pairs showed a decrease in dioxins concentration through all steps of the treatment train for all years. For the sedimentation basin outlet to the biofilter outlet and the influent runoff to the biofilter outlet, 100% of samples pairs had influent dioxins concentrations with larger concentrations than their paired effluent sample. For lead, the majority of samples from the influent runoff to the sedimentation basin outlet exhibited a decrease in lead concentration. However, for the sedimentation basin outlet to the biofilter outlet and the influent runoff to the biofilter outlet, more than half of data pairs showed larger effluent lead concentrations than their paired influent concentrations.

Overall, eight out of 15 (53%) TSS influent runoff concentrations were greater than their paired effluent (biofilter outlet) concentrations. Six out of 15 (40%) influent runoff concentrations for lead samples were greater than paired biofilter outlet concentrations, and 15 out of 15 (100%) paired samples for dioxins had greater influent runoff concentrations than their paired biofilter outlet concentrations. TSS, lead, and dioxins had average net reductions across the system, for all 15 storm events sampled, of 37%, 22%, and 94%, respectively. Only the biofilter and overall dioxin reductions were statistically significant based on the number of samples available.

[13] The sedimentation basin was eroding during the 2012/2013 sample event, which increased TSS levels at the outlet structure.

Table 5. Lower Lot Biofilter Performance Data – Influent Runoff to Sedimentation Basin Outlet

	TSS (mg/L)		Dioxin (µg/L)		Lead (µg/L)	
	Influent	Effluent	Influent	Effluent	Influent	Effluent
Minimum	6.5	8.8	2.7E-08	3.0E-08	1.1	1.0
Maximum	280	110	4.7E-07	2.8E-07	20	6.6
Average	54	40	1.2E-07	9.7E-08	4.3	3.0
Median	30	26	8.3E-08	5.6E-08	2.8	2.8
Standard Deviation	68	31	1.2E-07	8.2E-08	4.7	1.7
Coefficient of Variation (COV)	1.2	0.77	1.0	0.85	1.1	0.55
Total pairs of observations	14		14		14	
Number of influent samples having larger concentrations than effluent samples	7		10		9	
Number of effluent samples having larger concentrations than influent samples	7		4		4	
Number of samples having equal influent and effluent concentrations	0		0		1	
p-value by paired nonparametric sign test[1]	0.50		0.09		0.13	
Average percent change (- sign indicating higher effluent results)	27%		20%		30%	

[1] One-tail sign test used to evaluate data. P values of ≤ 0.05 are considered statistically significant.

Table 6. Lower Lot Biofilter Performance Data – Sedimentation Basin Outlet to Biofilter Outlet

	TSS (mg/L)		Dioxin (µg/L)		Lead (µg/L)	
	Influent	Effluent	Influent	Effluent	Influent	Effluent
Minimum	8.8	6.9	1.8E-10	1.0E-10	1.0	1.4
Maximum	240	110	2.8E-07	2.7E-08	8.5	5.6
Average	53	34	9.1E-08	3.7E-09	3.4	3.5
Median	26	21	5.4E-08	2.9E-10	2.9	3.3
Standard Deviation	58	31	8.3E-08	8.9E-09	2.1	1.2
Coefficient of Variation (COV)	1.1	0.91	0.92	2.4	0.62	0.36
Total pairs of observations	15		15		15	
Number of influent samples having larger concentrations than effluent samples	10		15		7	
Number of effluent samples having larger concentrations than influent samples	5		0		8	
Number of samples having equal influent and effluent concentrations	0		0		0	
p-value by paired nonparametric sign test[1]	0.15		<0.001		0.50	
Average percent change (- sign indicating higher effluent results)	36%		96%		-2.0%	

[1] One-tail sign test used to evaluate data. P values of ≤ 0.05 are considered statistically significant.

Table 7. Lower Lot Biofilter Performance Data – Influent Runoff to Biofilter Outlet

	TSS (mg/L)		Dioxin (µg/L)		Lead (µg/L)	
	Influent	Effluent	Influent	Effluent	Influent	Effluent
Minimum	6.5	6.9	2.7E-08	1.0E-10	1.1	1.4
Maximum	280	110	4.7E-07	7.5E-08	20	5.6
Average	54	34	1.4E-07	8.7E-09	4.3	3.3
Median	32	21	8.7E-08	3.0E-10	2.8	3.3
Standard Deviation	65	31	1.4E-07	2.0E-08	4.5	1.2
Coefficient of Variation (COV)	1.2	0.92	1.0	2.3	1.1	0.35
Total pairs of observations	15		15		15	
Number of influent samples having larger concentrations than effluent samples	8		15		6	
Number of effluent samples having larger concentrations than influent samples	7		0		8	
Number of samples having equal influent and effluent concentrations	0		0		1	
p-value by paired nonparametric sign test[1]	0.50		<0.001		0.40	
Average percent change (- sign indicating higher effluent results)	37%		94%		22%[2]	

[1] One-tail sign test used to evaluate data. P values of ≤ 0.05 are considered statistically significant.

[2] Average percent change was calculated using the average influent and effluent concentrations before rounding, resulting in a value slightly different than what is calculated using influent and effluent results shown in the table.

4.3 ELV Treatment BMP

The ELV Treatment BMP was installed in November 2013. To date, samples have been collected at this location during the February/March 2014 storm event, two events in the 2014/2015 reporting year, and three events in the most recent reporting year. Extenuating circumstances relevant to this site during the February/March 2014 storm event included high flows from Helipad Road to the ELV treatment system (resulting in excess inflows to the sump), inadequate erosion controls along the earthen ELV channel (resulting in excess sediment in the sump [approximately one foot in sump and less than an inch in the sedimentation tanks]), and a power outage (resulting in the sump pump turning off). The February/March 2014 ELV Treatment BMP effluent data are still considered representative for the analysis herein, although it is recognized that because this monitoring event was the first at the ELV, media bed loss may have been occurring.

Samples were collected at three locations within the ELV treatment train (influent, sedimentation tank outlet, and media tank effluent) during the 2014/2015 and 2015/2016 reporting years, and samples were only collected at two locations (influent and effluent) during the 2013/2014 reporting year. Table 8, Table 9, and Table 10 summarize the paired data for this location. The majority of data pairs from the influent to the sedimentation tank effluent showed a decrease in TSS concentrations. However, there were more effluent samples with higher TSS concentrations than their paired influent samples from the sedimentation tank effluent to the media tank effluent and from the influent to the media tank effluent. For each step of the treatment train, the majority of sample pairs had influent dioxin concentrations greater than their paired effluent concentrations. This is also true for lead, where the majority of sample pairs in every step of the treatment train had larger influent lead concentrations than their paired effluent concentrations. For TSS, one out of six (17%) influent concentrations were greater than their paired media tank effluent concentrations. For one of the two cases where a net increase in TSS occurred, during the 2013/2014 reporting year, the ELV Treatment BMP was heavily loaded by sediments eroded from the denuded ELV channel prior to implementation of recent erosion control improvements. Five out of six (83%) influent concentrations for dioxins were greater than their paired media tank effluent concentration. Six out of six (100%) data pairs showed a decrease in lead concentrations from the influent to the media tank effluent. Dioxins and lead had net reductions across the system of 79% and 53%, respectively. TSS exhibited an average net increase across the system of 56%. Only TSS and dioxin reductions in the media filter (p-value = 0.03) and overall system lead (p-value = 0.02) reductions were statistically significant based on the available number of samples.

Table 8. ELV Treatment BMP Performance Data – Influent to Sedimentation Tank Effluent

	TSS (mg/L)		Dioxin (µg/L)		Lead (µg/L)	
	Influent	Effluent	Influent	Effluent	Influent	Effluent
Minimum	7.4	7.9	2.3E-10	1.9E-10	2.0	1.9
Maximum	66	47	3.4E-08	5.1E-10	11	3.5
Average	34	20	1.9E-08	3.4E-10	5.1	2.4
Median	25	18	2.7E-08	3.2E-10	4.5	2.0
Standard Deviation	23	14	1.5E-08	1.1E-10	3.3	0.61
Coefficient of Variation (COV)	0.68	0.69	0.81	0.34	0.64	0.25
Total pairs of observations	5		5		5	
Number of influent samples having larger concentrations than effluent samples	4		4		4	
Number of effluent samples having larger concentrations than influent samples	1		1		1	
Number of samples having equal influent and effluent concentrations	0		0		0	
p-value by paired nonparametric sign test[1]	0.19		0.19		0.19	
Average percent change (- sign indicating higher effluent results)	41%		98%		53%	

[1] One-tail sign test used to evaluate data. P values of ≤ 0.05 are considered statistically significant.

Table 9. ELV Treatment BMP Performance Data – Sedimentation Tank Effluent to Media Tank Effluent

	TSS (mg/L)		Dioxin (µg/L)		Lead (µg/L)	
	Influent	Effluent	Influent	Effluent	Influent	Effluent
Minimum	7.9	10	1.9E-10	1.0E-10	1.9	1.7
Maximum	47	144	5.1E-10	3.0E-10	3.5	3.7
Average	20	53	3.4E-10	1.5E-10	2.4	2.4
Median	18	38	3.2E-10	1.4E-10	2.0	2.3
Standard Deviation	14	47	1.1E-10	9.7E-11	0.61	0.68
Coefficient of Variation (COV)	0.69	0.88	0.34	0.65	0.25	0.28
Total pairs of observations	5		5		5	
Number of influent samples having larger concentrations than effluent samples	0		5		3	
Number of effluent samples having larger concentrations than influent samples	5		0		2	
Number of samples having equal influent and effluent concentrations	0		0		0	
p-value by paired nonparametric sign test[1]	0.031		0.031		0.50	
Average percent change (- sign indicating higher effluent results)	-160%[2]		56%		-0.91%	

[1] One-tail sign test used to evaluate data. P values of ≤ 0.05 are considered statistically significant.

[2] Negative percent change potentially caused by media export.

Table 10. ELV Treatment BMP Performance Data – Influent to Media Tank Effluent

	TSS (mg/L)		Dioxin (µg/L)		Lead (µg/L)	
	Influent	Effluent	Influent	Effluent	Influent	Effluent
Minimum	7.4	10	2.3E-10	1.0E-10	2.0	1.7
Maximum	66	144	1.2E-07	4.4E-08	11	3.7
Average	32	51	3.6E-08	7.5E-09	5.0	2.4
Median	24	38	3.0E-08	1.6E-10	4.3	2.1
Standard Deviation	22	43	4.1E-08	1.6E-08	3.0	0.65
Coefficient of Variation (COV)	0.67	0.85	1.1	2.2	0.61	0.28
Total pairs of observations	6		6		6	
Number of influent samples having larger concentrations than effluent samples	1		5		6	
Number of effluent samples having larger concentrations than influent samples	5		1		0	
Number of samples having equal influent and effluent concentrations	0		0		0	
p-value by paired nonparametric sign test[1]	0.11		0.11		0.016	
Average percent change (- sign indicating higher effluent results)	-56%[2]		79%		53%[2]	

[1] One-tail sign test used to evaluate data. P values of ≤ 0.05 are considered statistically significant.

[2] Average percent change was calculated using the average influent and effluent concentrations before rounding, resulting in a value slightly different than what is calculated using influent and effluent results shown in the table.

4.4 Vegetated Channel

As previously described, samples were collected downstream of the vegetated channel in the upper Northern Drainage above the biofilter outlet starting during the 2012/2013 reporting year. However, samples were not collected from the B-1 culvert outfall (influent location) until January of 2016. Treatment from the vegetated channel is expected to occur between the B-1 culvert outfall and downstream of the vegetated channel.

The vegetated channel was sampled during three storm events during the 2015/2016 reporting year, but samples were collected at both the influent (B-1 culvert outfall) and effluent (downstream of the vegetated channel) location for only two of these events. Because there were only two paired samples for the vegetated channel influent to effluent, the p-value calculations were not performed. Table 11 summarizes the paired data for this location.

For both TSS and dioxins, one out of two data pairs (50%) had influent concentrations that were larger than their paired effluent concentrations. For lead, one of the two data pairs (50%) had an effluent concentration that was higher than its paired influent concentration, and the remaining data pair had equal influent and effluent concentrations. TSS had a net average reduction across the system of 23%, and dioxins and lead had net average increases across the system of 19% and 7%, respectively. The few sample pairs obtained do not allow statistical significance evaluations to me made at this location.

Table 11. Vegetated Channel Performance Data

	TSS (mg/L)		Dioxin (µg/L)		Lead (µg/L)	
	Influent	Effluent	Influent	Effluent	Influent	Effluent
Minimum	9.6	28	1.2E-07	9.7E-08	2.2	2.7
Maximum	75	37	2.0E-07	2.8E-07	4.6	4.6
Average	42	33	1.6E-07	1.9E-07	3.4	3.7
Median	42	33	1.6E-07	1.9E-07	3.4	3.7
Standard Deviation	33	4.5	4.1E-08	9.2E-08	1.2	0.95
Coefficient of Variation (COV)	0.77	0.14	0.26	0.49	0.35	0.26
Total pairs of observations	2		2		2	
Number of influent samples having larger concentrations than effluent samples	1		1		0	
Number of effluent samples having larger concentrations than influent samples	1		1		1	
Number of samples having equal influent and effluent concentrations	0		0		1	
p-value by paired nonparametric sign test[1]	N/A		N/A		N/A	
Average percent change (- sign indicating higher effluent results)	23%[2]		-19%		-7.4%[2]	

[1] p-value was not calculated because the dataset only contained two paired samples.

[2] Average percent change was calculated using the average influent and effluent concentrations before rounding, resulting in a value slightly different than what is calculated using influent and effluent results shown in the table.

4.5 Detention Bioswales

The B1436 detention bioswales were constructed in December 2014, and data pairs were collected for the first time during the 2015/2016 reporting year[14]. For the events that occurred post-construction in the 2014/2015 reporting year, influent samples were not collected due to flows not being observed at the time of collection. Only one effluent sample was collected due to challenges associated with the location and configuration of the effluent pipe. The detention bioswales are intended to slow and treat a portion of the flow draining to the lower lot biofilter. Some treatment is expected to be achieved, but the primary purpose is to slow the influent runoff to the lower lot biofilter and reduce flow that bypasses the lower lot biofilter during large storm events.

Samples were collected at three locations representing the southern detention bioswale: two influent locations (the rock crib swale outlet and runoff from the adjacent contractor laydown area) and the effluent location. Results from the two influent locations were area-weighted to determine a representative influent concentration. The southern detention bioswale was sampled during eight rain events during the 2015/2016 reporting year. However, the rock crib swale outlet was not sampled during one of these events and the effluent was not sampled during another event. Therefore, only seven data pairs representing the southern detention bioswale were collected. The effluent of the northern detention bioswale was sampled during seven rain events during the 2015/2016 reporting year, but the influent location was only sampled during one of these events. Therefore, there was only one data pair sampled at the northern detention bioswale during this reporting year. Table 14 summarizes the paired data for this location. Performance data represents both the northern and southern detention bioswales.

For TSS, dioxins, and lead, the majority of data pairs had influent concentrations that were larger than their paired effluent concentrations. For both dioxins and lead, seven out of the eight data pairs (88%) had influent concentrations that were larger than their paired effluent concentrations. For TSS, six of the eight data pairs (75%) had influent concentrations that were greater than their paired effluent concentrations. TSS, dioxins, and lead had net average reductions across the system of 84%, 99%, and 76%, respectively. The dioxins and lead reductions were found to be statistically significant (p-value = 0.008 and 0.04, respectively).

[14] The effluent location for the northern detention bioswale (ILBMP0007) was sampled during the 2014/2015 reporting year. However, the influent location (ILBMP0006) was not sampled until the most recent reporting year.

Table 12. Southern and Northern Detention Bioswale Performance Data

	TSS (mg/L)		Dioxin (µg/L)		Lead (µg/L)	
	Influent	Effluent	Influent	Effluent	Influent	Effluent
Minimum	5.0	3.2	1.0E-10	1.0E-10	0.50	0.50
Maximum	220	24	2.2E-05	1.9E-07	24	3.0
Average	85	14	4.4E-06	4.7E-08	7.8	1.8
Median	42	13	3.1E-07	2.6E-08	5.4	1.9
Standard Deviation	80	7.0	7.6E-06	6.1E-08	6.8	0.81
Coefficient of Variation (COV)	0.94	0.52	1.7	1.3	0.87	0.44
Total pairs of observations	8		8		8	
Number of influent samples having larger concentrations than effluent samples	6		7		7	
Number of effluent samples having larger concentrations than influent samples	2		0		1	
Number of samples having equal influent and effluent concentrations	0		1		0	
p-value by paired nonparametric sign test[1]	0.14		0.0078		0.035	
Average percent change (- sign indicating higher effluent results)	84%		99%		76%[2]	

[1] One-tail sign test used to evaluate data. P values of ≤ 0.05 are considered statistically significant.

[2] Average percent change was calculated using the average influent and effluent concentrations before rounding, resulting in a value slightly different than what is calculated using influent and effluent results shown in the table.

4.6 Statistical Analysis Summary

A summary of the statistical analyses performed on the paired data presented in this section, ranging from 2009 to 2016, is shown in Table 13. A statistically significant difference in the number of data pairs that show an increase in concentration from the influent to effluent and data pairs with a decrease in concentration from influent to effluent was exhibited for CM sites (excluding background sites CM-8 and CM-11) for dioxins and lead, CM-8 and CM-11 background sites for TSS and lead, the lower lot biofilter for dioxins, the ELV Treatment BMP for lead, and the detention bioswales for dioxins and lead. This statistical analysis was not performed on the vegetated channel because only two paired data samples have been collected at this location.

Table 13. Summary of Performance Data

Location	TSS		Dioxins		Lead	
	p-value[1]	Significant Difference Observed?	p-value[1]	Significant Difference Observed?	p-value[1]	Significant Difference Observed?
CM non-background (CM-1 [background samples excluded], CM-9, and B-1)	0.059	No	0.0011	**Yes**	<0.001	**Yes**
CM-8 and CM-11 background	0.0036	**Yes**	0.50	No	<0.001	**Yes**
Lower Lot Biofilter (Influent Runoff to Biofilter Outlet)	0.50	No	<0.001	**Yes**	0.40	No[3]
ELV Treatment BMP (Influent to Media Tank Effluent)	0.11	No	0.11	No	0.016	**Yes**
Vegetated Channel (B-1 culvert outfall to downstream of the vegetated channel)[2]	N/A	N/A	N/A	N/A	N/A	N/A
Detention Bioswale	0.14	No	0.0078	**Yes**	0.035	**Yes**

[1] One-tail sign test used to evaluate data. P values of ≤ 0.05 are considered statistically significant.

[2] p-value was not calculated because the dataset only contained two paired samples.

[3] Can likely be attributed to the significantly lower influent concentrations to the lower lot biofilter in recent years (to be discussed further).

5 Influent v. Effluent Correlation Charts

Figure 49 through Figure 51compare influent to effluent concentrations for the paired data presented above for CM sites (B-1, CM-9, and CM-1 non-background sites; CM-1, CM-3, CM-8, and CM-11 background sites are excluded). Correlation charts for the lower lot biofilter are shown in Figure 52 through Figure 54, Figure 55 through Figure 57 for the ELV Treatment BMP, Figure 58 through Figure 60 for the vegetated channel in the upper Northern Drainage above the biofilter outlet, and Figure 61 through Figure 63 for the detention bioswales. The plots reflect the same data pairs used to represent the influent and effluent locations in the statistical analyses in the previous section. For example, the lower lot biofilter plots reflect influent runoff samples for the influent and sedimentation basin outlet samples for the effluent, while the detention bioswales plots show the influent location as the area-weighted average of the rock crib swale outlet and runoff from the adjacent contractor laydown area.

A least-squares regression was used to fit a line to log-transformed data (log(y) = mlog(x) + b). The slope of the lines, m, is shown in the least-squares regression equation in the upper left corner of the graph. In addition, the p-value is also shown to indicate the significance of the reported slope. The null hypothesis is that the slope (m) is equal to 0. If the p-value is less than 0.05, the null hypothesis is rejected, which shows that the slope is non-zero and is statistically significant. The p-value to indicate the significance of the reported y-intercept (also represented in the least-square regression equation) is also shown. A 1:1 line was also added to each plot. **Data above the 1:1 line indicate an effluent increase in concentrations, while data below the 1:1 line indicate an effluent decrease in concentrations (or positive BMP performance in the case of the CMs). Additionally, the location where the 1:1 line intersects the best-fit line represents the irreducible concentration for each constituent (e.g. ~ 10 mg/L for TSS at CM sites).** Pairs where one or both results were not detected were included on these graphs with different symbols.

Many of the regression equations and associated ANOVA analyses indicated non-significant equation intercepts (p-value >0.05). In this case, the regressions were re-calculated with the intercept equal to zero, and this result is shown on the plots below (with the intercept p-value shown as N/A). This indicates that in general, the performance of the controls did not change by influent concentration (the percent reduction was constant). In other cases, both the slope and intercept terms were not significant, and the regression is therefore also not significant. In this case, the effluent concentrations are not related to the influent concentrations. Although there is no regression relationship in this case, the regression equation and p-values are still shown on the plots below.

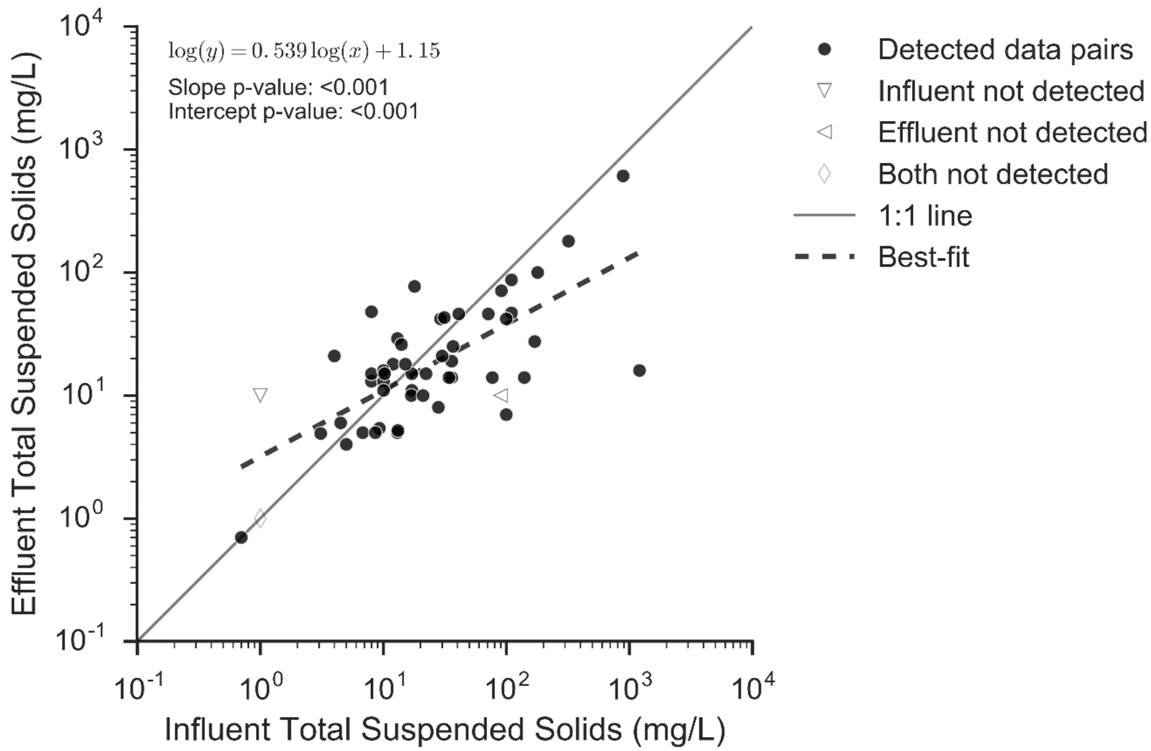

Figure 49. Paired TSS Concentrations at CM Sites

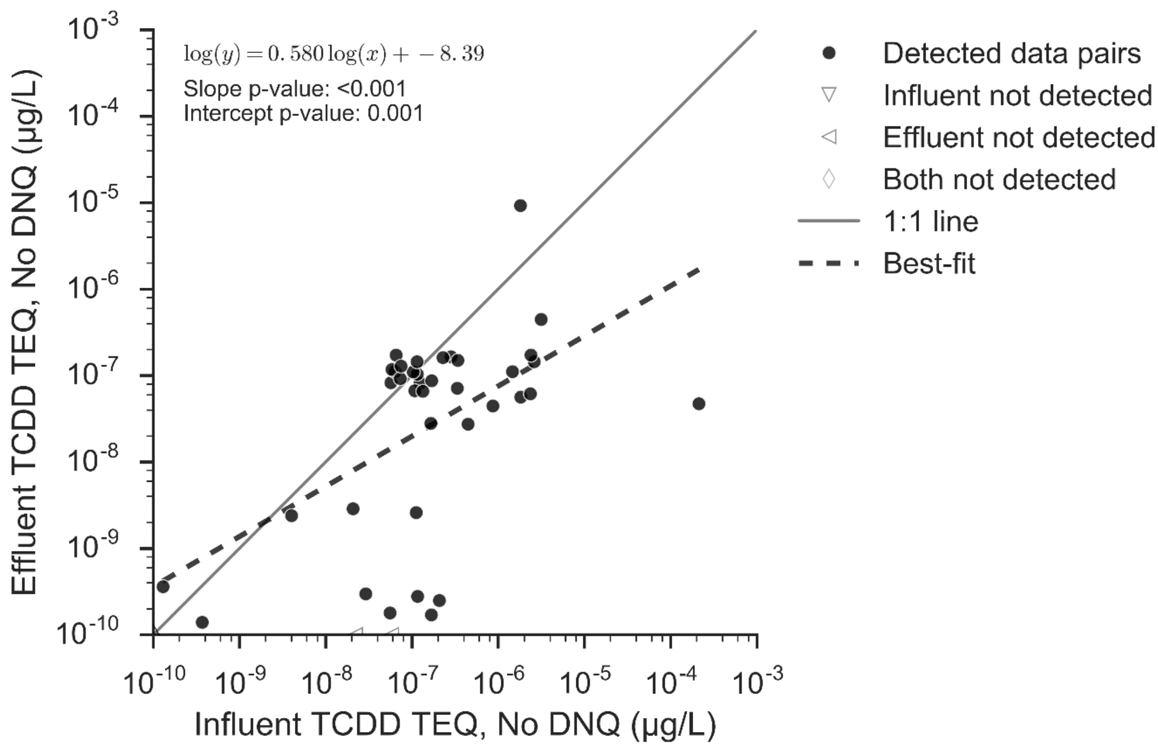

Figure 50. Paired Dioxins Concentrations at CM Sites

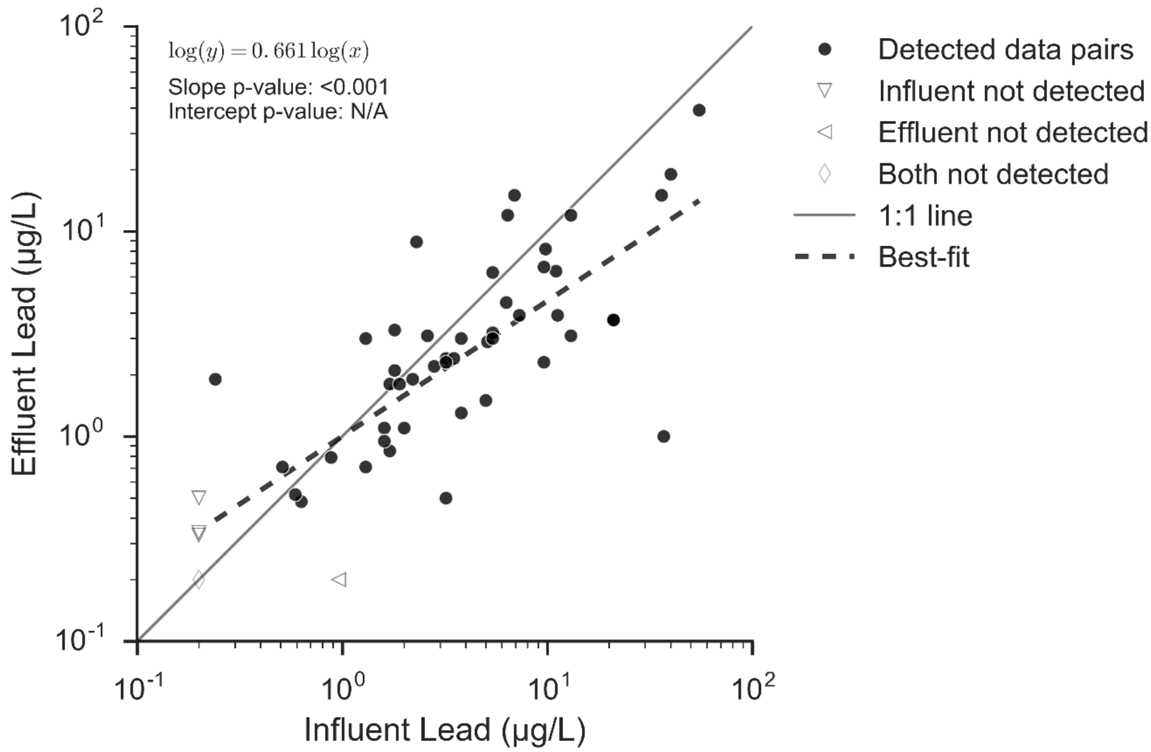

Figure 51. Paired Lead Concentrations at CM Sites

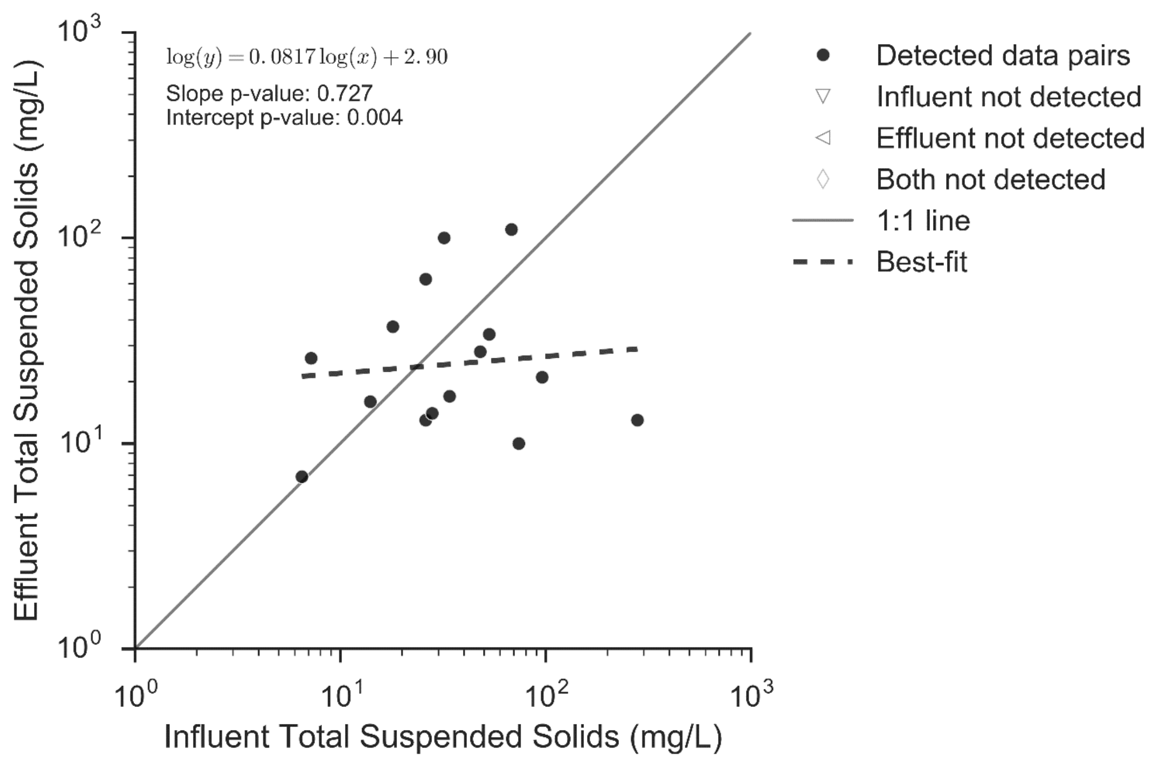

Figure 52. Paired TSS Concentrations at Lower Lot Biofilter

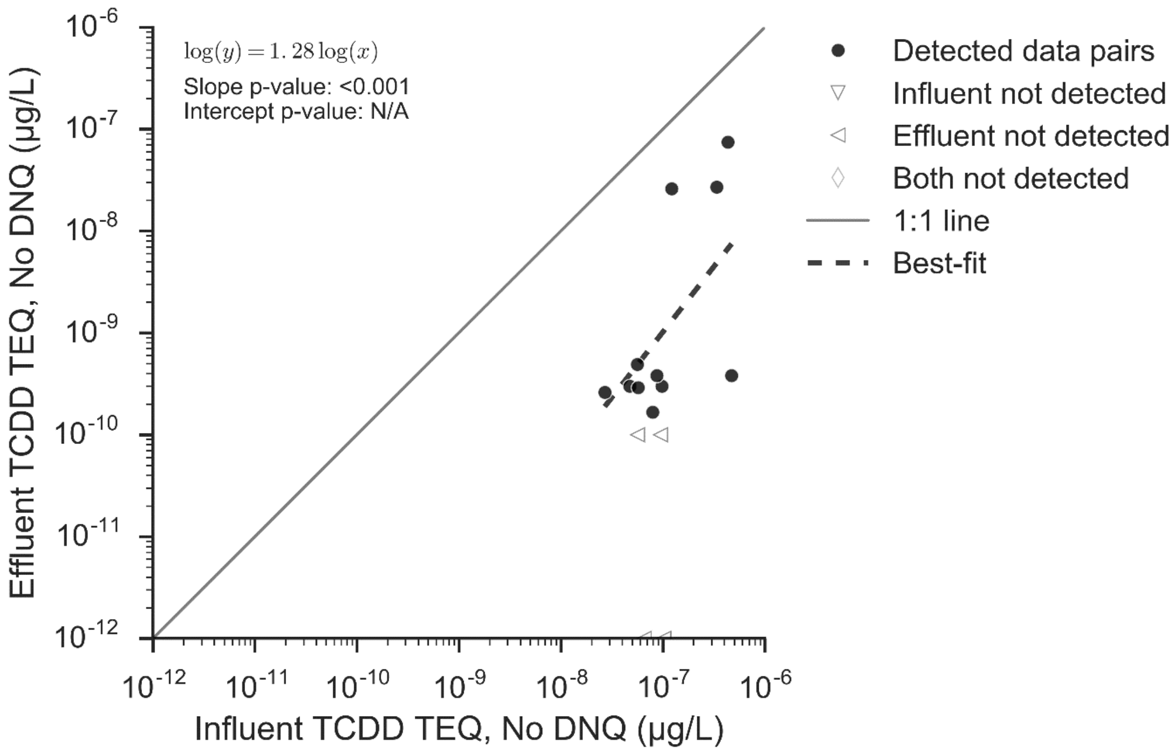

Figure 53. Paired Dioxins Concentrations at Lower Lot Biofilter

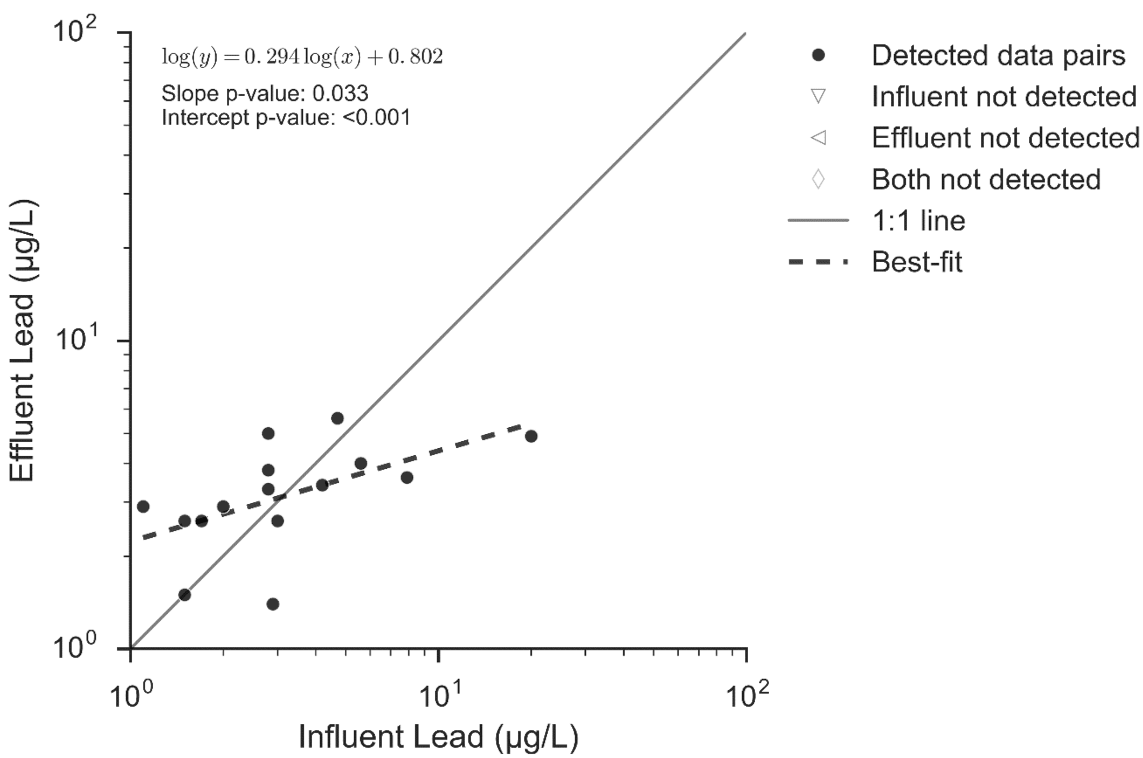

Figure 54. Paired Lead Concentrations at Lower Lot Biofilter

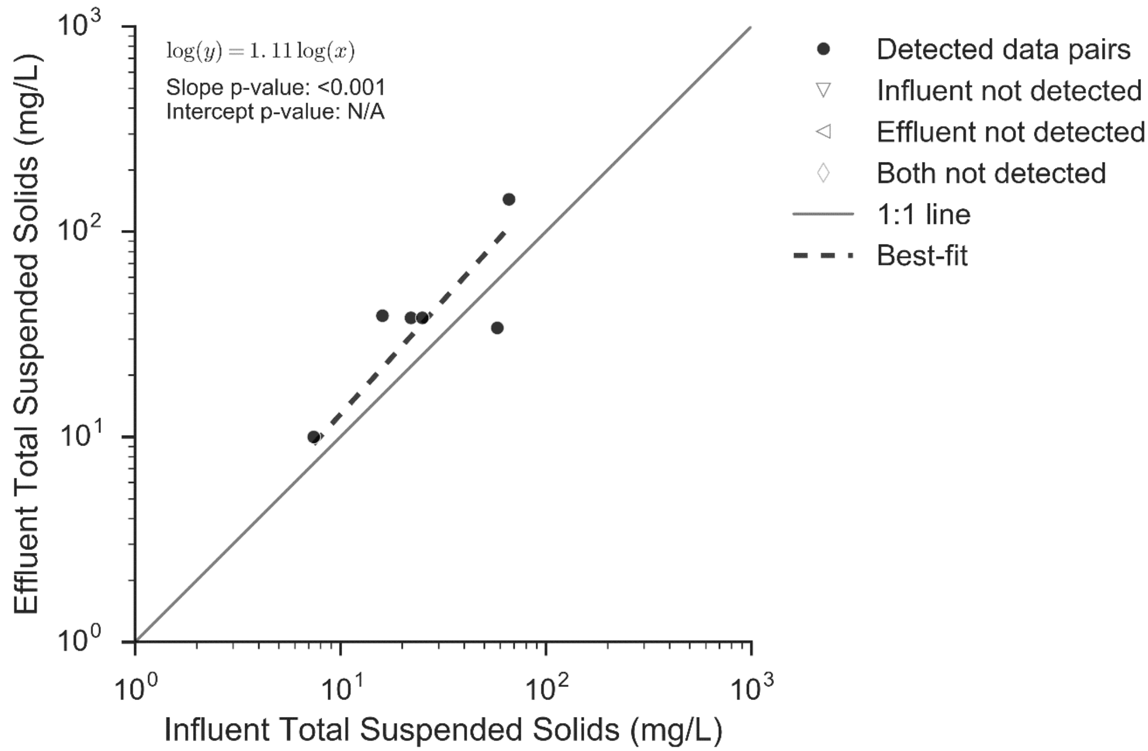

Figure 55. Paired TSS Concentrations at ELV Treatment BMP

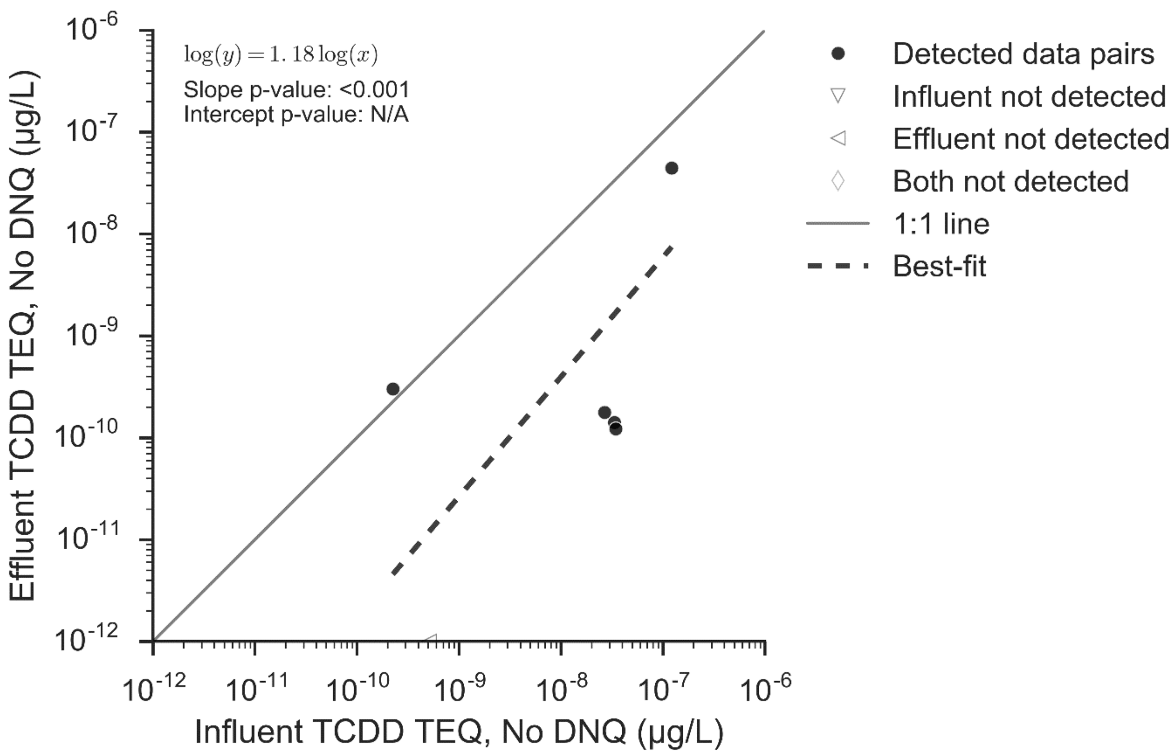

Figure 56. Paired Dioxins Concentrations at ELV Treatment BMP

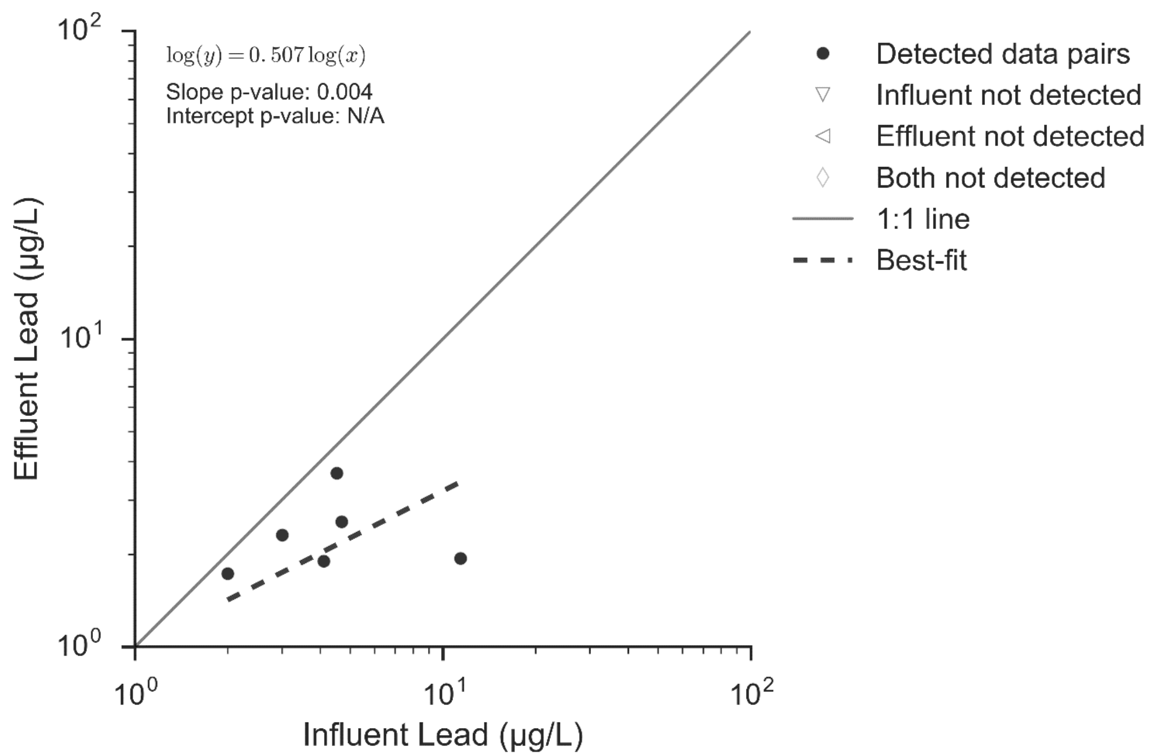

Figure 57. Paired Lead Concentrations at ELV Treatment BMP

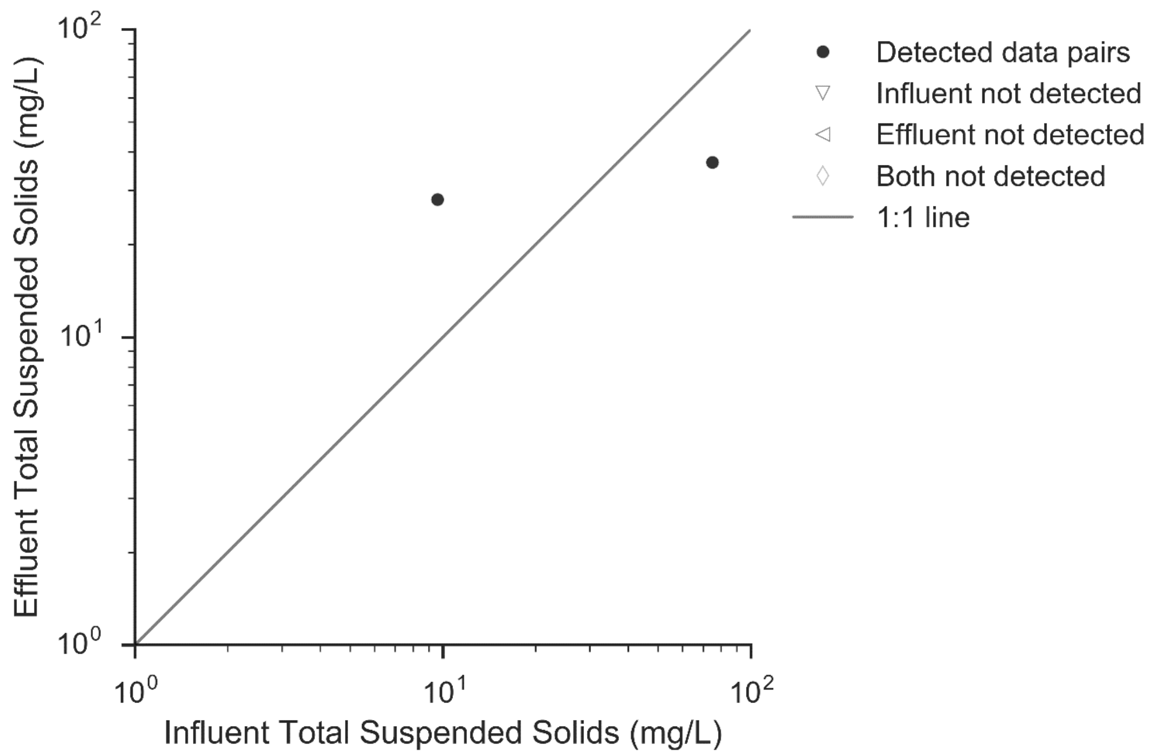

Figure 58. Paired TSS Concentrations at Vegetated Channel

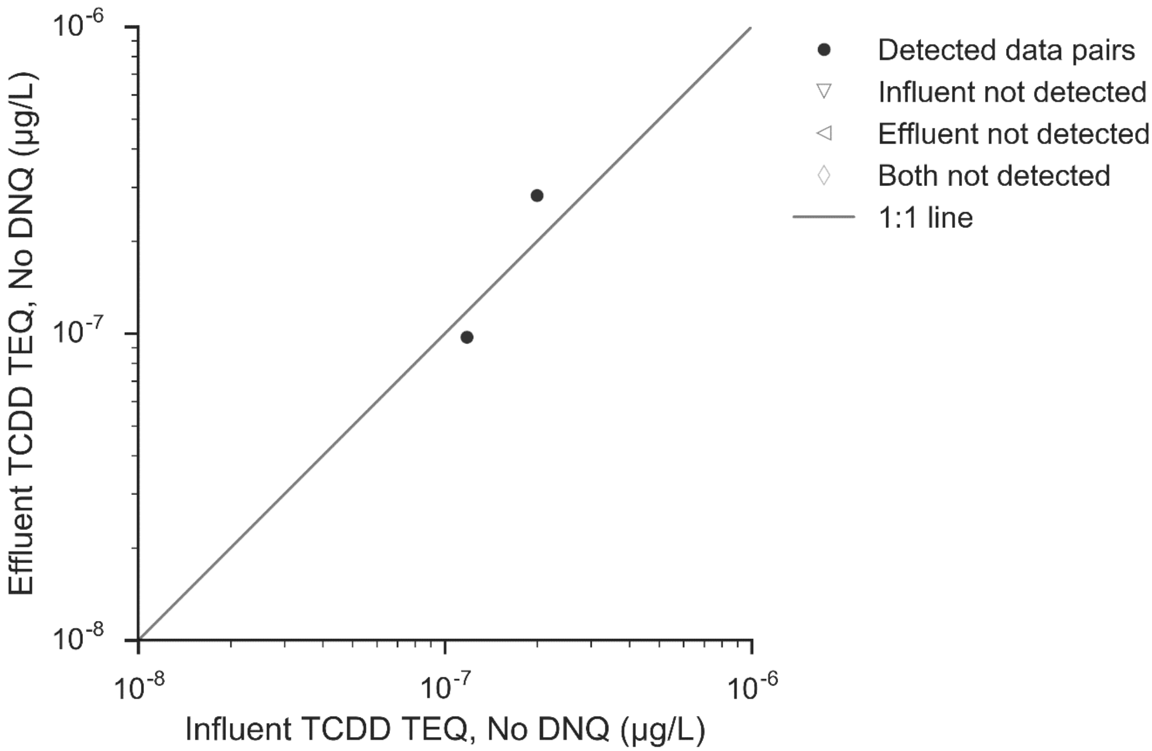

Figure 59. Paired Dioxins Concentrations at Vegetated Channel

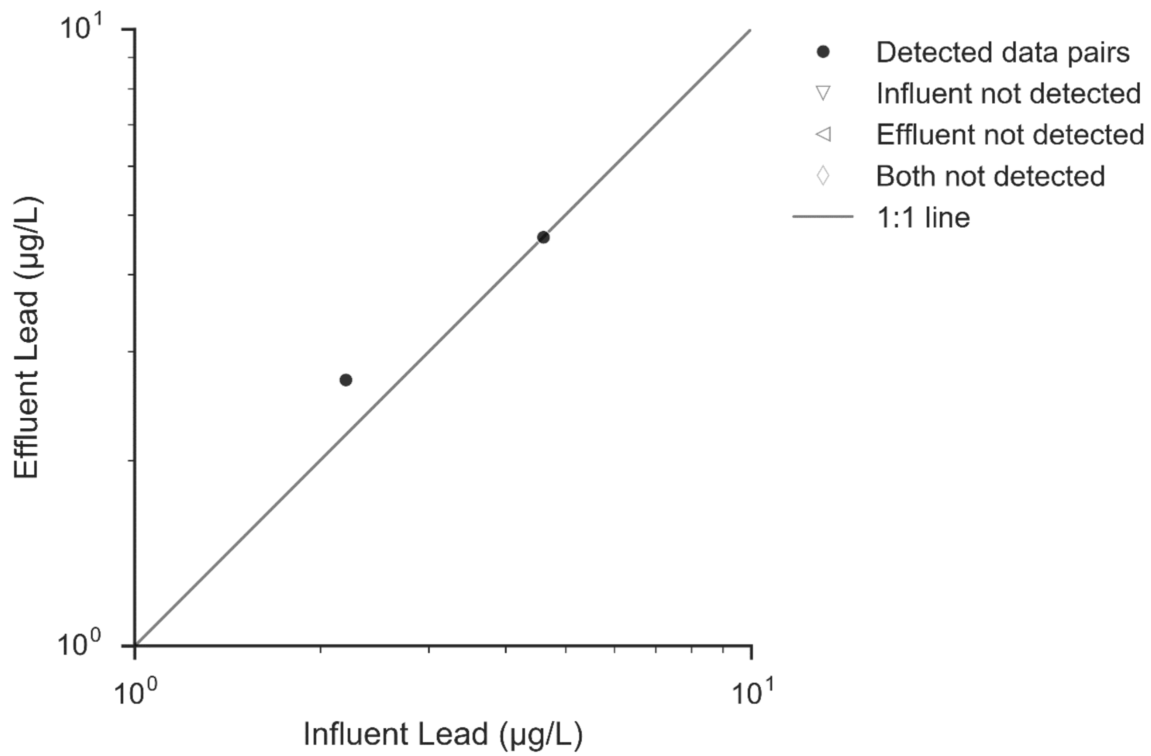

Figure 60. Paired Lead Concentrations at Vegetated Channel

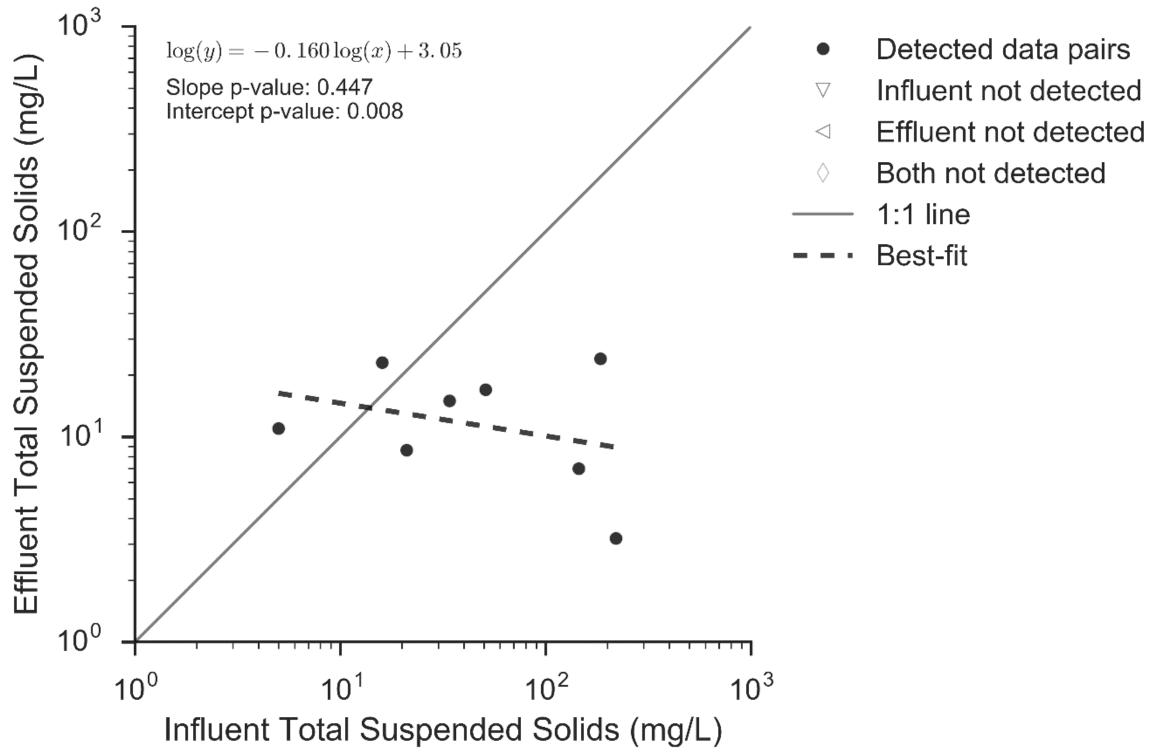

Figure 61. Paired TSS Concentrations at Detention Bioswales

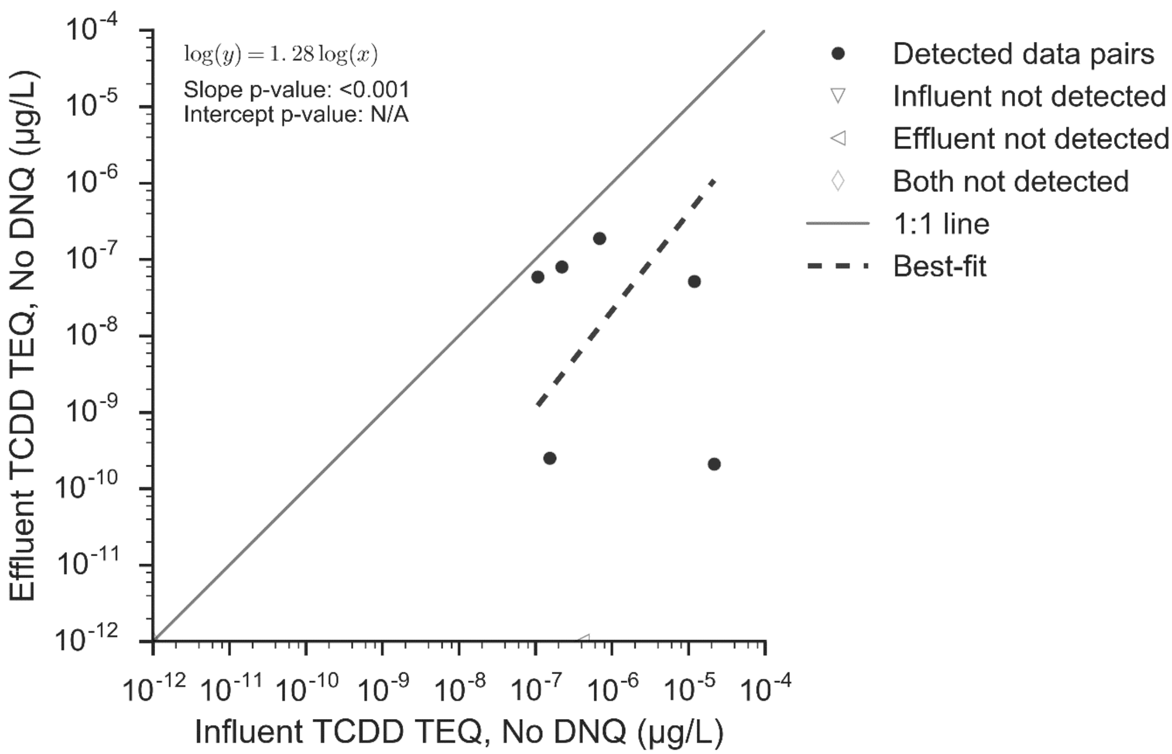

Figure 62. Paired Dioxins Concentrations at Detention Bioswales

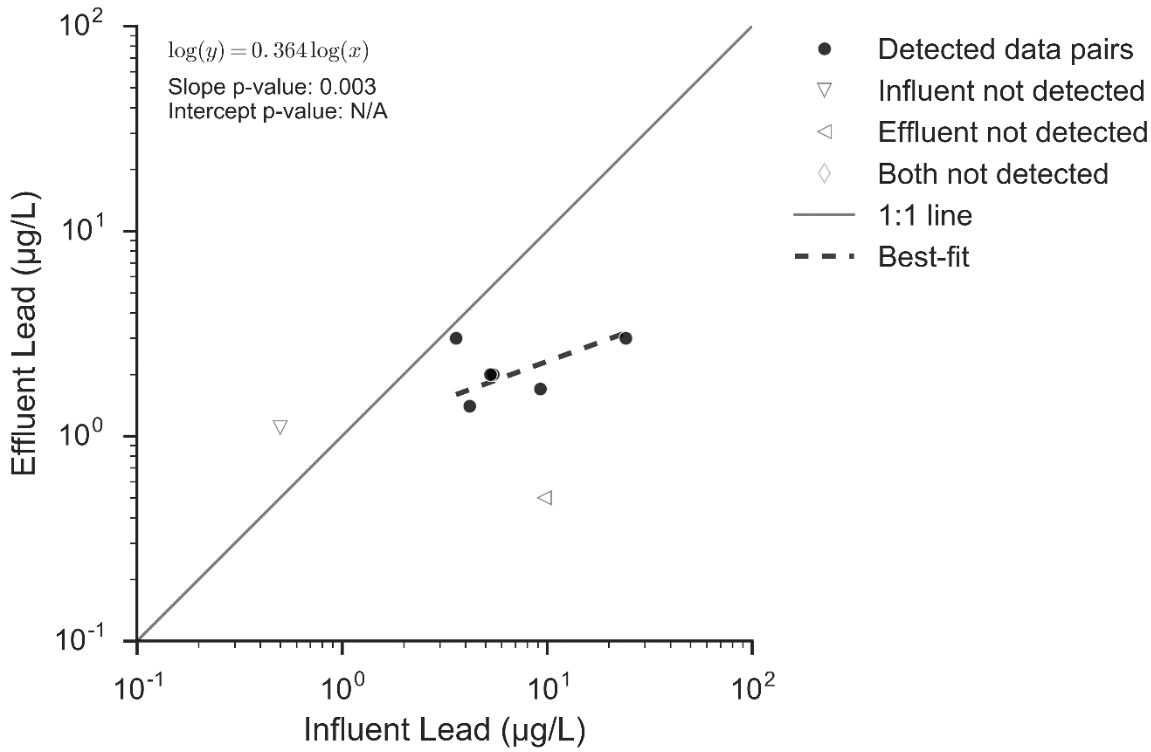

Figure 63. Paired Lead Concentrations at Detention Bioswales

6 Probability Plots

Probability plots for CM sites (B-1, CM-9, and CM-1 non-background sites), excluding CM-1 background areas, CM-3, CM-8, and CM-11 (due to the substantial flows that they receive from unimpaired/background areas), are shown in Figure 64 through Figure 66. Probability plots for the lower lot biofilter are shown in Figure 67 through Figure 69, and plots for the ELV Treatment BMP are displayed in Figure 70 through Figure 72. Probability plots for the vegetated channel in the upper Northern Drainage above the biofilter outlet are shown in Figure 73 through Figure 75, and plots for the detention bioswales are displayed in Figure 76 through Figure 78. These log-normal probability plots are prepared by ranking the available log-transformed data and calculating their probability of occurrence. These probability values (shown on the vertical axis) are plotted against their concurrent concentrations. While determining the plotting positions, non-detect (ND) data were assigned to the lowest positions, effectively truncating the probability plots at the fraction of non-detected samples. Therefore, only detected results positions are plotted, which leads to the correct probability of occurrence for the observed data, while values less than the detection limit show their unknown specific occurrences. These figures illustrate trends for influent concentrations as compared to effluent concentrations and vice versa, and for those that have p-values greater than 0.05 for both influent and effluent distributions, they may serve as a useful tool for predicting effluent concentrations at a given percentile.

The figures also contain some basic statistics describing the data shown on the graphs. For each influent and effluent dataset, the number of ND results is shown. The p-value resulting from an Anderson-Darling test for lognormal distributions is also shown. The Anderson-Darling test assesses if the data follows an examined distribution (p-values <0.05 indicate that the actual distribution is significantly different from log-normal distributions for these plots). The null hypothesis here is that the data comes from a lognormal distribution. If the p-value is less than 0.05, the null hypothesis is rejected and it is concluded that the data are not lognormal distributed. The 95th percentile confidence intervals are also shown on the plots for both influent and effluent sample results. If all of the influent or effluent data points are located within the confidence interval and the p-value is greater than 0.05, once can be 95% confident that the lognormal distribution appears to fit the data fairly well, and the fitted line may be used to estimate concentrations at various percentiles.

Where influent data (blue circles) consistently fall above the effluent points (green squares), consistent water quality improvement is occurring at these areas. The vertical distance between the datasets (noting it is a log scale) also indicates the magnitude of the concentration change at these BMP types.

The relative difference in the amount of scatter observed in these plots indicates that BMP effectiveness may vary depending on the location and constituent. These plots indicate the influent concentrations above which the CMs are most effective (low concentrations are expected to represent concentrations unlikely to be significantly reduced by the BMP).

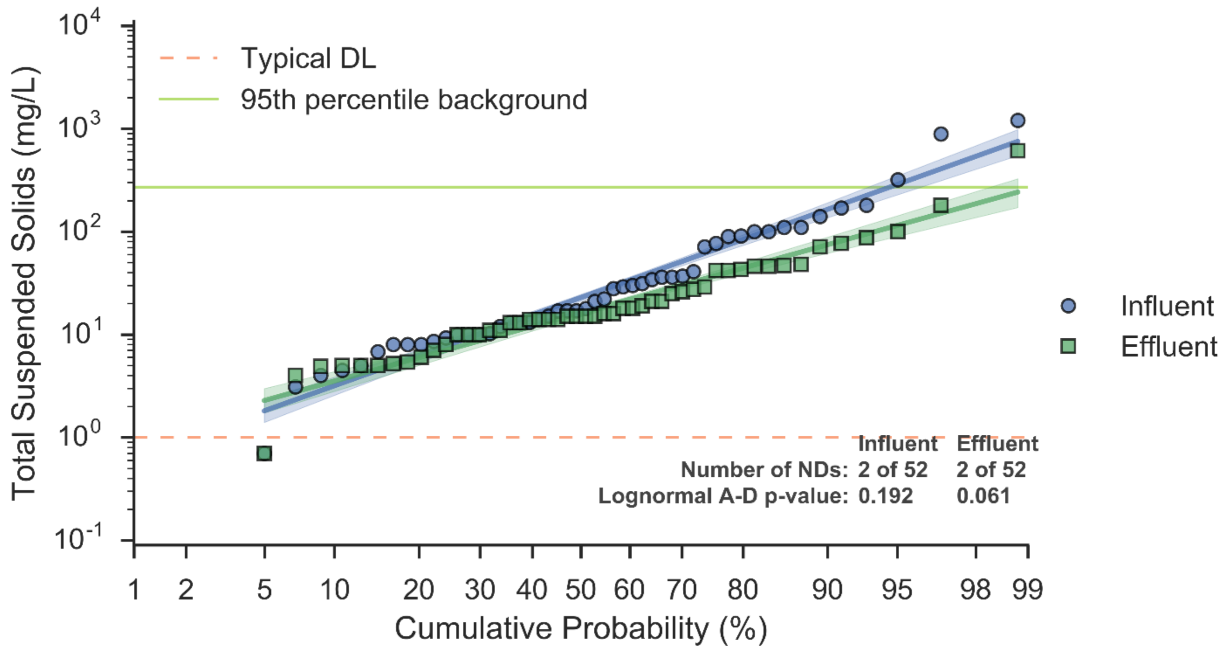

Figure 64. Log-normal Probability Plot of TSS at CM Locations

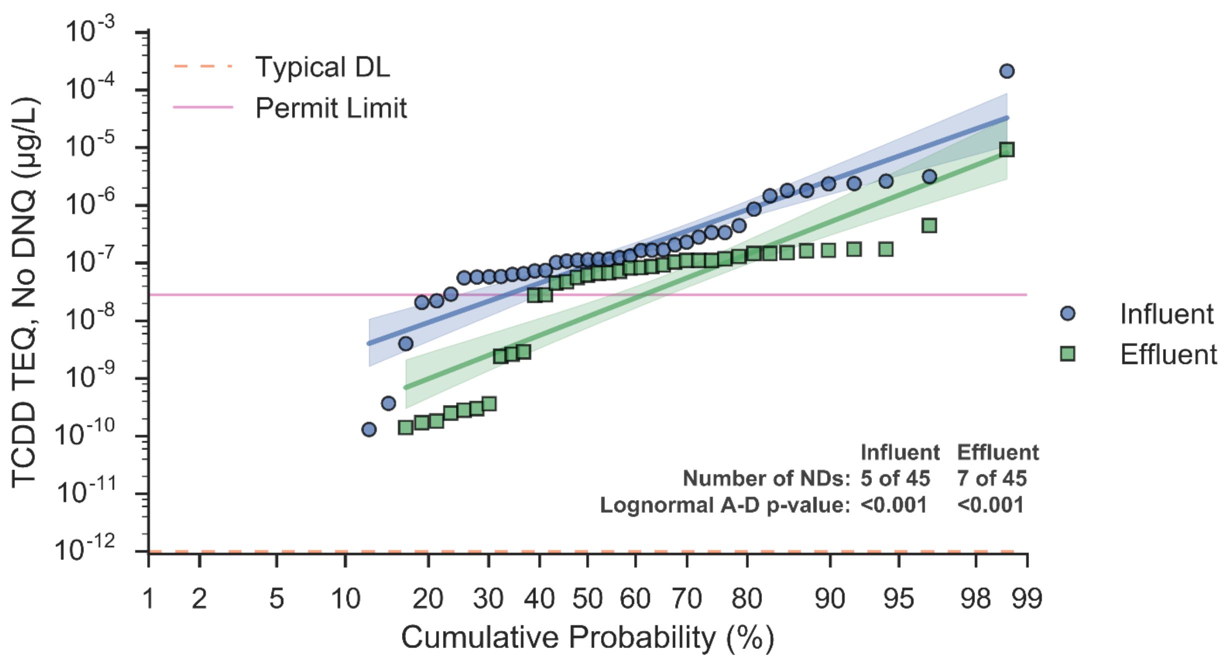

Figure 65. Log-normal Probability Plot of Dioxins at CM Locations

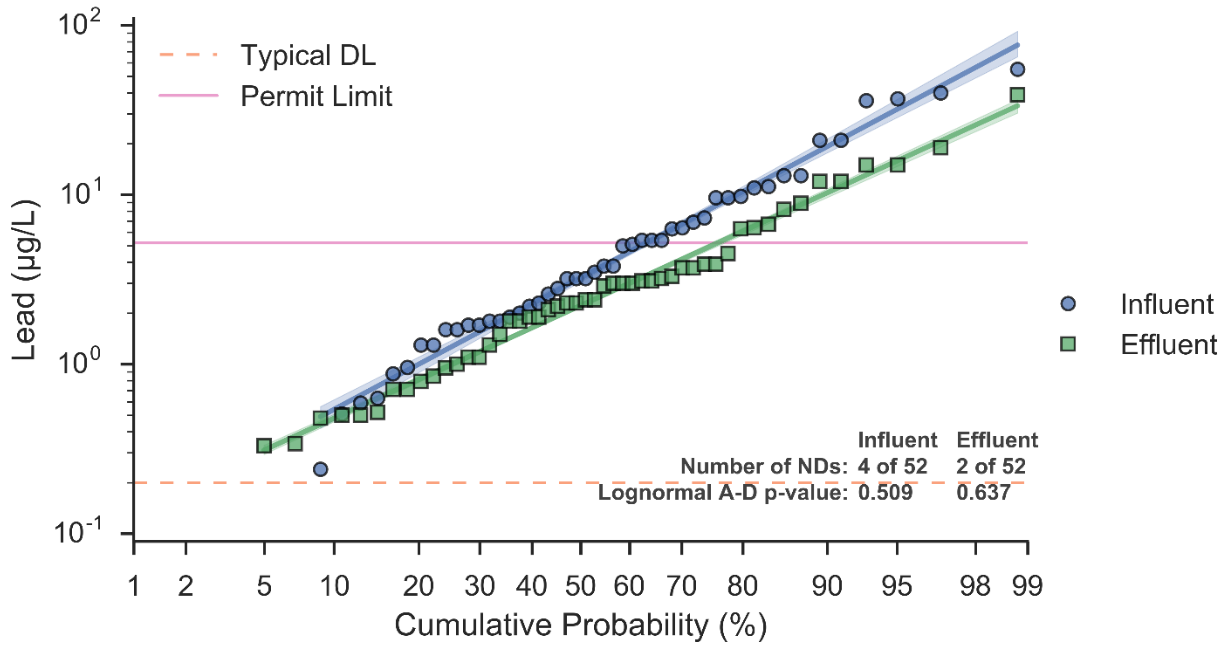

Figure 66. Log-normal Probability Plot of Lead at CM Locations

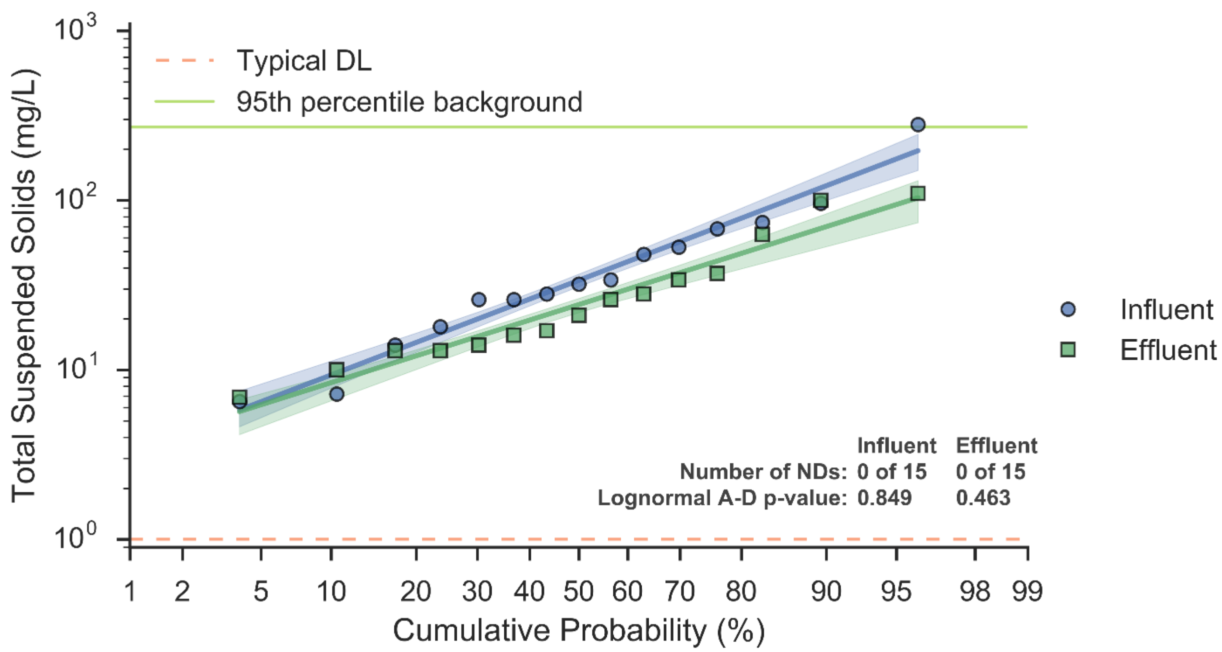

Figure 67. Log-normal Probability Plot of TSS at Lower Lot Biofilter

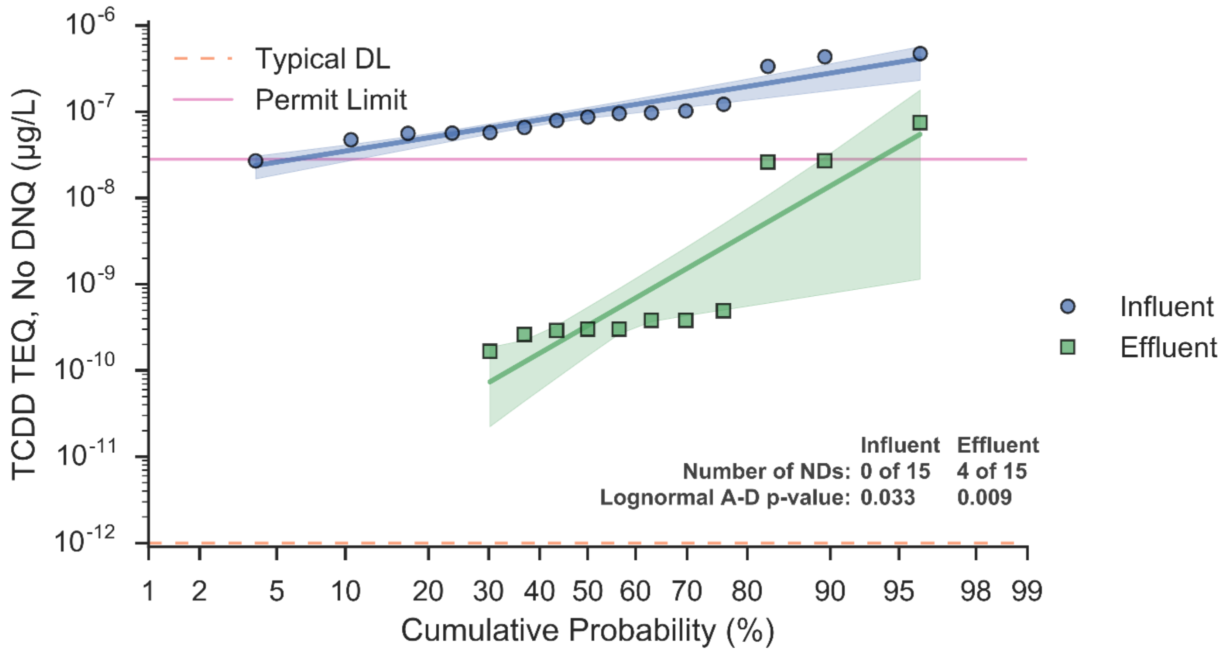

Figure 68. Log-normal Probability Plot of Dioxins at Lower Lot Biofilter

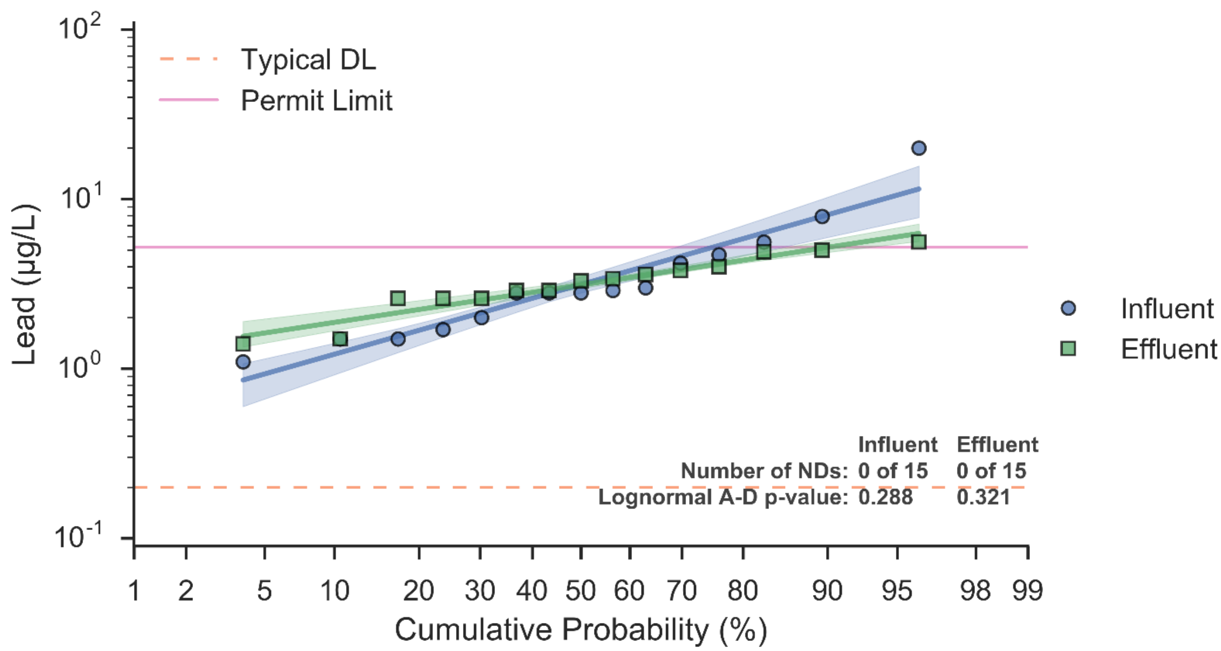

Figure 69. Log-normal Probability Plot of Lead at Lower Lot Biofilter

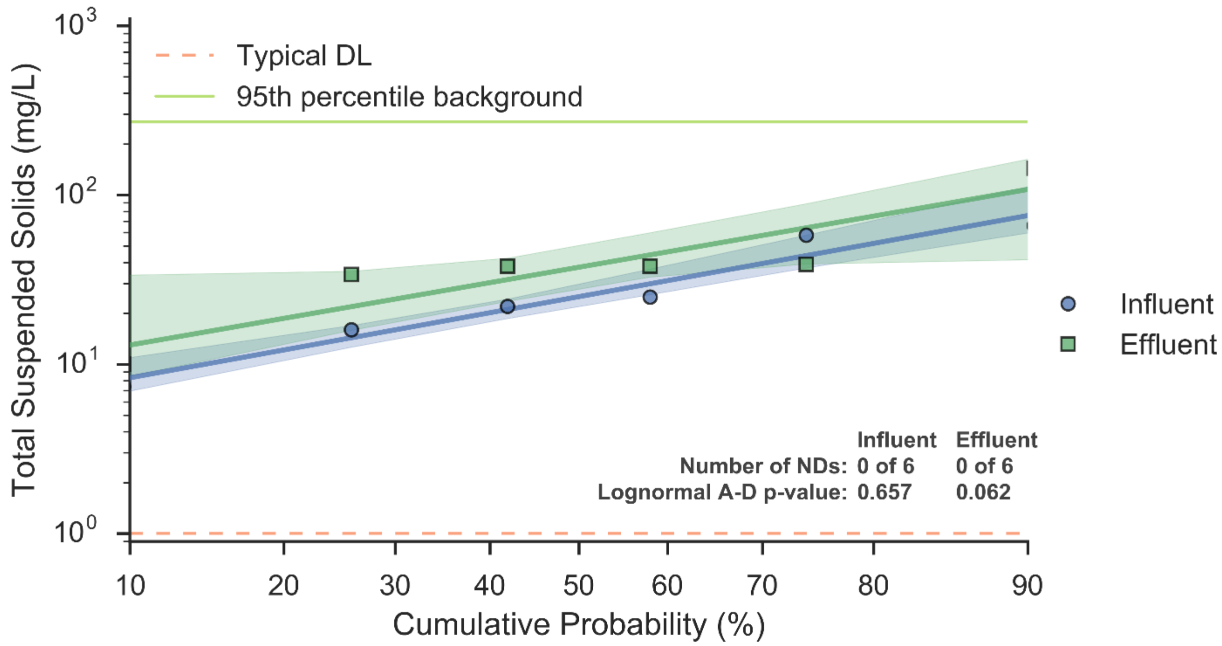

Figure 70. Log-normal Probability Plot of TSS at ELV Treatment BMP

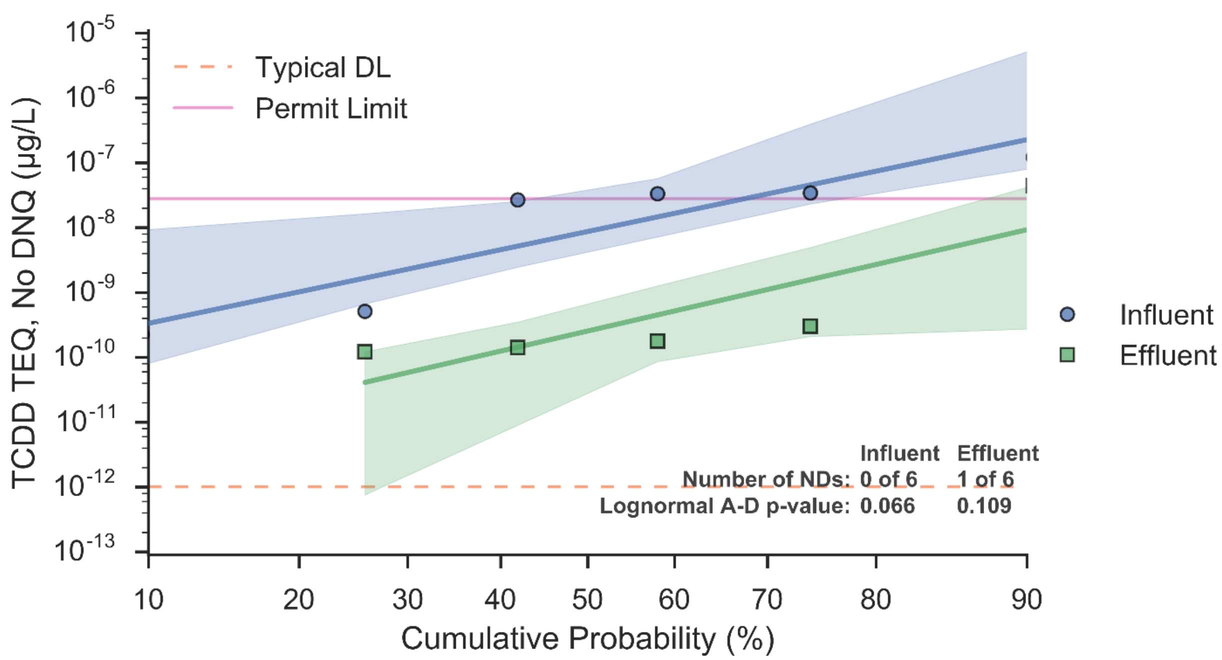

Figure 71. Log-normal Probability Plot of Dioxins at ELV Treatment BMP

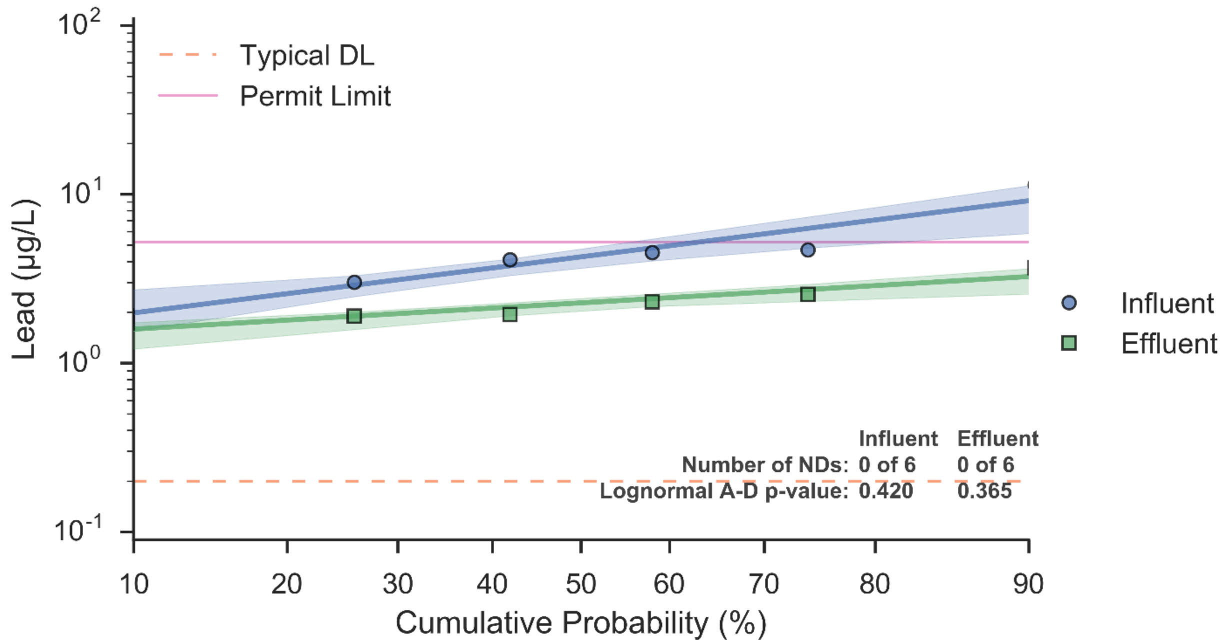

Figure 72. Log-normal Probability Plot of Lead at ELV Treatment BMP

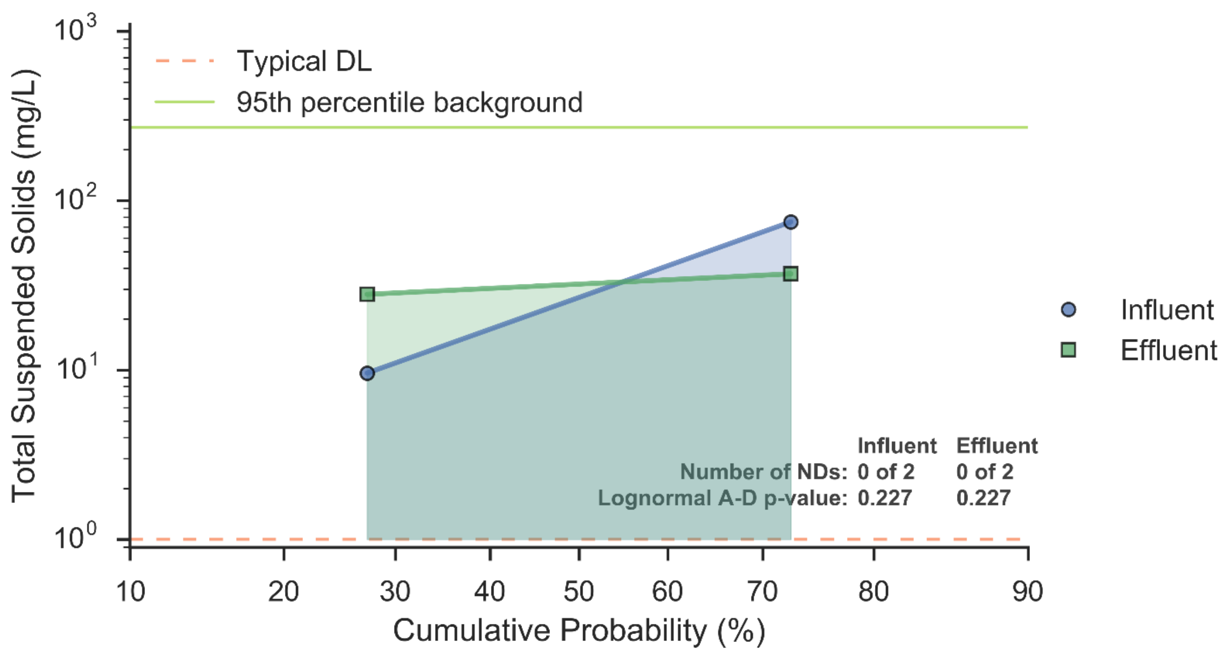

Figure 73. Log-normal Probability Plot of TSS at Vegetated Channel

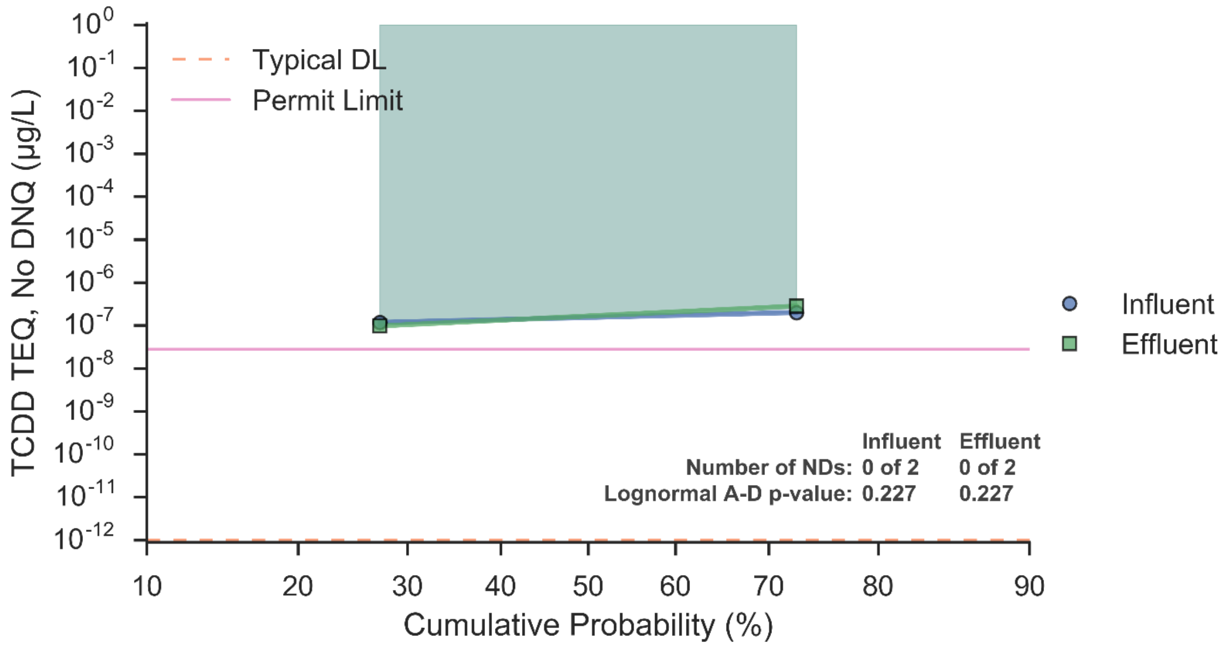

Figure 74. Log-normal Probability Plot of Dioxins at Vegetated Channel

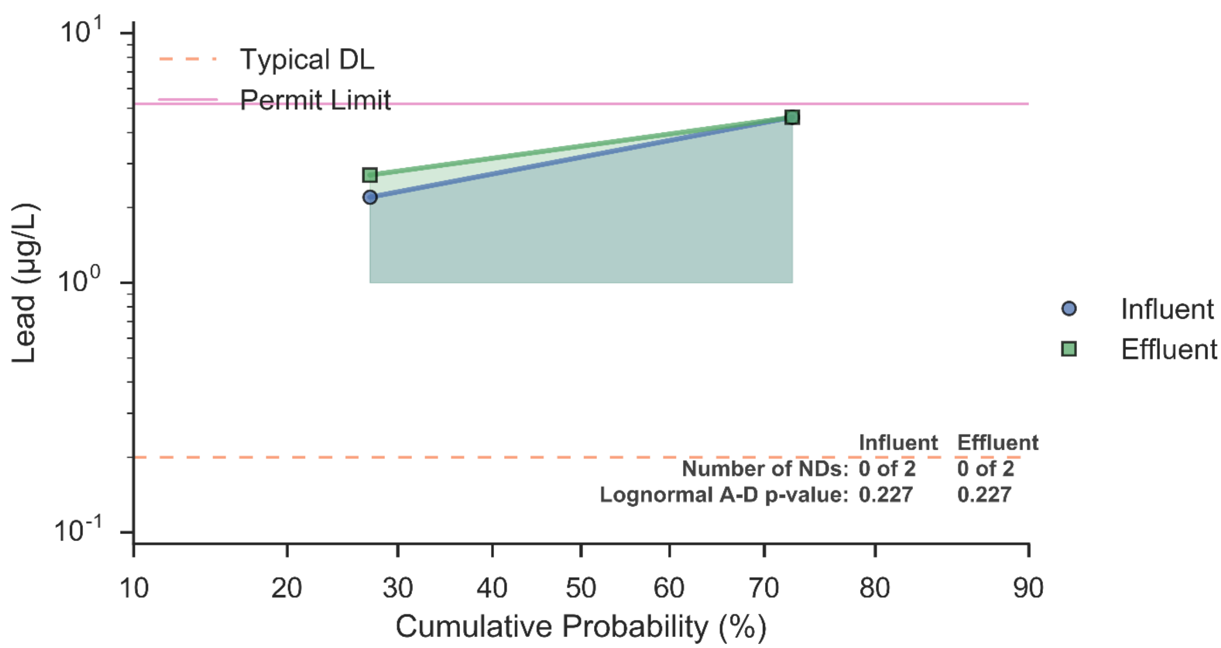

Figure 75. Log-normal Probability Plot of Lead at Vegetated Channel

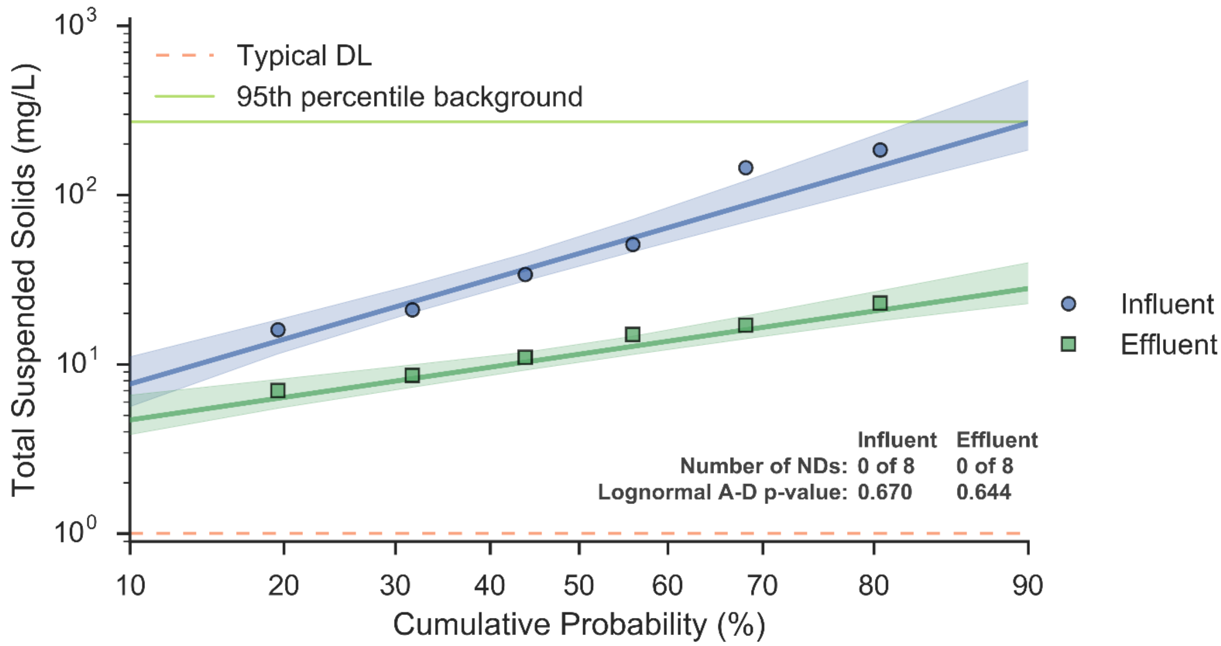

Figure 76. Log-normal Probability Plot of TSS at Detention Bioswales

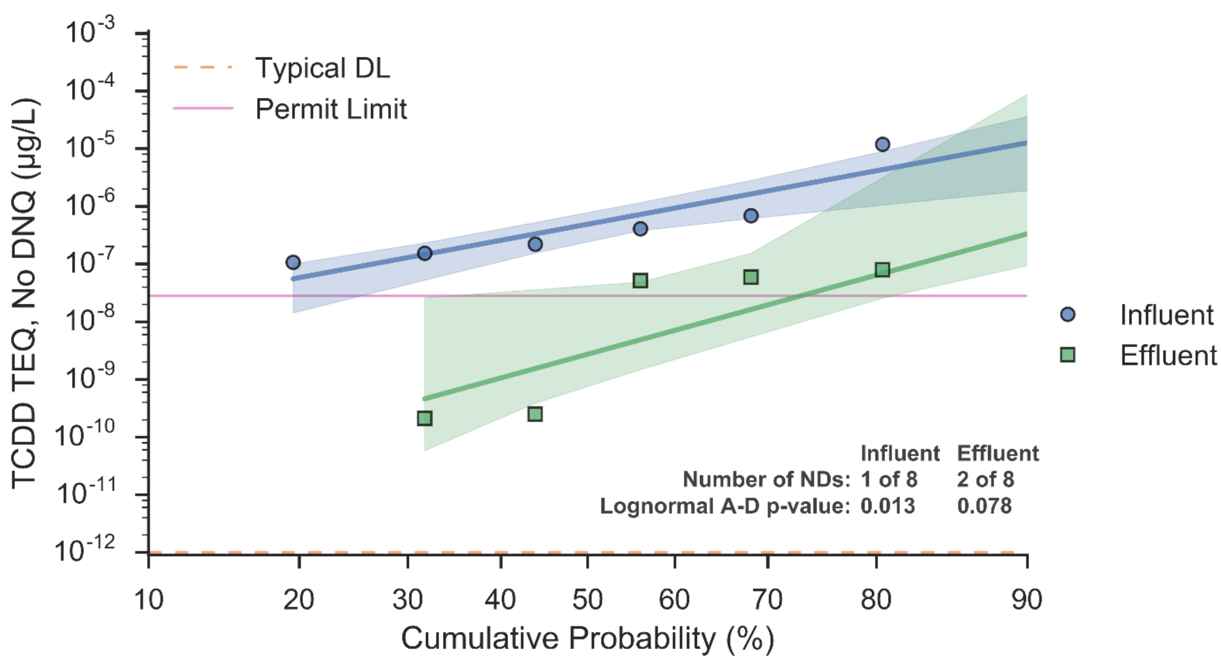

Figure 77. Log-normal Probability Plot of Dioxins at Detention Bioswales

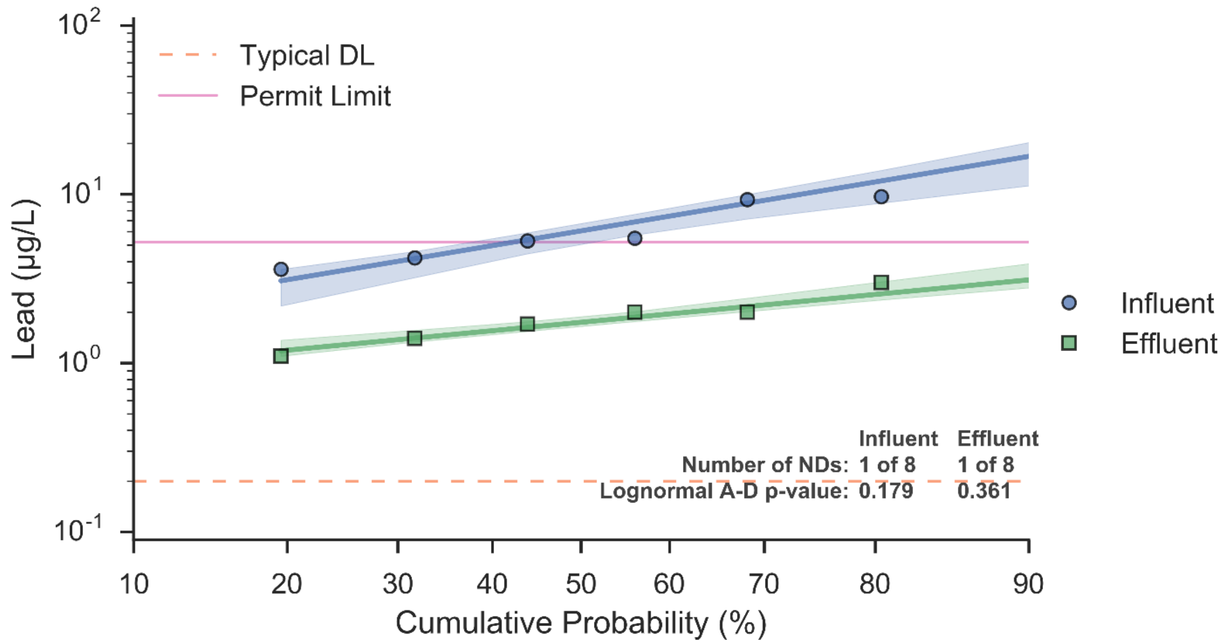

Figure 78. Log-normal Probability Plot of Lead at Detention Bioswales

7 Multiple BMP Box Plots

Multiple BMP box plots for TSS, dioxins, lead, and copper for all BMPs presented herein are shown in Figure 80, Figure 81, Figure 82, and Figure 83, respectively. These plots illustrate basic statistics of influent and effluent performance data, relative to each of the CM sites (B-1, CM-9, and CM-1 non-background sites), the lower lot biofilter, ELV Treatment BMP, the detention bioswales, and the vegetated channel in the upper Northern Drainage above the biofilter outlet. As shown in Figure 79, the box plots reflect the median, 25th percentile, 75th percentile, minimum, and maximum values, in addition to outliers, if applicable (shown as diamonds). These plots reflect paired data results only (the same data used in the statistical analyses, influent vs. effluent correlation charts, and probability plots). These plots are intended to illustrate the range of influent and effluent concentrations at each BMP and also show how influent and effluent concentrations compare (i.e., overall lower, higher, or equal effluent concentrations compared to the influent concentrations). If single sample results were included in these plots, the comparison between influent and effluent concentrations would be misleading, especially if there were a much larger number of influent or effluent sample results. The amount of overlap of the boxes indicate visual differences in the influent and effluent concentrations. Influent and effluent datasets that are widely separated (such as TSS at the detention bioswales) indicate more robust controls. Influent and effluent datasets that have substantial overlaps (such as TSS at the CM sites) indicate similar influent and effluent concentrations.

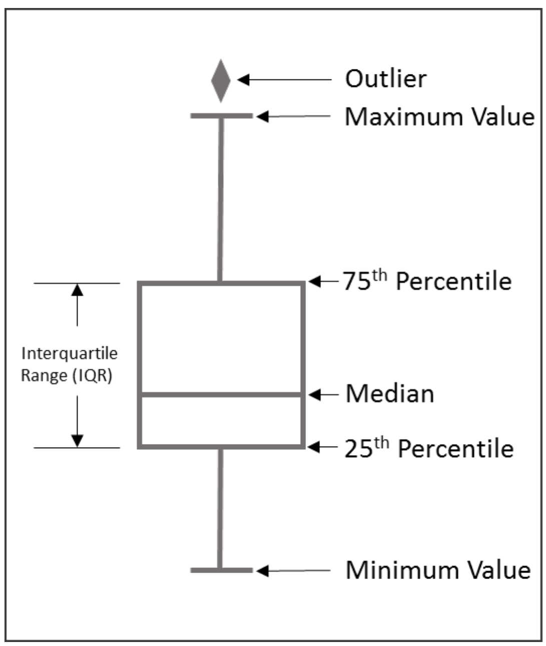

Figure 79. Box Plot Legend

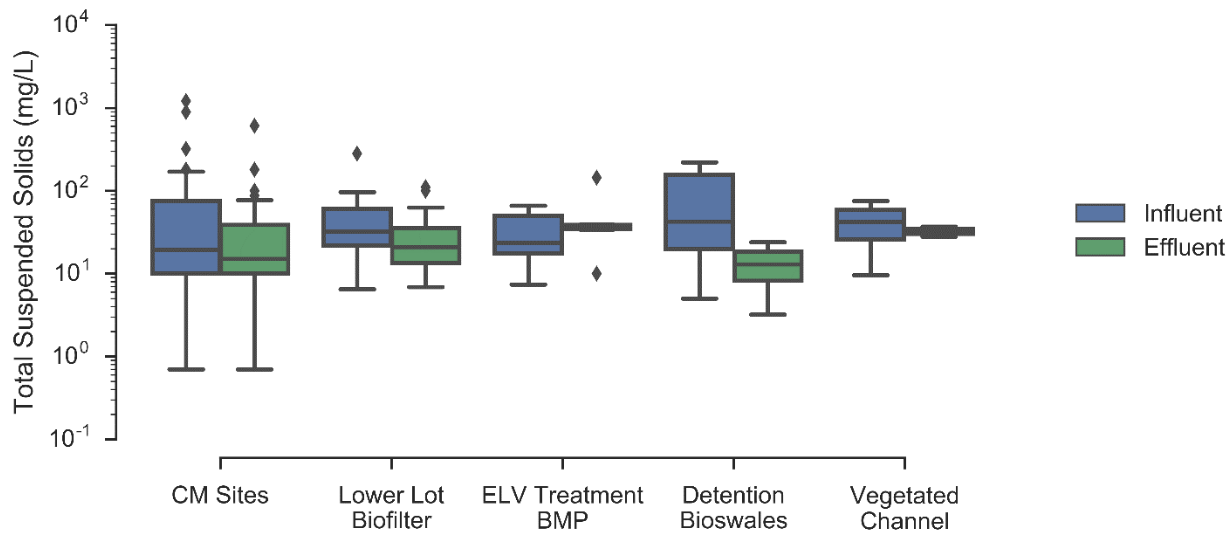

Figure 80. Multiple BMP Box Plot for TSS

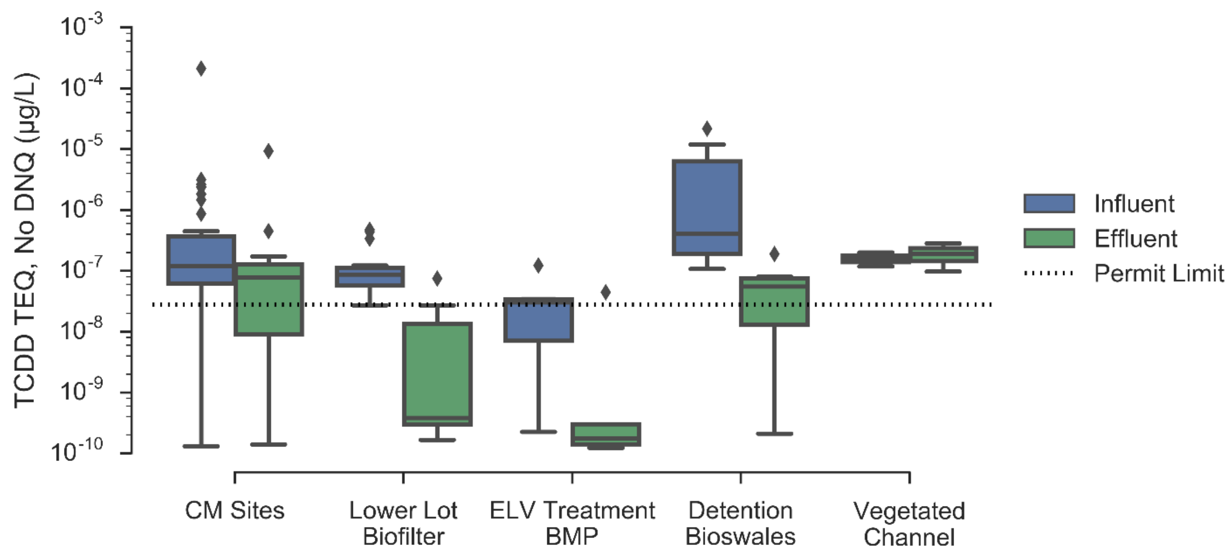

Figure 81. Multiple BMP Box Plot for Dioxins

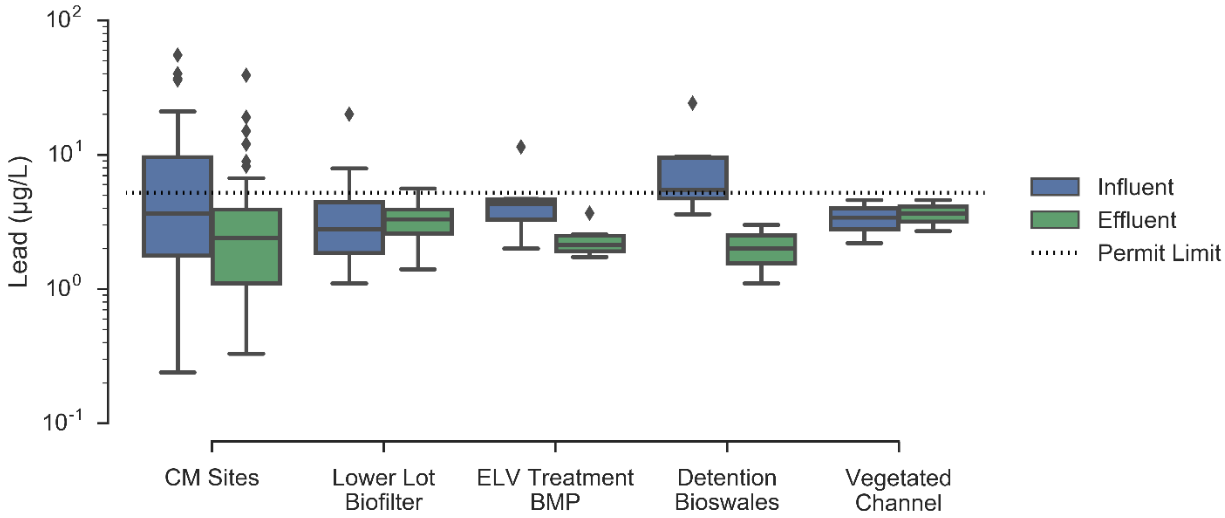

Figure 82. Multiple BMP Box Plot for Lead

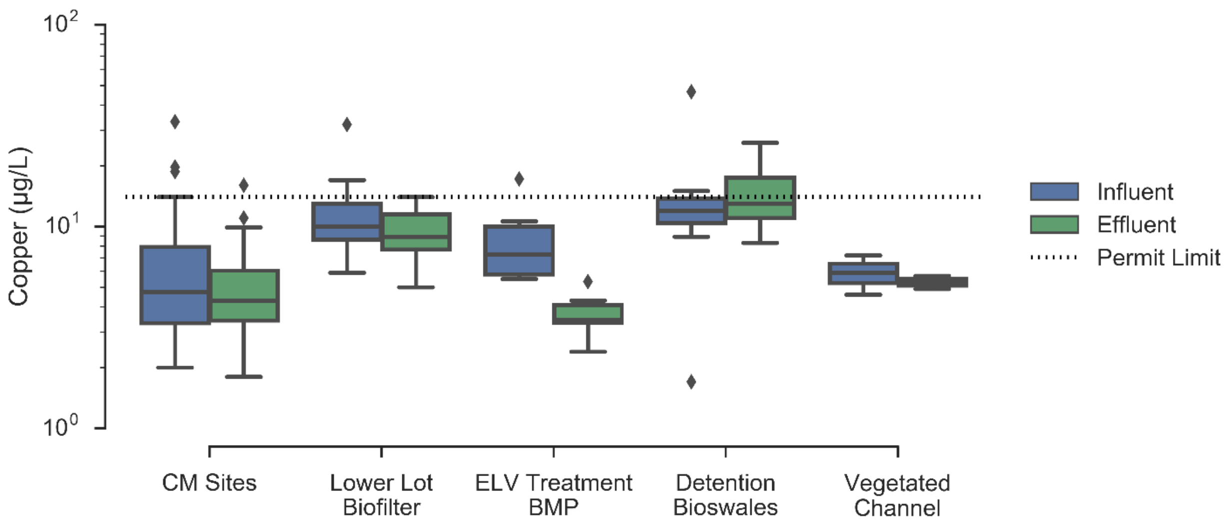

Figure 83. Multiple BMP Box Plot for Copper

8 Comparison to Permit Limits

The number of results greater than the Permit Limits for each of the influent and effluent samples at B-1, CM-9, and CM-1 are summarized in Table 14. This comparison for lower lot biofilter, the ELV Treatment BMP, the vegetated channel in the upper Northern Drainage above the biofilter outlet, and the detention bioswales is shown in Table 15, Table 16, Table 17, and Table 18, respectively. The analyses included in Table 14 through Table 18 include paired data samples analyzed in this memorandum and do not include samples collected that do not have associated paired data. There were no exceedances of permit limits for copper at any watershed 009 location during the 2015/2016 reporting year[15].

For CM sites analyzed, influent concentrations were more often higher than the Outfall 009 Permit Limits as compared to effluent concentrations for lead (20 influent vs. 11 effluent) and dioxins (36 influent vs. 26 effluent). Looking at the maximum and average ratios of concentration to Permit Limit, a higher ratio is calculated for lead influent than lead effluent, suggesting lead reduction through the CMs. This pattern is also true for dioxins in that the influent ratios (7,566 maximum and 230 average) are greater than the effluent ratios (330 maximum and 17 average). This result is skewed by one effluent result of $9.3x10^{-6}$ µg/L and one exceptionally high influent result of $2.12x10^{-4}$ µg/L. If those results are removed, then the maximum influent ratio drops to 113 and the average becomes 21, while the maximum effluent ratio decreases to 16 and the average drops to 4.3. These results reflect the same general trend of effluent ratios lower than the influent ratios, suggesting that in general dioxins are also reduced in the CMs. These results enhance the weight of evidence, especially when not enough samples are available for statistical tests.

The number of results exceeding the Permit Limits for the influent and effluent samples at the lower lot biofilter are summarized in Table 15. Influent concentrations were more often higher than the Outfall 009 Permit Limits as compared to effluent concentrations for lead (three influent vs. one effluent) and dioxins (14 influent vs. one effluent). Observation of the maximum and average ratios of concentration to Permit Limit show that a higher ratio is calculated for influent than effluent samples for lead and dioxins, suggesting reduction in both pollutants through the lower lot biofilter.

Similar trends are observed for the ELV Treatment BMP, as shown in Table 16. There were a greater number of influent sample concentrations exceeding the Outfall 009 Permit Limits compared to effluent concentrations for lead and dioxins. Only one influent sample exceeded Permit Limits for lead, while there were three exceedances over limits of influent samples and only one exceedance of effluent samples for dioxins. As observed with the CM sites and lower lot biofilter, higher maximum and average ratios of concentration to Permit Limits were calculated for influent samples compared to effluent samples. This trend suggests reduction in lead and dioxins through the ELV Treatment BMP.

A comparison of sample results at the vegetated channel in the upper Northern Drainage above the biofilter outlet to Outfall 009 Permit Limits (Table 17) show that there were no exceedances in influent or effluent samples for lead. However, both samples exceeded permit limits for dioxins at both the

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[15] Figure 46 and Figure 47 show sample results that exceed copper permit limits at the detention bioswales. However, permit limits are not applicable at this location.

influent and effluent locations. In contrast to other BMPs, the maximum and average exceedance ratios were greater for the effluent results than the influent. This can be attributed to a fairly high dioxins concentration measured at the effluent location on 1/5/2016.

The number of results exceeding the Permit Limits for the influent and effluent samples at the detention bioswales are shown in Table 18. Influent concentrations were more often higher than the Outfall 009 Permit Limits as compared to effluent concentrations for both lead and dioxins. Seven influent concentrations exceeded permit limits for dioxins, and four effluent samples exceeded limits. Five influent concentrations of lead exceeded limits, while no effluent concentrations exceeded limits for lead. The maximum and average influent exceedance ratios for dioxins are greater than the effluent ratios, suggesting that dioxins are generally reduced through the detention bioswales.

Table 14. Influent and Effluent Summary as compared to the Outfall 009 Permit Limits (B-1, CM-9, and CM-1), 2009-2016

Parameter	% of Samples Greater than Permit Limits		Maximum Exceedance Ratio (Result: Permit Limit)		Average Exceedance Ratio (Result: Permit Limit)	
	Influent	Effluent	Influent	Effluent	Influent	Effluent
Lead	38%	21%	11	7.5	3.2	2.6
TCDD TEQ no DNQ	78%	57%	7,566	330	230	17

Table 15. Influent and Effluent Summary as compared to the Outfall 009 Permit Limits (Lower Lot Biofilter), 2012-2016

Parameter	% of Samples Greater than Permit Limits		Maximum Exceedance Ratio (Result: Permit Limit)		Average Exceedance Ratio (Result: Permit Limit)	
	Influent	Effluent	Influent	Effluent	Influent	Effluent
Lead	20%	6.7%	3.8	1.1	2.1	1.1
TCDD TEQ no DNQ	93%	6.7%	17	2.7	5.4	2.7

Table 16. Influent and Effluent Summary as compared to the Outfall 009 Permit Limits (ELV Treatment BMP), 2013-2016

Parameter	% of Samples Greater than Permit Limits		Maximum Exceedance Ratio (Result: Permit Limit)		Average Exceedance Ratio (Result: Permit Limit)	
	Influent	Effluent	Influent	Effluent	Influent	Effluent
Lead	17%	0%	2.2	N/A	2.2	N/A
TCDD TEQ no DNQ	50%	17%	4.4	1.6	2.3	1.6

Table 17. Influent and Effluent Summary as compared to the Outfall 009 Permit Limits (Vegetated Channel), 2015-2016

Parameter	% of Samples Greater than Permit Limits		Maximum Exceedance Ratio (Result: Permit Limit)		Average Exceedance Ratio (Result: Permit Limit)	
	Influent	Effluent	Influent	Effluent	Influent	Effluent
Lead	0%	0%	N/A	N/A	N/A	N/A
TCDD TEQ no DNQ	100%	100%	7.1	10	5.7	6.8

Table 18. Influent and Effluent Summary as compared to the Outfall 009 Permit Limits (Detention Bioswales), 2015-2016

Parameter	% of Samples Greater than Permit Limits		Maximum Exceedance Ratio (Result: Permit Limit)		Average Exceedance Ratio (Result: Permit Limit)	
	Influent	Effluent	Influent	Effluent	Influent	Effluent
Lead	63%	0%	4.6	N/A	2.1	N/A
TCDD TEQ no DNQ	88%	50%	776	6.7	180	3.4

9 BMP Influent and Effluent Ranks

In addition, results from the subarea ranking analysis may also be used to evaluate water quality improvement resulting from the BMPs. As described in the Ranking Memo, potential BMP subarea monitoring locations were ranked based on water quality sample comparisons between both stormwater concentrations and permit limits, and subarea stormwater particulate strengths and background stormwater particulate strengths. A statistical methodology was used to rank the subareas based on these comparison results and pollutant-specific "weighting factors", which were combined to produce a multi-constituent score for the potential BMP subareas.

The subareas were ranked from the highest multi-constituent scores to the lowest scores, such that higher rankings (i.e., closer to 1) indicate the monitoring locations with poorer historical water quality. The rankings for monitoring locations corresponding to the BMPs discussed in this memo are shown in Table 19. For BMPs with multiple influent monitoring locations, the rankings of both locations are shown and an area-weighted ranking was calculated (based on the same weights used to calculate single influent concentrations as described in section 3). It should be noted that area-weighting the rankings is not as accurate as weighting the multi-constituent scores and re-ranking all subareas, but this approach shows an approximate representation. Only influent and effluent locations for the BMPs are included in Table 19; intermediate locations are not included (e.g., sedimentation basin effluent at the ELV Treatment BMP).

Improved water quality from treatment by a BMP can be demonstrated by a decrease between the influent and effluent rank. As shown in Table 19, in most cases, there was a decrease in location rank based on the multi-constituent score after the BMP treatment, demonstrating that BMP implementation has generally resulted in improved water quality. The only exception is the northern detention bioswale, where limited monitoring has occurred. Additional details of the subarea ranking analysis are included in the Ranking Memo.

Table 19. Comparison of Ranking between Influent and Effluent Locations

BMP	Influent Location(s) and Ranking(s)		(Area-weighted) Influent Ranking	Effluent Location and Ranking
B-1 Media Filter	B1BMP0004 - **14**	B1BMP0005 - **42**	27	B1BMP0006 - **43**
CM-9	ILBMP0002 - **1**	A1BMP0002-A - **34**	12	A1BMP0003 - **48**
CM-1	EVBMP0003-A - **23.5**		-	A2BMP0007 - **53**
Lower Lot Biofilter	LPBMP0002 - **16**		-	LPBMP0004 - **80**
ELV Treatment BMP	EVBMP0007 - **35.5**		-	EVBMP0008 - **80**
Vegetated Channel	B1BMP0008 - **38**		-	B1BMP0007 - **45**
Southern Detention Bioswale	ILBMP0008 - **9**	ILBMP0004 - **17**	9	ILBMP0005 - **55**
Northern Detention Bioswale	ILBMP0006 - **80**		-	ILBMP0007 - **26**

10 Runoff Volume Discharge Analysis

In addition to water quality performance, the lower lot biofilter is also designed to reduce the frequency of smaller storms discharging untreated runoff to the Northern Drainage by retaining the storm volumes and allowing evapotranspiration to take place. It is estimated that the average volume pumped to the biofilter has increased from 52,000 gallons per inch of rainfall to 82,000 gallons per inch of rainfall since the detention bioswales were constructed. Similarly, the estimated percent of total runoff volume (from both the 24-inch drain and the lower lot drainage areas) has increased from 22% to 44% on average since the detention bioswales were constructed.

To evaluate how many storms have been prevented from discharging to the Northern Drainage this year, a binned presence/absence of discharge plot was developed as shown in Figure 84. All storms sampled since the lower lot biofilter was constructed are included (3/8/2013 to present). The storm events with discharge to the Northern Drainage (i.e., bypass of the low flow diversion weir or treated effluent from the biofilter) were identified and counted. The total number of storm events compared to the number of events where discharge occurred were then binned based on storm depth in one inch increments. Additionally, this plot shows the percent of discharging events (i.e., number of events with discharge divided by the number of total events for that storm depth bin). As is shown in Figure 84, the lower lot biofilter successfully prevented 50% of all storms less than or equal to one inch from discharging to the Northern Drainage.

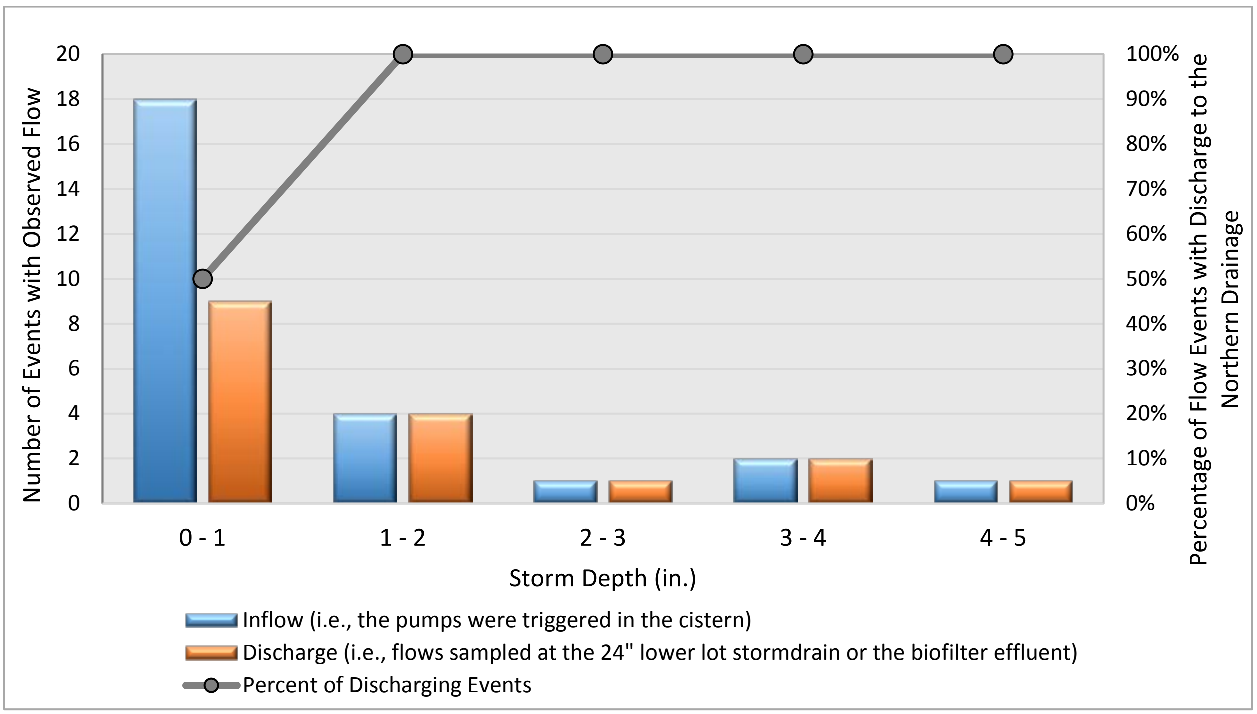

Figure 84. Binned Presence/Absence of Discharge at the SSFL Biofilter

11 Sampling Event Analysis

To evaluate whether the paired samples collected at B-1, CM-1, and CM-9 represent BMP performance during a variety of rainfall patterns, the paired samples taken to date were compared to probability plots of average storm event intensity, maximum storm event intensity, and total storm event depth as shown in Figure 85, Figure 86, and Figure 87, respectively. The period of record (POR) for rainfall data in this analysis ranges from October 2009 through May 2016 and reflects precipitation from the Area 4 gauge (moved to Area 1 on January 1, 2013). The purpose of these plots is to determine whether sampling at these locations can be discontinued if the data collected are representative of varying site conditions (i.e., collecting additional data will not add significant value to the findings). As is shown in the figures, there have been 16 paired samples collected at the B-1 media filter post installation of the curb cuts in 2012. These samples are well distributed across the average storm event intensities, maximum intensities, and total depths of the storms at the site since its installation. As shown on Figure 88 (Burton and Pitt, 2001), 16 pairs of samples are suitable to allow significant differences to be quantified for at least 90% reductions, at high power and confidence). Therefore sampling at B-1 is recommended to be discontinued.

There have been 21 paired samples collected at CM-1 (including both pre and post filter fabric installation), and 22 paired samples have been collected at CM-9 (pre and post improvements). These numbers of samples should allow the quantification of at least 80% differences between the influent and effluent locations, at high power and confidence. However, the number of paired samples collected at CM-1 post filter fabric installation and at CM-9 post improvements are much lower (i.e., seven paired samples at CM-1 and five paired samples at CM-9 vs. 16 paired samples at B-1) and less distributed, especially with respect total annual rainfall (Figure 87), and therefore do not represent a variety of average storm event intensities, maximum intensities, or total storm depths. It is recommended that stormwater sampling continue at these locations to better represent the long-term distribution of rainfall patterns at SSFL, and therefore more accurately assess the performance of these BMPs.

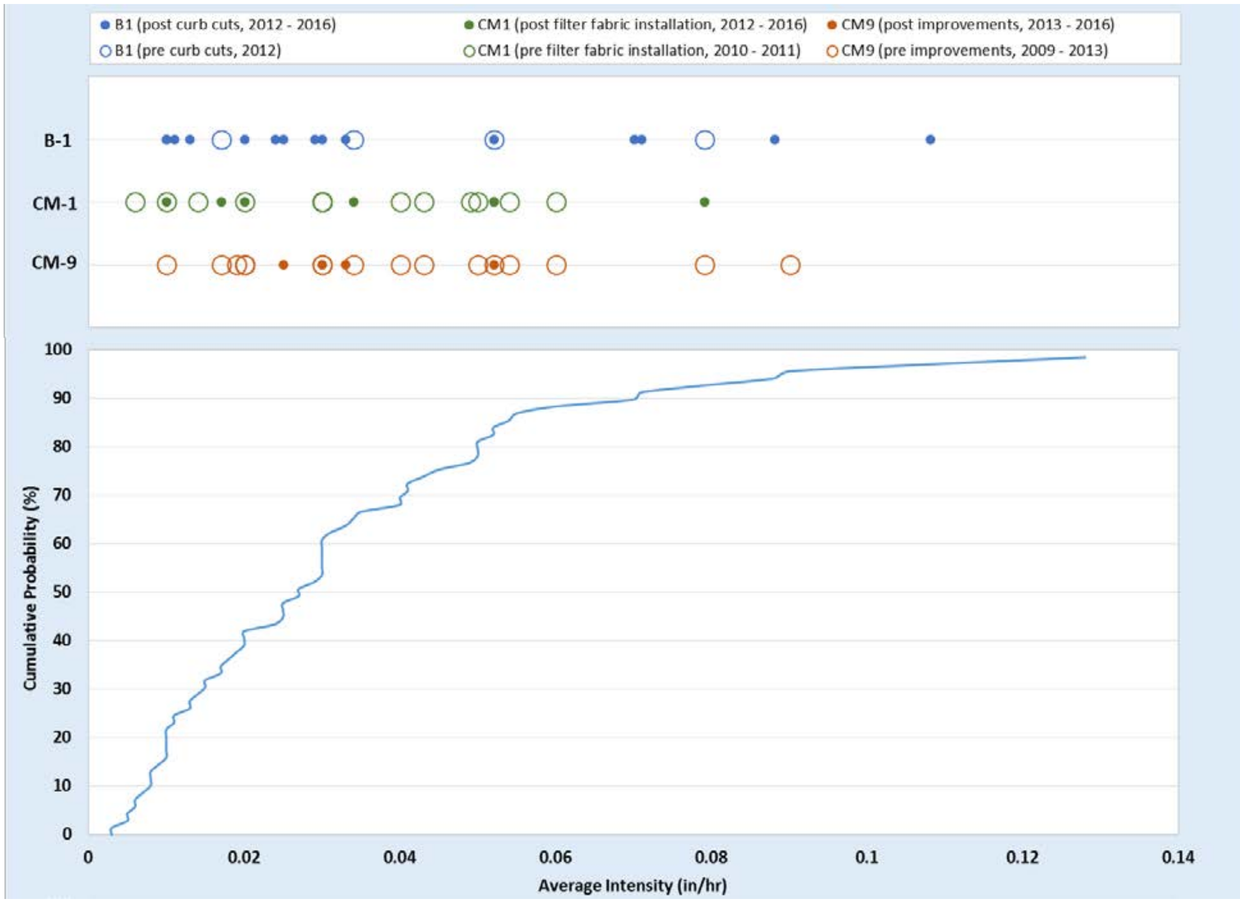

Figure 85. Paired Samples and Probability of Average Storm Event Intensity

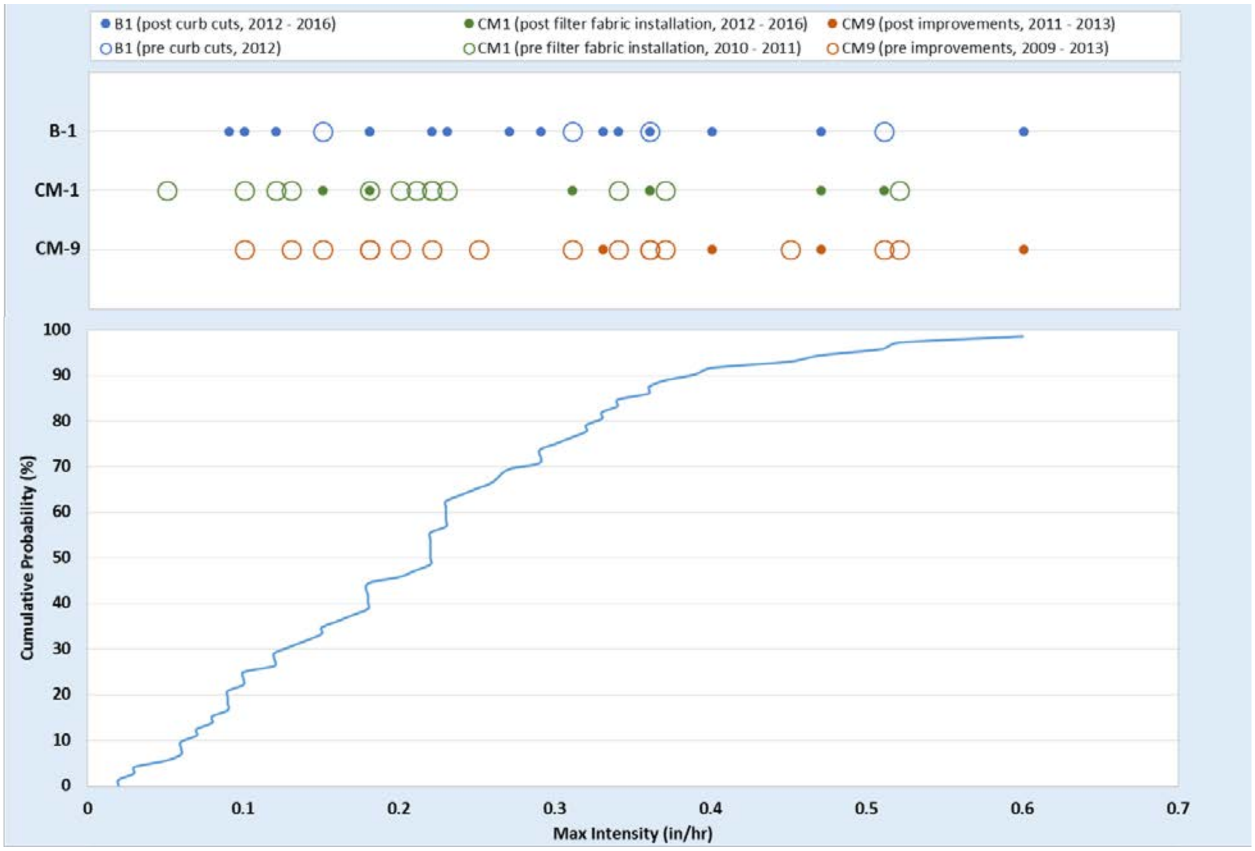

Figure 86. Paired Samples and Probability of Maximum Storm Event Intensity

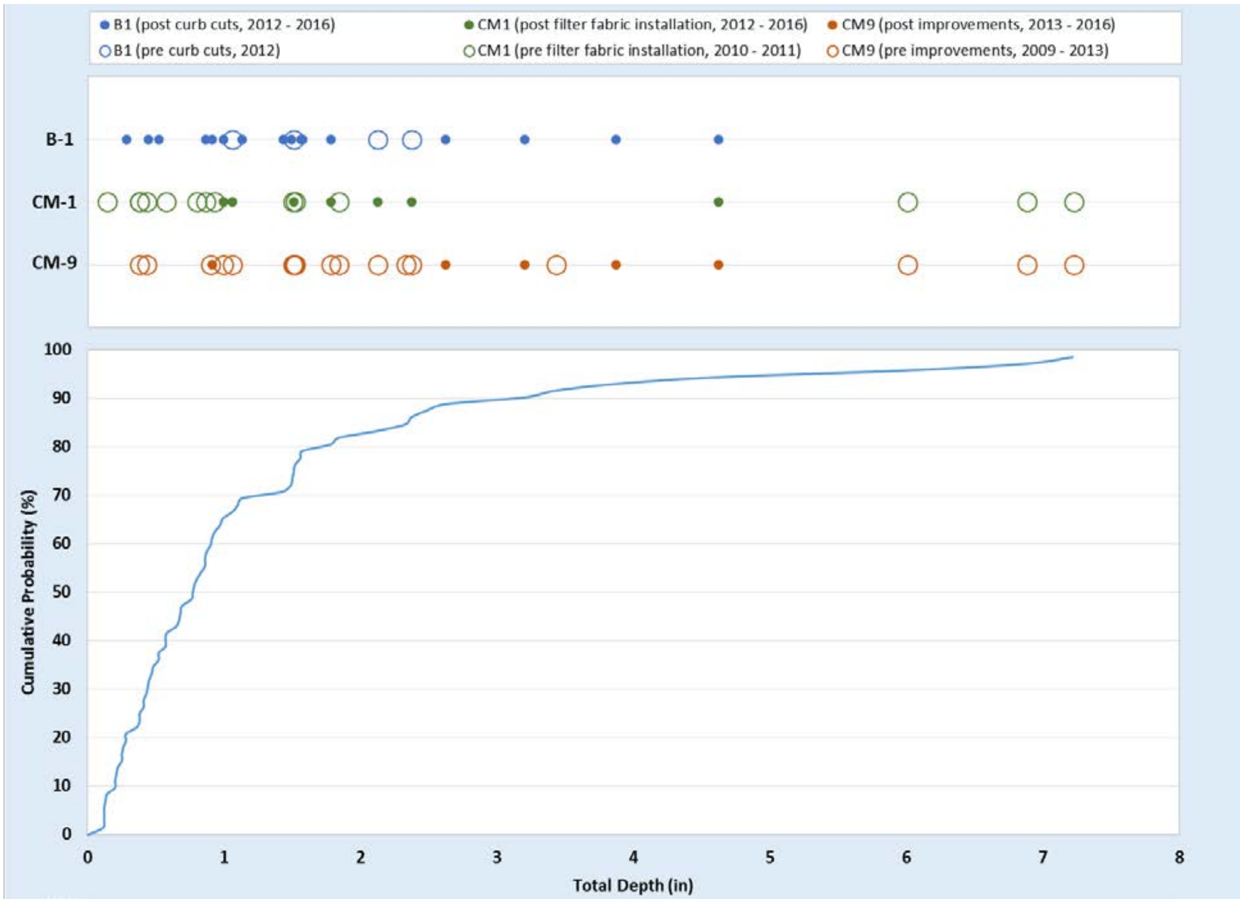

Figure 87. Paired Samples and Probability of Total Storm Event Depth

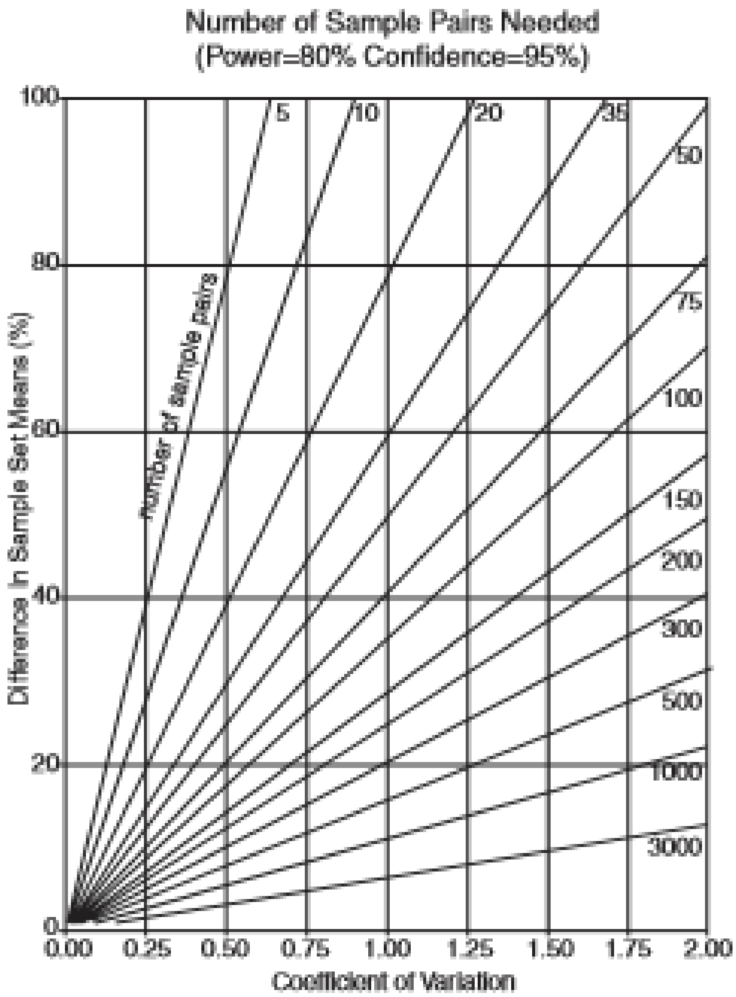

Figure 88. Experimental design curves showing sampling efforts to distinguish differences in sampling locations, at high power and confidence (Burton and Pitt, 2001).

12 Cumulative TSS Loading Analysis

An analysis was performed to calculate the cumulative TSS loading to each BMP thus far, based on historical storm event depths and the measured influent concentrations of TSS. These values were compared to the estimated sediment load that would result in initial clogging of the media, based on a study by Pitt and Clark (2010).

The estimated TSS loading to each BMP containing media and with sufficient data (ELV Treatment BMP, lower lot biofilter, B-1 media filter, CM-1, and CM-9) was estimated for each storm event where a sample was collected (at either the influent or effluent location[16]). The estimated cumulative TSS loading was determined using the following steps:

- The average annual percent capture and treatment (i.e., the percentage of incoming runoff that does not bypass the BMP) was determined using USEPA's Storm Water Management Model (SWMM) for each BMP.
- The runoff coefficient for each BMP's drainage area was determined using SWMM, simulated over the average annual year scenario[17].
- The total area of each BMP's drainage area was determined using available Geographic Information System (GIS) shapefiles.
- The runoff volume treated by each BMP during each individual storm event was calculated as follows:
    - Storm event volume treated = BMP drainage area x Storm event depth x Runoff coefficient of the BMP drainage area x Average annual percent capture
- The storm event TSS loading contributed to each BMP during each individual storm event was then calculated as follows:
    - Storm event TSS loading = Storm event volume treated x Event-dependent TSS influent sample result (concentration)
- The cumulative TSS loading since implementation of the BMP was calculated by summing the storm event TSS loading results from all storms collected to date.

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[16] In the event that an effluent sample was taken and an influent sample was **not** taken during the same storm event, the average of all TSS influent samples at the BMP was used to represent the influent loading of TSS during this specific event.

[17] Because the runoff coefficient is determined by modeling an average year scenario in SWMM, it will reflect both runoff producing storm events and events that do not produce runoff. As described, the runoff coefficient is used to calculate TSS loading for storm events where a sample was collected (i.e., a runoff producing event). Therefore, use of the runoff coefficient from the average annual year scenario may slightly underestimate TSS loading for the runoff producing events.

- The media area of each BMP was estimated from plans[18], and the cumulative TSS loading per unit area of media was calculated for each BMP.

For BMPs with pretreatment (ELV Treatment BMP and lower lot biofilter), the sample collected at the effluent of the sedimentation basin or the influent to the media was collected to represent actual TSS loading to the media. The cumulative TSS loading per media unit area to each BMP was compared to the estimated sediment load to the media until initial maintenance is needed (49 kg/m^2) (Pitt and Clark, 2010). The percentage of cumulative sediment loading until clogging for each BMP is shown in Table 20.

The estimated number of years until media replacement is needed for each BMP, assuming an average reporting year for all subsequent years, is also shown in Table 20. This was estimated using a similar procedure outlined above based on an average rainfall year. The long-term average annual rainfall of 16.8 inches was used as the storm event depth and the average TSS concentration from all sampled events was used as the TSS influent sample result. The estimated TSS loading to each BMP (per media area) during an average rainfall year and the number of average years until media replacement is needed is shown in Table 20. It should be noted that varying annual rainfall, in addition to smaller or larger storm events, will result in varying TSS loading and this serves as a rough estimate of when replacement may be expected.

Table 20. Percent of Cumulative Sediment Loading until Clogging

BMP	Cumulative TSS load (kg)	Cumulative TSS load per media area (kg/m^2)	% of "sediment load to the media until initial maintenance is needed"	TSS load per media area in average rainfall year (kg/m^2)	Number of average years until media replacement is expected
ELV Treatment BMP	44.7	2.2	4.5%	2.7	17
Lower Lot Biofilter	674	3.1	6.2%	2.0	23
B-1	219	12	24%	4.8	7.8
CM-1	387	65	132%	9.3	N/A
CM-9	215	36	74%	8.7	1.5

[18] For CM-1 and CM-9, it was assumed that the front half of the media mound received flow, especially during small storm events. However, ponding can occur above the media filter, especially during large storm events, and infiltrate over a larger surface area. Therefore, the media area estimate is conservative for CM-1 and CM-9.

13 Discussion and Observations

The following general observations were made based on an evaluation of the aforementioned data summary charts and tables.

1. **Are the CMs reducing the concentrations of lead, dioxin, and TSS between the untreated influent and the treated effluent?**

   The CMs were originally installed as provisional (pending further evaluation) stormwater controls that could be installed in areas where existing culverts carried the stormwater below the roads. As a result, they handle the wide range of flows during a typical rain year and experience relatively short treatment residence times and the weirs overflow during average to large size storms. However, the performance monitoring results indicate that statistically significant pollutant concentration reductions are occurring for dioxins and lead at the non-background CMs (i.e., CM-1, CM-9, and B-1) as a result of their sedimentation and media treatment unit processes. Pollutant concentrations are also being reduced for TSS at the non-background CM sites, although results are only marginally statistically significant (p-value of 0.059). Average pollutant reductions in the non-background CMs ranged from 42-95%[19]. Effluent concentrations of TSS and lead were lower than corresponding influent samples for the CM background locations (i.e., CM-8 and CM-11), with statistically significant pollutant removal observed. Dioxins at the CM background locations showed an increase in concentrations of dioxins from the influent to effluent. However, influent concentrations were likely at levels low enough that they were unlikely to be significantly reduced by the specific BMPs installed. Monitoring results show that the CMs are reducing the concentrations of TSS, dioxins, and lead between the influent and effluent of the non-background CM. TSS and lead concentrations are decreasing from the influent to effluent at the background CMs.

2. **Are the detention bioswales, Lower Lot Biofilter, and ELV Treatment BMPs reducing the concentrations of lead, dioxin, and TSS between the untreated influent and the treated effluent?**

   Cumulative performance monitoring data (as summarized by the statistical analysis tables, correlation charts, and probability plots) indicate that detention bioswales effluent concentrations were lower than corresponding influent samples for all COCs evaluated. Statistically significant pollutant removals were observed for dioxins and lead (but not for TSS which exhibited a p-value of 0.14). Effluent concentrations were also generally lower at the lower lot biofilter for TSS and dioxins, with statistically significant pollutant removal noted for dioxins. Over half of data pairs at the lower lot biofilter showed effluent results with larger lead concentrations than their paired influent samples. However, the average percent change in lead concentration was 22%, indicating overall lower effluent results (see additional discussion on question #4 of this section). Data from the ELV Treatment BMP showed that the majority of sample pairs had lower effluent concentrations for dioxins and lead than corresponding influent

[19] As previously described, the high value of 95% (for dioxins) was heavily influenced by two data pairs. If these pairs are removed, the range will instead be 42-84%.

samples, with statistical significance shown for lead. However, the majority of data pairs had higher effluent TSS concentrations than influent concentrations. Overall, average percent change of lead, dioxin, and TSS concentrations from the influent to effluent shows reduced effluent concentrations of COCs at the detention bioswales, lower lot biofilter, and ELV Treatment BMP, with the exception of TSS at the ELV Treatment BMP.

3. **Are the treatment controls aiding in compliance with NPDES permit limits at Outfall 009?**

   Collectively, the treatment controls are expected to support water quality improvement and NPDES compliance at Outfall 009, where lead and dioxin compliance challenges persist. The only COC-BMP combination to have the majority of effluent concentration results above its Permit Limit was dioxins for the non-background CMs (CM-1, CM-9, and the B-1 media filter) (i.e., 57% of the 46 total paired effluent samples), in contrast to 78% of the paired influent samples. For lead at the non-background CMs, 38% of the 53 total paired influent samples were above the Permit Limit, and 21% of the paired effluent samples were above the Permit Limit. Average paired influent concentrations to the non-background CM treatment controls were 3.2 and 20[20] times higher than average Outfall 009 concentrations for lead and dioxins, respectively, during this same time period, suggesting that the treatment control drainage areas (which include paved roads) are pollutant generating source areas that, without treatment, would have worsened water quality at the downstream NPDES compliance location. This is further supported by the BMP Ranking Analysis (Appendix F to the 2015/2016 Annual Report), which ranks Outfalls 008 and 009 lower than many of the potential source areas, based on their multi-pollutant rank, which is intended to indicate "quality" of runoff sampled. A lower rank indicates better runoff quality and Outfalls 008 and 009 are both ranked 77.5, which is the lowest possible rank in the 2015/2016 reporting year.

4. **Is there a reason why some recent monitoring data at the lower lot biofilter has shown net increases in pollutant concentrations across the system in recent years?**

   Data collected to date at the lower lot biofilter showed net TSS, dioxins, and lead reductions of 37%, 94%, and 22%, respectively, for the 15 monitoring events available since completion of the biofilter. As previously noted, eight of the 15 paired samples had higher influent concentrations than their paired effluent concentrations for TSS, and six of the 15 samples had larger influent concentrations than their paired effluent concentrations for lead. It should first be noted that there are no applicable permit limits for TSS and only one effluent sample has exceeded permit limits for lead (sample collected on 12/2/2014). In addition, 15 out of 15 dioxins concentrations decreased from the sedimentation basin outlet to the biofilter outlet. However, this pattern of net increases in TSS and lead concentrations across the system can likely be attributed to the significantly lower influent concentrations to the lower lot biofilter in recent years. The B1436 detention bioswales, which were constructed in December 2014, slow and treat a portion of the drainage area which would have previously flowed to the lower lot biofilter. Some treatment is

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[20] This ratio excludes two influent results also excluded from prior analyses due to anomalies: 1) A2SW0001 on 10/6/2010 (1.81E-6 ug/L), and 2) weighted average between B1BMP0004 (4.00E-4 µg/l) and B1BMP0005 (4.89E-08 µg/L) on 12/2/2014.

expected to be achieved by the detention bioswales, but the primary purpose is to slow the influent runoff to the lower lot biofilter and reduce flow that bypasses the BMP during large storm events. As previously noted, the average volume pumped to the biofilter has increased since the detention bioswales were constructed. Similarly, the estimated percent of total runoff volume (from both the 24-inch drain and the lower lot drainage areas) has increased since the detention bioswales were constructed. The average influent TSS concentration to the Lower Lot biofilter for samples collected before or during December 2014 was 109 mg/L, and the average for samples collected after December 2014 was 28 mg/L. This trend of significantly lower influent concentrations following construction of the detention bioswales was also observed for lead. The average influent concentration before construction of the detention bioswales was 8.0 µg/L, and the average influent concentration after construction was 2.6 µg/L. The average effluent concentrations of both TSS and lead were slightly lower in post-detention bioswales samples when compared pre-detention bioswales (i.e., 41 mg/L vs. 32 mg/L for TSS and 4.0 µg/L vs. 3.0 µg/L for lead). The fairly low average percent reductions across the system and the number of sample pairs with higher effluent concentrations than their paired influent concentrations for TSS and lead can be explained by the significant reduction in average influent concentrations to the Lower Lot biofilter since construction of the detention bioswales.

5. **Why are there no statistical analyses presented for the vegetated channel in the upper Northern Drainage above the biofilter outlet?**

   Samples were collected downstream of the vegetated channel in the upper Northern Drainage above the biofilter outlet during previous reporting years. However, samples were not collected at the B-1 culvert outfall (influent location) until the most recent reporting year. Observation of concentrations from the B-1 culvert outfall compared to the location downstream of the vegetated channel would provide the best indication of performance of the vegetated channel. Only two sample pairs have been collected at these locations. Additional data are needed to perform statistical analyses on the performance of the vegetated channel. However, initial results show minimal water quality benefit resulting from the vegetated channel.

6. **Is the lower lot biofilter preventing stormwater runoff from discharging to the Northern Drainage?**

   Monitoring data at the lower lot biofilter were also examined to determine its ability to prevent smaller storms from discharging to the Northern Drainage. The lower lot biofilter successfully prevented 50% of all storms less than or equal to one inch from discharging to the Northern Drainage.

7. **Has an adequate number of samples been collected such that sampling can be potentially discontinued at some locations?**

   The samples collected to date at the B-1 media filter (post curb cut installation) are well distributed across the average storm intensities, maximum intensities, and total depths of the storms. Further sampling at B-1 is recommended to be discontinued. The number of samples collected have also allowed reliable statistical analyses of the performance of this media filter. There are a significant number of paired samples at CM-1 both pre and post filter fabric installation and at CM-9 pre and post improvements. However, paired samples collected at CM-

1 post filter fabric installation and at CM-9 post improvements are more sparse and do not represent a variety of storm events. It is recommended to continue sampling at CM-1 and CM-9 in order to accurately assess the performance of these BMPs.

8. How much cumulative sediment loading has occurred at the BMPs and how do these loads compare to when initial maintenance may be required?

The cumulative TSS loading to the ELV Treatment BMP, lower lot biofilter, B-1 media filter, CM-1, and CM-9 was investigated and compared to the estimated value of cumulative sediment loading to the media before initial maintenance is needed (Pitt and Clark, 2010). The ELV Treatment BMP and lower lot biofilter were only 4.5% and 6.2%, respectively, towards requiring initial maintenance, and it was estimated that maintenance would not be needed for another 17 and 23 years, respectively, assuming average rainfall years. Calculations showed that CM-1 has reached the cumulative sediment loading where maintenance is needed (132%). Maintenance was performed on CM-1 during this reporting year. The filter fabric was re-attached to the weir boards and rip-rap and gravel were added to the check dam, to replace the sand bag berm, but the media was not replaced. However, there has not been any observed flow associated with media clogging at CM-1. B-1 and CM-9 were estimated to be 24% and 74% respectively, towards media clogging, and initial maintenance is expected to be needed in 7.8 and 1.5 years, respectively, assuming average rainfall years. Observations of clogging, overflow, and underdrain flows should continue to be taken at each BMP during storms so that this condition is tracked and timely maintenance can be performed when needed.

14 References

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Pitt, R. E. and Clark, S.E., 2010. *Evaluation of Biofiltration Media for Engineered Natural Treatment Systems.* May.

Appendix H: Outfall 008 Stormwater Background Evaluation

Prepared for

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Appendix H: Outfall 008 Stormwater Background Evaluation

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SB0363W
October 2016

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1 Introduction

1.1 Purpose

The purpose of this memorandum is to compare the quality of stormwater runoff at The Boeing Company's (Boeing) Santa Susana Field Laboratory (SSFL) Outfall 008 to local background stormwater monitoring data collected within SSFL. Throughout this memorandum, "background" is intended to represent stormwater runoff from areas without historic industrial operations, Resource Conservation and Recovery Act (RCRA) feasibility investigation (RFI) areas, or development surfaces (e.g., buildings, paved roads, or lots). This comparison is being performed to assess whether the remedial and restoration activities completed by Boeing within the Happy Valley area (i.e., Department of Toxic Substances Control [DTSC] Interim Measure, Interim Source Removal Action [ISRA], and Best Management Practices [BMP] programs) have restored stormwater quality at Outfall 008 to natural background conditions. The Outfall 008 watershed is 62 acres, entirely owned by Boeing, and unlike most other SSFL watersheds, lacks paved roads, buildings, lots, and/or unaddressed RFI areas.

1.2 Background

Stormwater discharges[1] from SSFL are currently regulated by the Los Angeles Regional Water Quality Control Board (LARWQCB) under *National Pollutant Discharge Elimination System (NPDES) Permit No. CA0001309 for the Boeing Company, SSFL, Canoga Park, CA, Order No. R4-2015-0033* ("2015 Permit") (LARWQCB, 2015a), which became effective on February 12, 2015. The 2015 Permit follows *NPDES Permit No. CA0001309 for the Boeing Company, SSFL, Canoga Park, CA, Order No. R4-2009-0058* ("2009 Permit") (LARWQCB, 2009), which became effective on May 8, 2009. Stormwater discharges at most regulated outfalls are captured and treated using advanced treatment systems. An exception to this outfall treatment control is at Outfalls 008 and 009, where due to the challenge of treating stormwater at these canyon outfalls (i.e., outfall-based treatment would require construction of large dams with substantial associated environmental impact and potential risk to the public downstream), the stormwater management strategy focuses on distributed source controls and natural treatment systems.

Stormwater sampling has been performed at Outfall 008 for NPDES compliance since reporting year 2005, at ISRA areas since 2010, and at potential BMP subareas and background locations (in both watersheds 008 and 009) since reporting year 2010 (See Figures 1 and 2). ISRA stormwater monitoring is intended to measure water quality upstream and downstream of the ISRA areas after and during remediation. Potential BMP subarea locations were selected to assess the existing runoff quality and inform the potential need for, and performance of, BMPs located upstream of the outfall. Background locations were selected to represent runoff from mostly undeveloped drainage areas with minimal to no Resource Conservation and Recovery Act (RCRA) Facility Investigations (RFI), ISRA, or developed (i.e., roof or pavement) areas. Background monitoring is a voluntary program.

In addition to the ISRAs, stormwater BMPs within the Outfall 008 watershed included installation of erosion control BMPs including fiber rolls, hay bales, silt fences, and hydroseed mulch, as well as vegetated plantings. Road abandonment was also included as a BMP to limit the industrial traffic and

[1] Treated groundwater discharges are also covered in the 2015 Permit however these discharges are not addressed in this memorandum.

imperviousness throughout the watershed, and to allow for the reintroduction of native vegetation. The restoration activities also included the implementation of BMPs recommended by the Surface Water Expert Panel (as documented in the BMP Plan [MWH, 2010]), which were completed in February 2012.

This memorandum follows previous background reports developed for SSFL, including: 1) *SSFL Stormwater Dioxin Background Report* (Surface Water Expert Panel, 2010); 2) *Boeing SSFL Metals Background Report – Sources of Metals in the SSFL Watersheds* (Pitt, R., 2009); and 3) *Potential Background Constituent Levels in Storm Water at Boeing's SSFL* (Flow Science Incorporated, 2007).

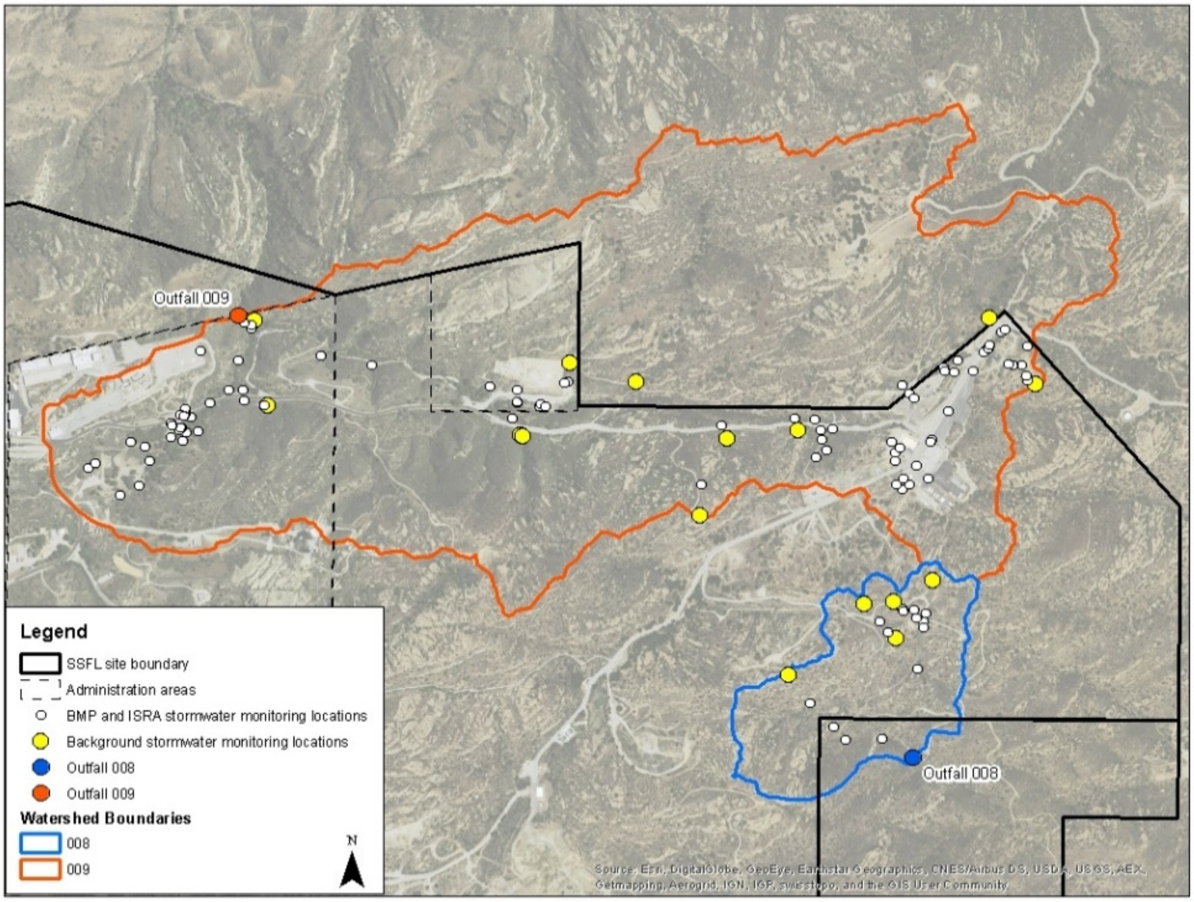

Figure 1. SSFL Watershed 008 and 009 Monitoring Locations

Note: Bars represent reporting years (June 1 – May 31)

Figure 2. Timeline of Outfall 008 Restoration Activities and Outfall Sampling

2 Historic Results at Outfall 008

As documented in the *BMP Plan, Outfalls 008 and 009 Watersheds, Santa Susana Field Laboratory* (*BMP Plan*) (MWH, 2010), constituents that had historically exceeded NPDES water quality-based effluent limitations (WQBELs) and benchmarks within the Outfall 008 watershed at concentrations above DTSC-approved background comparison concentrations included copper, lead, and tetrachlorodibenzo-p-dioxin toxicity equivalent excluding data not qualified (TCDD TEQ noDNQ). These constituents were thereafter referred to as the Outfall 008 constituents of concern (COCs). In the more recent *Site-Wide Stormwater Work Plan and 2014/15 Annual Report* (Santa Susana Surface Water Expert Panel, 2015), the Surface Water Expert Panel re-evaluated SSFL's COCs based on NPDES outfall monitoring results from 2012 to 2015. This analysis identified copper and lead as COCs at Outfall 008 (i.e., the monitoring results showed that dioxins were no longer a COC at Outfall 008). However, since dioxins were identified in the 2010 BMP Plan, they are included in this evaluation for informational purposes, and will be referred to as an Outfall 008 COC in this memorandum.

To reflect the impacts of activities within the Outfall 008 watershed over time, historical data have been analyzed over three distinct periods of record (PORs):

- Prior to December 31, 2009 ("Pre-ISRA Completion"): Original site condition, prior to any ISRA restoration or BMP implementation.
- 1/1/2010 - 2/29/2012 ("Post-ISRA Completion"): ISRA restoration completed and some BMPs implemented.
- 3/1/2012 - present ("Post-Restoration"): ISRA restoration completed and all BMPs completed.

During the BMP monitoring period (10/1/2009 through 5/31/2016), Outfall 008 only discharged 13 times out of 71 total rain events (18%). For comparison, during that same period, Outfall 009 discharged 41 times out of 71 total rain events (58%) due to its greater amount of directly connected impervious area. Based on field observations, Outfall 008 also provides more channel routing and attenuation and is more vegetated than Outfall 009, thus allowing additional opportunities for rainwater to pond, infiltrate, and/or evaporate, resulting in less surface discharge.

As shown in Tables 1 to 3 samples collected at Outfall 008 during the Pre-ISRA Completion POR exceeded the 2015 WQBELs one, eight, and zero time(s) for copper, lead, and TCDD TEQ noDNQ, respectively. Background samples were not collected during this POR. In addition, Tables 1 to 3 shows that the samples collected at Outfall 008 during the Post-ISRA Completion POR exceeded the 2015 WQBELs zero, four, and one time(s) for copper, lead, and TCDD TEQ (no DNQ), respectively. Background samples collected during this POR also exceeded the 2015 WQBELs for copper and lead. During the Post-restoration POR, Outfall 008 discharged only two times[2] out of 40 total rain events (5.0%), which is likely an indication of the restored hydrologic condition of the watershed (i.e., more vegetative coverage and depression storage). The changes in rainfall patterns and events during this historic drought period may also explain this reduction in discharge. Of the two samples collected at Outfall 008 during the Post-Restoration POR, one exceeded the WQBELs for copper and lead (Tables 1 and 2) and neither sample exceeded the WQBEL for TCDD TEQ (no DNQ) (Table 3). The exceeding sample was collected on

[2] Discharges occurred on April 13, 2012 and December 12, 2014.

4/13/2012 (event total 2.37 inches), while the non-exceeding sample was collected nearly three years later, on 12/12/2014 (event total 2.62 inches).

Table 1. Outfall 008 Stormwater Runoff Results vs. Background Results for Copper (Maximum Daily WQBEL 14 µg/L).

Monitoring Period	Outfall 008		Background	
	# of Samples (# of NDs)	# (%) of Results above 2015 WQBELs	# of Samples (# of NDs)	# (%) of Results above 2015 WQBELs
Pre-ISRA Completion POR Prior to 12/31/2009	20 (1 ND)	1 (5.0%)	0	N/A
Post-ISRA Completion POR 1/1/2010 to 2/29/2012	11 (0 ND)	0	21 (0 ND)	1 (4.8%)
Post-Restoration POR 3/1/2012 to Present	2 (0 ND)	1 (50%)	5 (0 ND)	0

Notes

1. # = Number
2. % = Percentage
3. ND = Not detected: The sample result was below the detection limit
4. Background sample results greater than the WQBEL is not a true exceedance, as the background monitoring locations do not have assigned WQBELs
5. If the WQBELs were to be revised per the Los Angeles River Site Specific Objective (LARWQCB, 2015b), to 81 µg/L for copper, Outfall 008 would have zero exceedances in the post-restoration POR.

Table 2. Outfall 008 Stormwater Runoff Results vs. Background Results for Lead (Maximum Daily WQBEL 5.2 µg/L).

Monitoring Period	Outfall 008		Background	
	# of Samples (# of NDs)	# (%) of Results above 2015 WQBELs	# of Samples (# of NDs)	# (%) of Results above 2015 WQBELs
Pre-ISRA Completion POR, Prior to 12/31/2009	20 (0 ND)	8 (40%)	0	N/A
Post-ISRA Completion POR, 1/1/2010 to 2/29/2012	11 (0 ND)	4 (36%)	39 (6 ND)	8 (21%)
Post-Restoration POR, 3/1/2012 to Present	2 (0 ND)	1 (50%)	5 (0 ND)	1 (20%)

Notes

1. # = Number
2. % = Percentage
3. ND = Not detected: The sample result was below the detection limit
4. Background sample results greater than the WQBEL is not a true exceedance, as the background monitoring locations do not have assigned WQBELs.
5. If the WQBELs were to be revised per the Los Angeles River Site Specific Objective (LARWQCB, 2015b), to 34 µg/L for lead, Outfall 008 would have zero exceedances in the post-restoration POR

Table 3. Outfall 008 Stormwater Runoff Results vs. Background Results for TCDD TEQ (no DNQ) (Maximum Daily WQBEL 2.8E-8 µg/L).

Monitoring Period	Outfall 008		Background	
	# of Samples (# of NDs)	# (%) of Results above 2015 WQBELs	# of Samples (# of NDs)	# of Results above 2015 WQBELs
Pre-ISRA Completion POR, Prior to 12/31/2009	20 (14 ND)	0	0	N/A
Post-ISRA Completion POR, 1/1/2010 to 2/29/2012	11 (7 ND)	1 (9.1%)	42 (32 ND)	0
Post-Restoration POR, 3/1/2012 to Present	2 (1 ND)	0	5 (4 ND)	0

Notes

1. # = Number
2. % = Percentage
3. ND = Not detected: The sample result was below the detection limit
4. Background sample results greater than the WQBEL is not a true exceedance, as the background monitoring locations do not have assigned WQBELs.

3 Analysis

The following sections compare available stormwater concentrations and particulate strengths of copper, lead, and TCDD TEQ (no DNQ) to background data to assess whether the improvements made within the Outfall 008 watershed have improved runoff water quality to be consistent with background conditions. Copper and lead were examined for both total recoverable concentrations and for particulate strengths (total concentration - filtered concentration divided by Total Suspended Solids). If filtered concentrations were below the detection limits, half of the detection limits were substituted in the particulate strength calculations. No particulate strength calculations were made when the total recoverable value was below the detection limit. In addition, no filtered concentrations for TCDD TEQ (no DNQ) were available, although it is likely that most of this compound is associated with particulate matter. Estimated particulate strengths were therefore examined for TCDD TEQ (no DNQ) assuming the entire sample was particulate bound (i.e., the filtered concentration was assumed to be zero).

The sections below also include a comparison of stormwater concentrations and particulate strengths of copper and lead to national land uses datasets, as well as statistical analyses for all analytes examined to determine whether statistically significant differences exist between Outfall 008 data and background or land use data. Total Suspended Solids (TSS) is not a POC for the Outfall 008 watershed, but since it is treated as a surrogate for many pollutants and can be representative of potential soil erosion, TSS data are included when relevant (i.e., in the box and whisker plots and statistical analyses).

3.1 Probability Plots

The following charts display both the cumulative probability of total concentration and the particulate strength of copper, lead, and TCDD TEQ (no DNQ) both at background locations and at Outfall 008. The cumulative probability charts illustrate the statistical likelihood, based on historical data, that a stormwater sample will be below certain concentrations or particulate strengths. The whole water concentrations represent constituent concentrations associated with both suspended sediment and dissolved constituent forms in water, while the particulate strength data are presented as a means to normalize particulate-bound constituent concentrations by total suspended solids (TSS), which is helpful for evaluating relative pollutant strength of suspended sediments in a stormwater sample. Outfall 008 results are categorized based on the previously defined PORs (Pre-ISRA Completion, Post-ISRA Completion, and Post-Restoration) to document water quality changes based on increasing levels of ISRA and BMP implementation in the watershed.

3.1.1 Copper

As shown in Figure 3, the total copper stormwater concentrations at Outfall 008 are higher than background concentrations monitored on the site, with most results below the Permit WQBEL (between 2005 and 2015, only two of the 33 samples at Outfall 008 have exceeded the WQBEL as shown in Table 1). When evaluating copper particulate strength (in order to normalize the concentration data in relation to the suspended solids), most particulate strengths at Outfall 008 are below background particulate strengths and are all below the 95th percentile background particulate strength. **Since Outfall 008 particulate strengths are below or similar to background particulate strengths, the total copper concentration Permit WQBEL exceedances may be largely due to natural background soils that are suspended in stormwater discharges**.

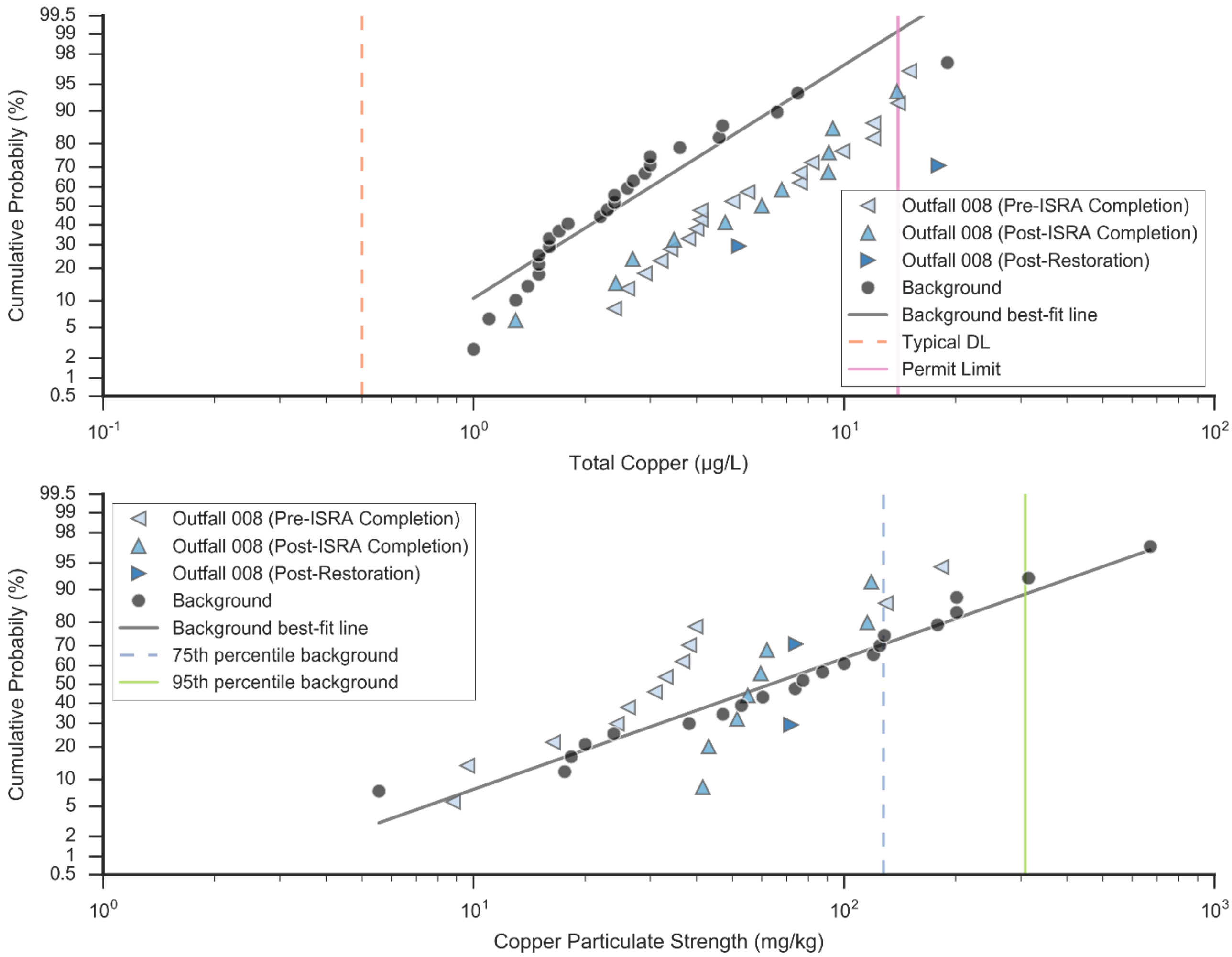

Figure 3. Total Copper Concentrations and Copper Particulate Strengths (NDs removed)

3.1.2 Lead

As shown in Figure 4, the total lead stormwater concentrations at Outfall 008 are similar to or higher than background concentrations. Both background and Outfall 008 concentrations for total lead periodically exceeded the Permit WQBEL historically. When evaluating lead particulate strength, most particulate strengths at Outfall 008 are below background and are all below the 75th percentile background particulate strength. **Since Outfall 008 particulate strengths are below or similar to background particulate strengths, the total lead concentration Permit WQBEL exceedances may be largely due to natural background soils that are suspended in stormwater discharges.**

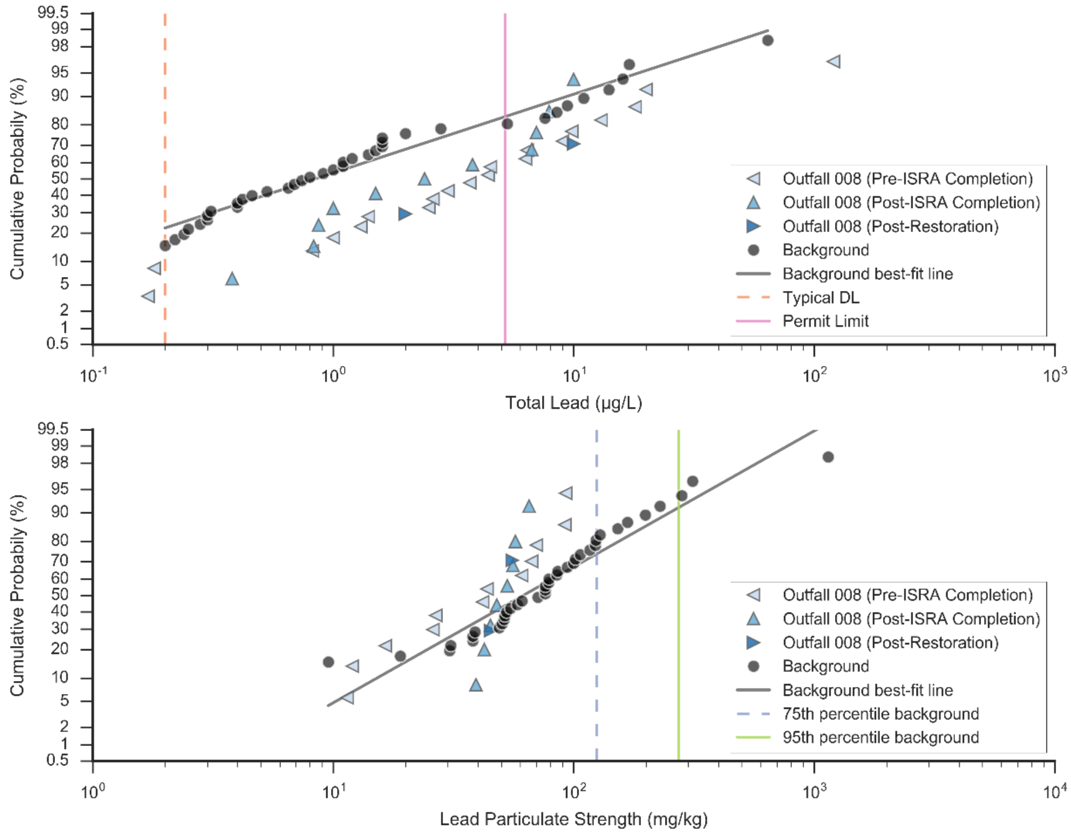

Figure 4. Total Lead Concentrations and Lead Particulate Strengths (NDs removed)

3.1.3 TCDD TEQ (no DNQ)

As shown in Figure 5, the TCDD TEQ (no DNQ) concentrations at Outfall 008 are similar to background concentrations (i.e., within the same order of magnitude). Only one TCDD TEQ (no DNQ) sample exceeded the permit's WQBEL over the entire POR at Outfall 008; this exceedance occurred during the Post-ISRA, Pre-Restoration period. Similarly, Outfall 008 particulate strengths for TCDD TEQ (no DNQ) are below background particulate strengths and, except for one Outfall 008 particulate strength result, are below the 75th percentile background particulate strength. In addition, the 2,3,7,8 TCDD congener was never detected (i.e., the sample result never exceeded the detection limit) in samples collected at Outfall 008 or background locations, which suggests that un-weathered anthropogenic dioxin contamination might not be present. **Since Outfall 008 particulate strengths are primarily below or similar to background particulate strengths, the single TCDD TEQ (no DNQ) Permit WQBEL exceedance may be largely due to natural background soils that are suspended in stormwater discharges.**

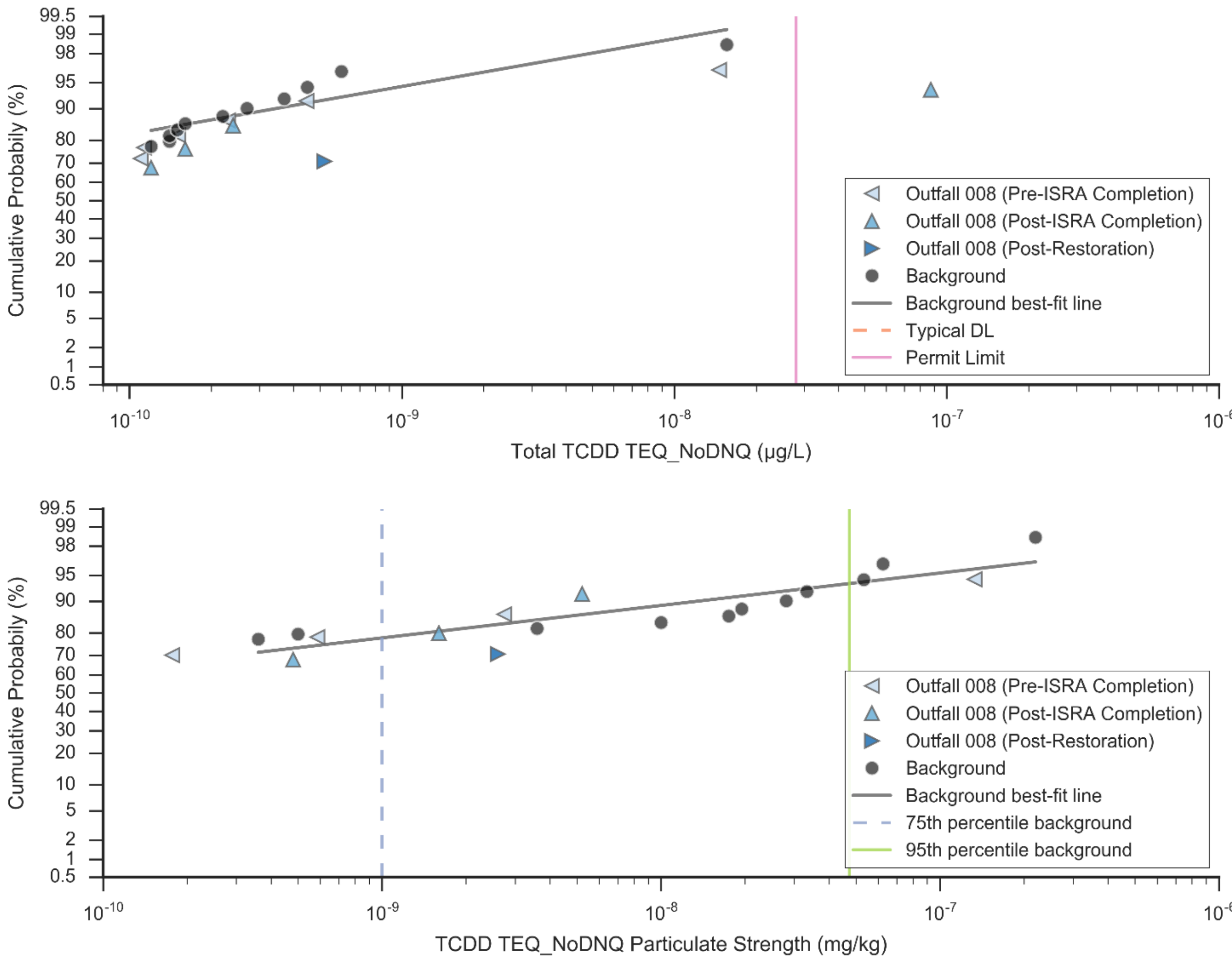

Figure 5. Total TCDD TEQ (no DNQ) Concentrations and TCDD TEQ (no DNQ) Particulate Strengths (NDs removed)

3.2 Dataset Comparisons and Statistical Analyses

The following figures and discussion illustrate the data spread of Outfall 008 and background concentrations and particulate strengths of TCDD TEQ (no DNQ), copper and lead. TSS is also included to evaluate whether site soils are impacting exceedances of POCs at the outfall. For copper, lead, and TSS, data from the following datasets were also included for comparison (these public datasets do not include data for TCDD TEQ (no DNQ)):

- National Stormwater Quality Database (NSQD) version 4.02 for different land uses (commercial (Com), freeways (Free), industrial (Indus), institutional (Instit), open space (OpSp)[3], and residential (Res)). All These data were downloaded for the most recent version located at: http://bmpdatabase.org/nsqd.html.
- Los Angeles County Sawpit Creek monitoring data, representing regional open space near SSFL. (Source: "Los Angeles County 1994-2000 Integrated Receiving Water Impacts Report" and "Los Angeles County 1994-2005 Integrated Receiving Water Impacts Report," LACDPW).

Grouped box and whisker plots were prepared using SigmaPlot 13 to compare the concentration and pollutant strength values for each data group. These plots show the median (central line in box), 25th and 75th percentile values (end of boxes), and the 5th and 95th percentile values (end of whiskers). Values larger or smaller than these end whiskers are represented by dots for the actual values. The sizes and shapes of the boxes (after transforming the values to log10 values) are very similar, but displaced against each other. This allows visual comparisons of the data groups to be easily observed.

Statistical analyses (using SigmaPlot13) were also conducted comparing each data group using the nonparametric Kruskal-Wallis one way analysis of variance on ranks tests. This test indicates if there is at least one data set that is significantly different from the others. With so many data groups (11) representing varying conditions, at least one data set was commonly found to be significantly different than the others. In order to identify which data sets were significantly different from the others, Dunn's all pairwise comparisons were conducted, with the p values (values <0.05 are usually accepted as indicating significant differences) displaced in a matrix comparing each data group. In addition to the overall comparisons, Kruskal-Wallis tests were also conducted to compare the Outfall 008 and background pre- and post-restoration site values. If the test indicated if any of these four groups were significantly different from the others, the Dunn's all pairwise tests were also used and the p results shown in a matrix to determine which data sets were statistically different from each other.

The following abbreviations are used in the tables below:

- Com = Commercial
- Free = Freeway
- Indus = Industrial
- Instit = Institutional
- OpSp = Open Space
- OF008 = Outfall 008
- Res = Residential

[3] Open space areas are in urbanized locations and include such areas as cemeteries, golf courses, and parks and do not represent undeveloped or agricultural areas

- Preres = Pre-restoration
- Postres = Post-restoration
- Bckgrd = Background
- Sawpit Crk = Sawpit Creek

3.2.1 TSS

As shown in the figures and tables below, there were many differences when comparing all data sets for TSS, especially for Sawpit Creek and the SSFL pre-restoration background data. There were few differences in SSFL TSS values when comparing Outfall 008 and background samples. One exception was a significant difference observed between pre-restoration Outfall 008 and pre-restoration background concentrations with the background concentrations being lower; however, there are insufficient data to show any statistically significant differences between the post-restoration datasets. Background pre-restoration concentrations were also observed to be substantially less than all other site values. The box and whisker plots and statistical analysis results are shown in the following figures and tables.

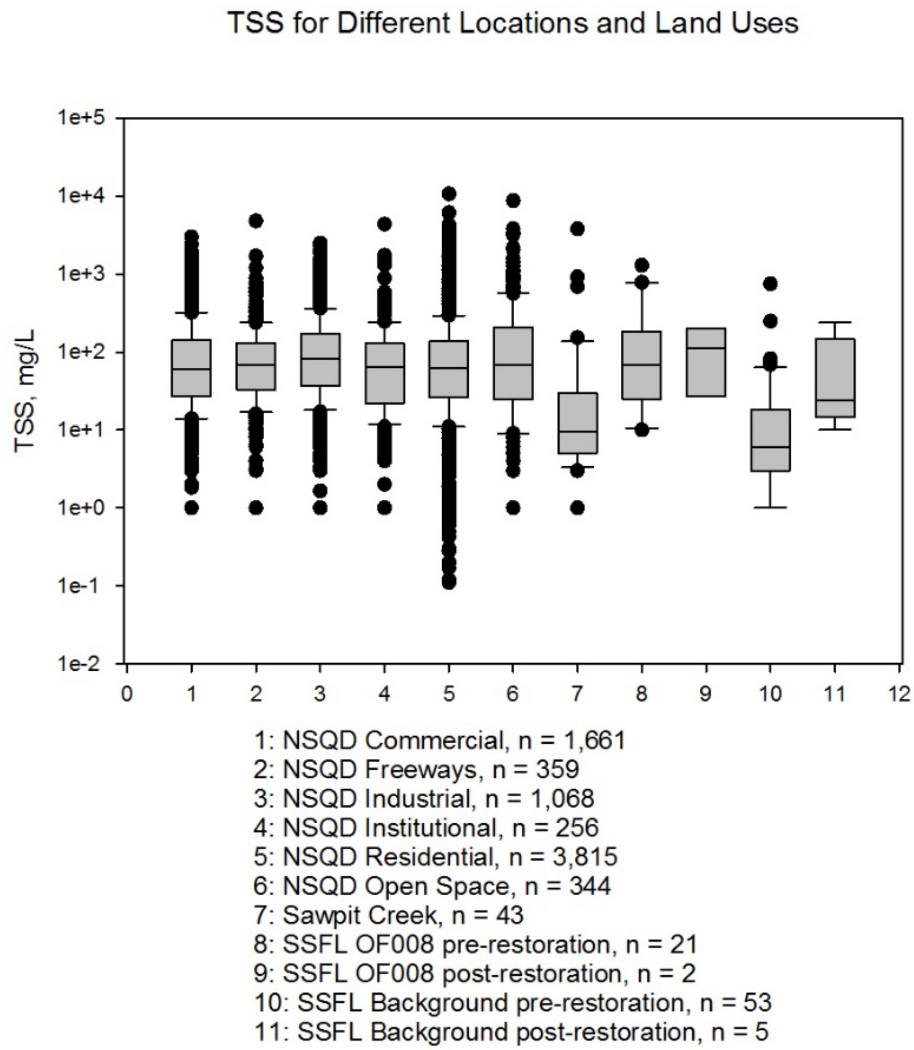

Figure 6. TSS Concentration Comparison for Site and Land Use Data

Table 4. TSS Concentration Comparisons using Kruskal-Wallis One Way Analysis of Variance on Ranks

Group	N	Missing	Median	25%	75%
NSQD Com	1661	0	60	27	141
NSQD Free	359	0	68	33.15	130
NSQD Indus	1068	0	81	37	172
NSQD Instit	256	0	64.13	22	129.96
NSQD Res	3815	0	63	26	137
NSQD OpSp	344	0	68.5	25	209
Sawpit Crk	43	0	9	5	28
SSFL OF008 preRes	21	0	68	25	185
SSFL OF008 postRes	2	0	113.5	27	200
SSFL Bckgrd preRes	53	0	6	3	18.5
SSFL Bckgrd postRes	5	0	24	14.5	146.5
H = 174.794 with 10 degrees of freedom. (P = <0.001)					

The differences in the median values among the treatment groups in Table 4 are greater than would be expected by chance; therefore, there is a statistically significant difference (P = <0.001). To determine which dataset pairs are statistically different, Dunn's all pairwise comparisons were performed as shown in the tables below.

Table 5. TSS Concentration Comparisons (Dunn's all pairwise comparisons, p values [<0.05 shaded yellow representing a significant difference])

TSS concentrations all pairwise comparisons	NSQD Com	NSQD Free	NSQD Indus	NSQD Instit	NSQD Res	NSQD OpSp	Sawpit Crk	SSFL OF008 preRes	SSFL OF008 postRes	SSFL Bckgrd preRes	SSFL Bckgrd postRes
NSQD Com	X	1	<0.001	1	1	1	<0.001	1	1	<0.001	1
NSQD Free	1	X	0.65	1	1	1	<0.001	1	1	<0.001	1
NSQD Indus	<0.001	0.65	X	0.012	<0.001	1	<0.001	1	1	<0.001	1
NSQD Instit	1	1	0.012	X	1	1	<0.001	1	1	<0.001	1
NSQD Res	1	1	<0.001	1	X	1	<0.001	1	1	<0.001	1
NSQD OpSp	1	1	1	1	1	X	<0.001	1	1	<0.001	1
Sawpit Crk	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	X	<0.001	1	1	1
SSFL OF008 preRes	1	1	1	1	1	1	<0.001	X	1	<0.001	1
SSFL OF008 postRes	1	1	1	1	1	1	1	1	X	1	1
SSFL Bckgrd preRes	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	1	<0.001	1	X	1
SSFL Bckgrd postRes	1	1	1	1	1	1	1	1	1	1	X

Table 6. TSS Concentration Comparisons for SSFL data (Dunn's all pairwise comparisons, p values [<0.05 shaded yellow representing a significant difference representing a significant difference])

TSS concentrations for SSFL data, all pairwise comparisons	SSFL OF008 preRes	SSFL OF008 postRes	SSFL Bckgrd preRes	SSFL Bckgrd postRes
SSFL OF008 preRes	X	1	<0.001	1
SSFL OF008 postRes	1	X	0.36	1
SSFL Bckgrd preRes	<0.001	0.36	X	0.21
SSFL Bckgrd postRes	1	1	0.21	X

3.2.2 Total Copper

As shown in the figures and tables below, there were many significant differences for the different total copper data groups, with Outfall 008 and background values generally less than the other data groups (Sawpit Creek, NSQD institutional and open space appear to be similar). Outfall 008 and background copper concentrations appear to be lower than all other situations observed; however there are too few data to statistically verify these differences. Pre-restoration Outfall 008 and background copper concentrations are significantly different, with the background concentrations being lower; however, there are insufficient data to show any difference between the post-restoration datasets. The box and whisker plots and statistical analysis results are shown in the following figures and tables.

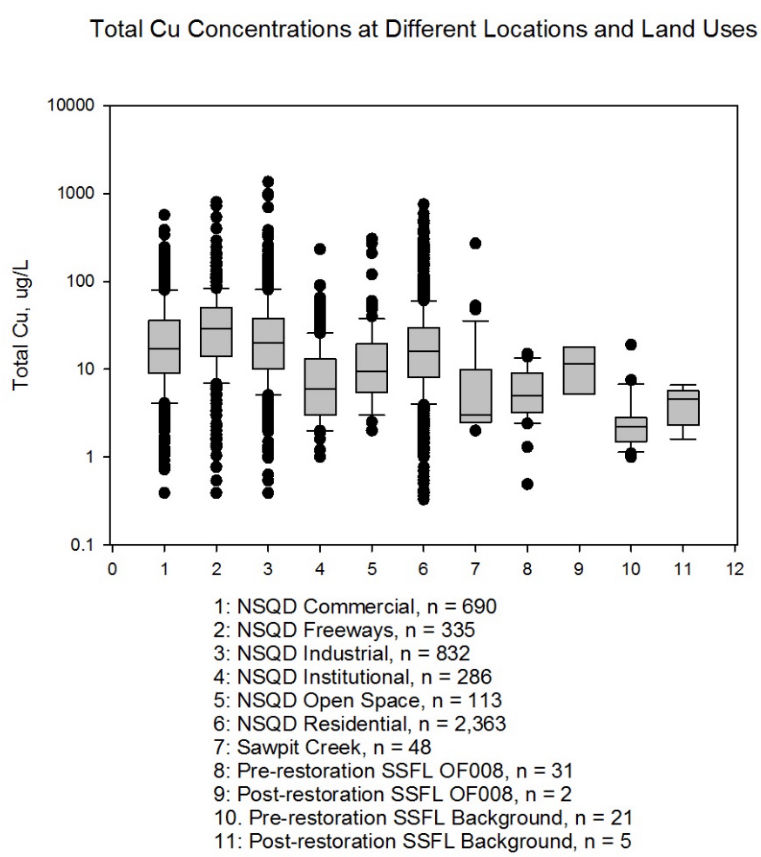

Figure 7. Total Copper Concentration Comparison for Site and Land Use Data

Table 7. Total Copper Concentration Comparisons using Kruskal-Wallis One Way Analysis of Variance on Ranks

Group	N	Missing	Median	25%	75%
NSQD Com Cu ug/L	690	0	17	9	36.025
NSQD Free Cu ug/L	335	0	29	14	50
NSQD Indus Cu ug/L	832	0	20	10	38
NSQD Instit Cu ug/L	286	0	6	3	13
NSQD OpSp Cu ug/L	113	0	9.5	5.45	19.5
NSQD Res Cu ug/L	2363	0	16	8	30
Sawpit Crk Cu ug/L	48	0	3	2.5	9.875
Preres SSFL OF008 Cu ug/L	31	0	5	3.2	9.1
Postres SSFL OF008 Cu ug/L	2	0	11.6	5.2	18
PreRes SSFL bckgrd Cu ug/L	21	0	2.2	1.5	2.8
PostRes SSFL Backgrd Cu ug/L	5	0	4.6	2.3	5.65
H = 437.679 with 10 degrees of freedom. (P = <0.001)					

The differences in the median values among the treatment groups in Table 7 are greater than would be expected by chance; therefore, there is a statistically significant difference (P = <0.001). To determine which dataset pairs are statistically different, Dunn's all pairwise comparisons were performed as shown in the table below.

Table 8. Total Copper Concentration Comparisons (Dunn's all pairwise comparisons, p values [<0.05 shaded yellow representing a significant difference])

Copper concentrations all pairwise comparisons	NSQD Com	NSQD Free	NSQD Indus	NSQD Instit	NSQD Res	NSQD OpSp	Sawpit Crk	SSFL OF008 preRes	SSFL OF008 postRes	SSFL Bckgrd preRes	SSFL Bckgrd postRes
NSQD Com	X	<0.001	1	<0.001	0.83	<0.001	<0.001	<0.001	1	<0.001	0.094
NSQD Free	<0.001	X	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	1	<0.001	0.003
NSQD Indus	1	<0.001	X	<0.001	<0.001	<0.001	<0.001	<0.001	1	<0.001	0.039
NSQD Instit	0.83	<0.001	<0.001	X	<0.001	0.31	1	1	1	0.15	1
NSQD Res	0.83	<0.001	<0.001	<0.001	X	<0.001	<0.001	<0.001	1	<0.001	0.2
NSQD OpSp	<0.001	<0.001	<0.001	0.31	<0.001	X	0.71	0.22	1	0.001	1
Sawpit Crk	<0.001	<0.001	<0.001	1	<0.001	0.71	X	1	1	1	1
SSFL OF008 preRes	<0.001	<0.001	<0.001	1	<0.001	0.22	1	X	1	1	1
SSFL OF08 postRes	1	1	1	1	1	1	1	1	X	1	1
SSFL Bckgrd preRes	<0.001	<0.001	<0.001	0.15	<0.001	0.001	1	1	1	X	1
SSFL Bckgrd postRes	0.094	0.003	0.039	1	0.2	1	1	1	1	1	X

3.2.3 Copper Particulate Strength

As shown in the figures and tables below, the four SSFL site groups had substantially lower copper particulate strengths than the other data groups, with some overlap from the NSQD institutional and residential data groups. When the four site data groups were compared, the Outfall 008 and background copper particulate strengths were found to be apparently lower than most other locations and land uses, but no statistically significant differences were detected for pre and post-restoration Outfall 008 and background copper particulate strengths. The box and whisker plots and statistical analysis results are shown in the following figures and tables.

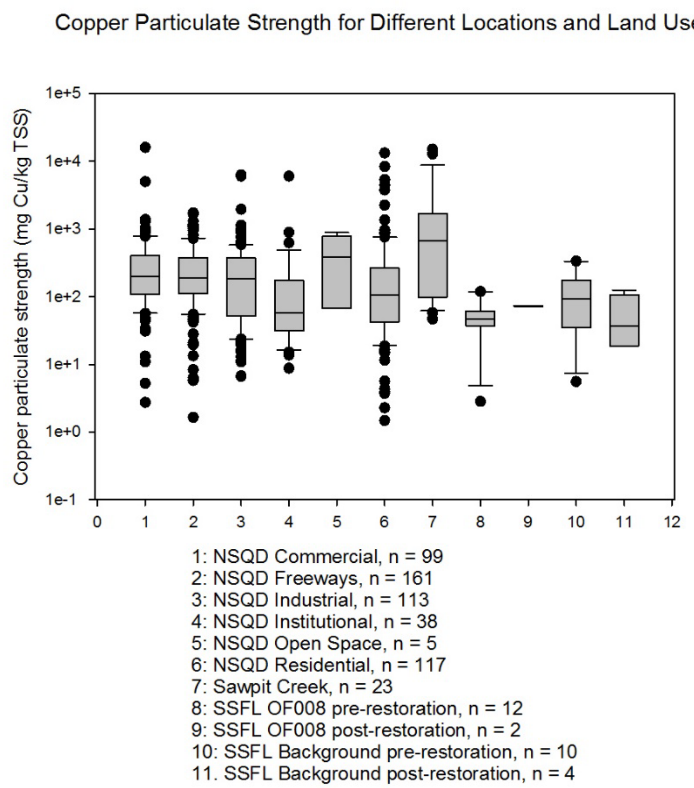

Figure 8. Copper Particulate Strength Comparison for Site and Land Use Data

Table 9. Copper Particulate Strength Comparisons using Kruskal-Wallis One Way Analysis of Variance on Ranks

Group	N	Missing	Median	25%	75%
NSQD Com Cu (mg/kg)	99	0	200	108.108	402.985
NSQD Free Cu (mg/kg)	161	0	191.035	110.556	372.368
NSQD Indus Cu (mg/kg)	113	0	186.047	51.802	370.062
NSQD Instit Cu (mg/kg)	38	0	58.172	31.099	173.75
NSQD OpSp Cu (mg/kg)	5	0	383.333	66.966	779.592
NSQD Res Cu (mg/kg)	117	0	105.263	42.338	264.357
Sawpit Crk Cu (mg/kg)	23	0	673.469	98.039	1700
preres SSFL OF008 Cu (mg/kg)	12	0	47.281	37.045	61.391
postres OF008 Cu (mg/kg)	2	0	73.037	72	74.074
preRes SSFL Bckgrd Cu (mg/kg)	10	0	93.75	34.603	175
postRes SSFL Bckgrd Cu (mg/kg)	4	0	36.415	18.75	106.958
H = 70.126 with 10 degrees of freedom. (P = <0.001)					

The differences in the median values among the treatment groups in Table 9 are greater than would be expected by chance; therefore, there is a statistically significant difference (P = <0.001). To determine which dataset pairs are statistically different, Dunn's all pairwise comparisons were performed as shown in the table below.

Table 10. Copper Particulate Strength Comparisons (Dunn's all pairwise comparisons, p values [<0.05 shaded yellow representing a significant difference])

Cu particulate strength all pairwise comparisons	NSQD Com	NSQD Free	NSQD Indus	NSQD Instit	NSQD Res	NSQD OpSp	Sawpit Crk	SSFL OF008 preRes	SSFL OF008 postRes	SSFL Bckgrd preRes	SSFL Bckgrd postRes
NSQD Com	X	1	1	0.002	0.011	1	1	0.001	1	0.83	0.52
NSQD Free	1	X	1	0.001	0.005	1	0.64	0.001	0.59	0.67	1
NSQD Indus	1	1	X	0.12	1	1	0.053	0.02	1	1	1
NSQD Instit	0.002	0.001	0.12	X	1	1	<0.001	1	1	1	1
NSQD Res	0.011	0.005	1	1	X	1	<0.001	0.45	1	1	1
NSQD OpSp	1	1	1	1	1	X	1	0.29	1	1	1
Sawpit Crk	1	0.64	0.053	<0.001	<0.001	1	X	<0.001	1	0.023	0.034
SSFL OF008 preRes	0.001	0.001	0.02	1	0.45	0.29	<0.001	X	1	1	1
SSFL OF008 postRes	1	0.59	1	1	1	1	1	1	X	1	1
SSFL Bckgrd preRes	0.83	0.67	1	1	1	1	0.023	1	1	X	1
SSFL Bckgrd postRes	0.52	1	1	1	1	1	0.034	1	1	1	X

3.2.4 Total Lead

As shown in the figures and tables below, there are large variations between the data groups for total lead concentrations, with the Outfall 008 and background concentrations being the lowest (with some overlap with the NSQD institutional land use data). When just the four site data groups were compared (pre and post-restoration for both Outfall 008 and background locations), the two pre-restoration Outfall 008 and background conditions were found to be significantly different, with the background concentrations being lower, but too few samples were available to show statistically significant differences with post-restoration lead concentrations. The box and whisker plots and statistical analysis results are shown in the following figures and tables.

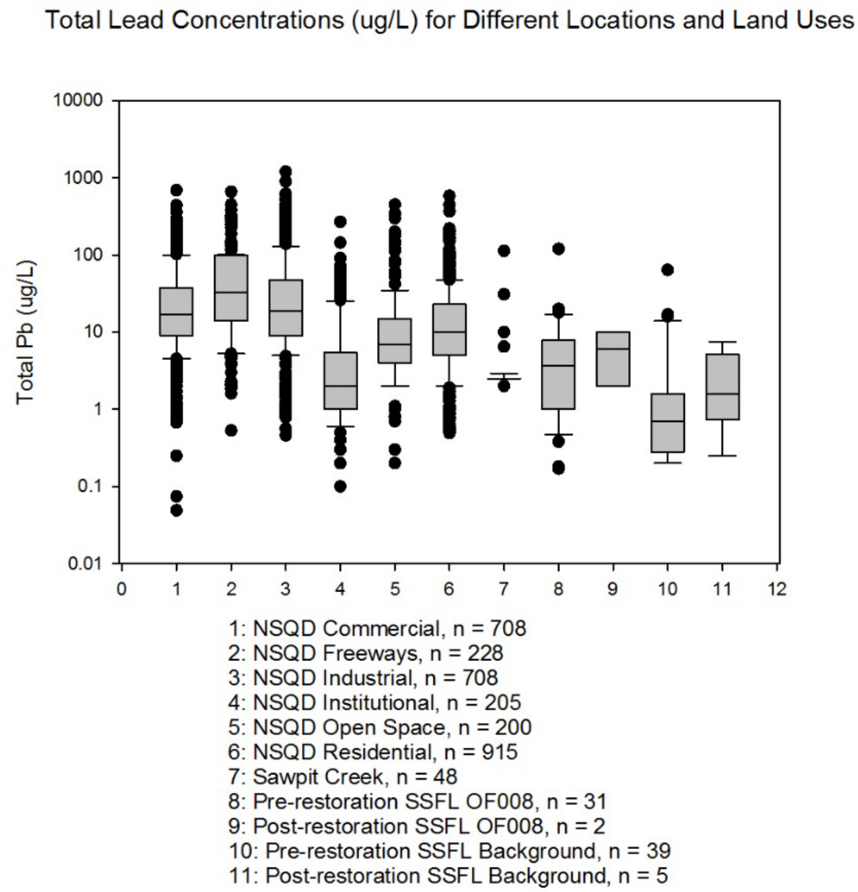

Figure 9. Total Lead Concentration Comparison for Site and Land Use Data

Table 11. Total Lead Concentration Comparisons using Kruskal-Wallis One Way Analysis of Variance on Ranks

Group	N	Missing	Median	25%	75%
NSQD Com Pb conc	708	0	17	9	37.75
NSQD Free Pb conc	228	0	32.5	14	100
NSQD Indus Pb conc	708	0	19	9	48
NSQD Instit Pb conc	205	0	2	1	5.5
NSQD OpSp Pb conc	200	0	7	4	15
NSQD Res Pb conc	915	0	10	5	23
Sawpit Crk Pb conc	48	0	2.5	2.5	2.5
PreRes OF008 Pb conc	31	0	3.7	1	7.9
PostRes OF008 Pb conc	2	0	6	2	10
preRes Bckgrd SSFL Pb conc	39	0	0.69	0.28	1.6
PostRes SSFL bckgrd Pb conc	5	0	1.6	0.725	5.2
H = 638.881 with 10 degrees of freedom. (P = <0.001)					

The differences in the median values among the treatment groups in Table 11 are greater than would be expected by chance; therefore, there is a statistically significant difference (P = <0.001). To determine which dataset pairs are statistically different, Dunn's all pairwise comparisons were performed as shown in the table below.

Table 12. Total Lead Concentration Comparisons (Dunn's all pairwise comparisons, p values [<0.05 shaded yellow representing a significant difference])

Lead concentrations all pairwise comparisons	NSQD Com	NSQD Free	NSQD Indus	NSQD Instit	NSQD Res	NSQD OpSp	Sawpit Crk	SSFL OF008 preRes	SSFL OF008 postRes	SSFL Bckgrd preRes	SSFL Bckgrd postRes
NSQD Com	X	<0.001	1	<0.001	<0.001	<0.001	<0.001	<0.001	1	<0.001	0.034
NSQD Free	<0.001	X	0.008	<0.001	<0.001	<0.001	<0.001	<0.001	1	<0.001	0.001
NSQD Indus	1	0.008	X	<0.001	<0.001	<0.001	<0.001	<0.001	1	<0.001	0.017
NSQD Instit	<0.001	<0.001	<0.001	X	1	<0.001	1	1	1	1	1
NSQD Res	<0.001	<0.001	<0.001	<0.001	X	0.3	<0.001	0.003	1	0.001	0.79
NSQD OpSp	<0.001	<0.001	<0.001	<0.001	0.3	X	<0.001	0.35	1	<0.001	1
Sawpit Crk	<0.001	<0.001	<0.001	1	<0.001	<0.001	X	1	1	1	1
SSFL OF008 preRes	<0.001	<0.001	<0.001	1	0.003	0.35	1	X	1	1	1
SSFL OF008 postRes	1	1	1	1	1	1	1	1	X	1	1
SSFL Bckgrd preRes	<0.001	<0.001	<0.001	1	0.001	<0.001	1	1	1	X	1
SSFL Bckgrd postRes	0.034	0.001	0.017	1	0.79	1	1	1	1	1	X

3.2.5 Lead Particulate Strengths

As shown in the figures and tables below, large differences in lead particulate strength data groups were observed with the Outfall 008 and background data being the lowest (with Sawpit Creek having some overlap). When the four site data groups were compared (pre and post-restoration for both Outfall 008 and background locations), there were no statistically significant differences found between pre and post-restoration Outfall 008 and background data; however, there were too few post-restoration samples taken to statistically determine any difference. The box and whisker plots and statistical analysis results are shown in the following figures and tables.

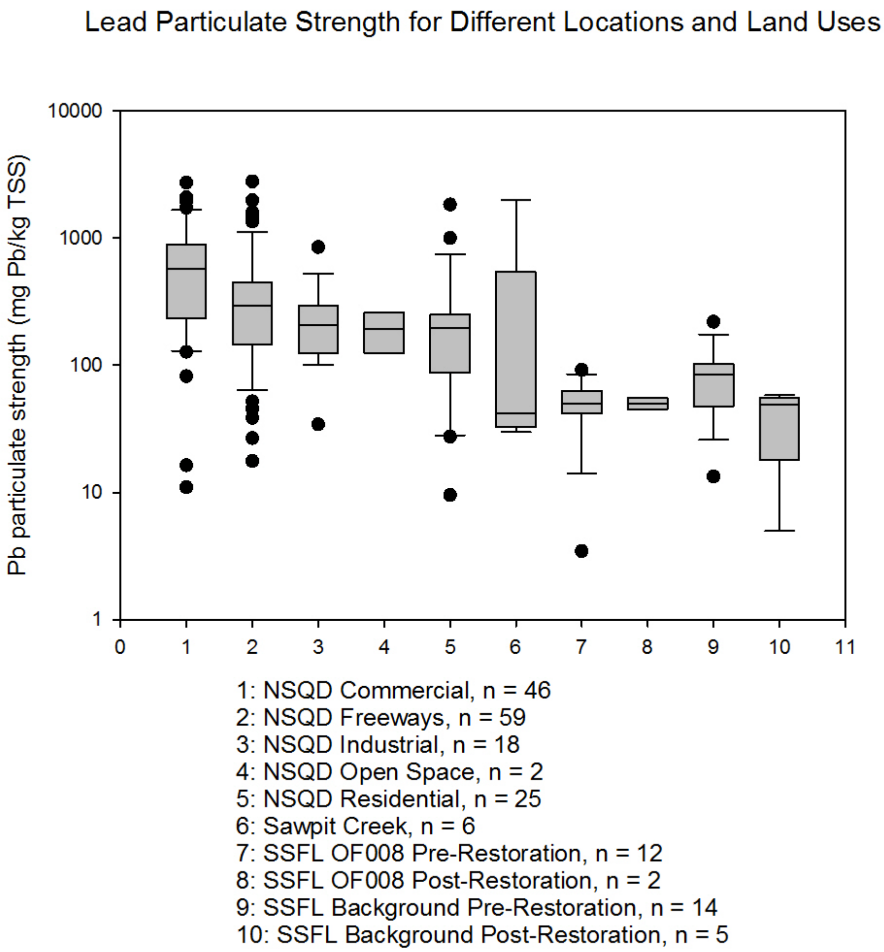

Figure 10. Outfall 008 Lead Particulate Strength Comparison for Site and Land Use Data

Table 13. Lead Particulate Strength Comparisons using Kruskal-Wallis One Way Analysis of Variance on Ranks

Group	N	Missing	Median	25%	75%
NSQD Com Pb (mg/kg)	46	0	571.163	234.797	893.429
NSQD Free Pb (mg/kg)	59	0	295.238	145	452.703
NSQD Indus Pb (mg/kg)	18	0	208.513	125	294.589
NSQD OpSp Pb (mg/kg)	2	0	192.935	125	260.87
NSQD Res (mg/kg)	25	0	196.429	87.247	250
Sawpit Crk Pb (mg/kg)	6	0	41.65	32.806	542.857
PreRes SSFL OF008 Pb (mg/kg)	12	0	50.384	41.997	63.186
PostRes SSFL OF008 Pb (mg/kg)	2	0	50.278	45	55.556
PreRes SSFL Bckgrd Pb (mg/kg)	14	0	85.35	47.813	103.125
PostRes SSFL Backgrd Pb (mg/kg)	5	0	49.057	17.917	55.482
H = 74.296 with 9 degrees of freedom. (P = <0.001)					

The differences in the median values among the treatment groups in Table 13 are greater than would be expected by chance; therefore, there is a statistically significant difference (P = <0.001). To determine which dataset pairs are statistically different, Dunn's all pairwise comparisons were performed as shown in the table below.

Table 14. Lead Particulate Strength Comparisons (Dunn's all pairwise comparisons, p values [<0.05 shaded yellow representing a significant difference])

Lead particulate strengths all pairwise comparisons	NSQD Com	NSQD Free	NSQD Indus	NSQD Res	NSQD OpSp	Sawpit Crk	SSFL OF008 preRes	SSFL OF008 postRes	SSFL Backgrd preRes	SSFL Backgrd postRes
NSQD Com	X	1	0.34	0.007	1	0.014	0.001	0.37	0.001	0.001
NSQD Free	1	X	1	1	1	0.35	<0.001	1	0.002	0.027
NSQD Indus	0.34	1	X	1	1	1	0.082	1	0.56	0.49
NSQD Res	0.007	1	1	X	1	1	0.28	1	1	1
NSQD OpSp	1	1	1	1	X	1	1	1	1	1
Sawpit Crk	0.014	0.35	1	1	1	X	1	1	1	1
SSFL OF008 preRes	0.001	<0.001	0.082	0.28	1	1	X	1	1	1
SSFL OF008 postRes	0.37	1	1	1	1	1	1	X	1	1
SSFL Backgrd preRes	0.001	0.002	0.56	1	1	1	1	1	X	1
SSFL Backgrd postRes	0.007	0.027	0.49	1	1	1	1	1	1	X

3.2.6 Total TCDD TEQ (no DNQ)

As shown in the figures and tables below, no statistically significant differences between the Outfall 008 and background TCDD TEQ (no DNQ) concentrations were observed; however, the most recent (post-restoration) values appear to be consistently lower than the other site values. The box and whisker plots and statistical analysis results are shown in the following figures and tables.

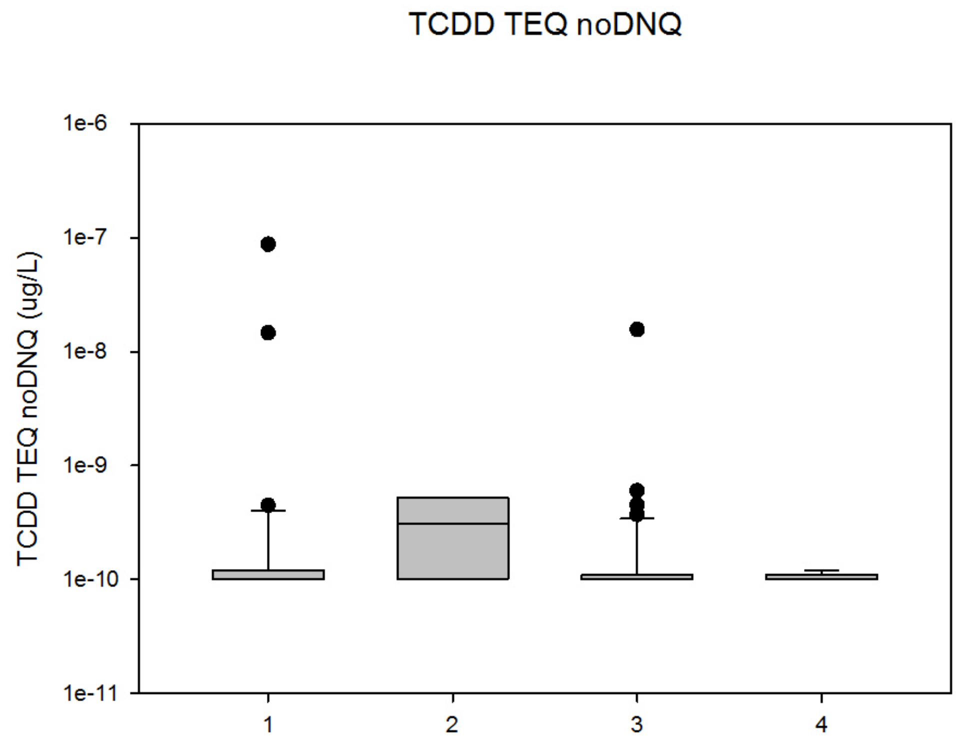

Figure 11. Total TCDD TEQ (no DNQ) Comparison for Site Data

Table 15. Total TCDD TEQ (no DNQ) Concentration Comparisons using Kruskal-Wallis One Way Analysis of Variance on Ranks

Group	N	Missing	Median	25%	75%
Preres SSFL OF008 TCDD	31	0	1.00E-10	1.00E-10	1.2E-10
Postres SSFL OF008 TCDD	2	0	3.1E-10	1.00E-10	5.2E-10
Preres SSFL bckgrd TCDD	42	0	1.00E-10	1.00E-10	1.1E-10
Postres SSFL bckgrd TCDD	5	0	1.00E-10	1.00E-10	1.1E-10
H = 1.662 with 3 degrees of freedom. (P = 0.645)					

The differences in the median values among the treatment groups in Table 15 are not great enough to exclude the possibility that the difference is due to random sampling variability; therefore, there is not a statistically significant difference (P = 0.626) and Dunn's all pairwise comparisons were not evaluated.

3.2.7 TCDD TEQ (no DNQ) Particulate Strengths

As shown in the figures and tables below, the pre-restoration background particulate strengths are significantly different (larger) than the pre-restoration Outfall 008 particulate strengths. There are apparent differences between the post-restoration Outfall 008 and post-restoration background conditions; however, there were too few samples taken to identify statistically significant differences. The box and whisker plots and statistical analysis results are shown in the following figures and tables.

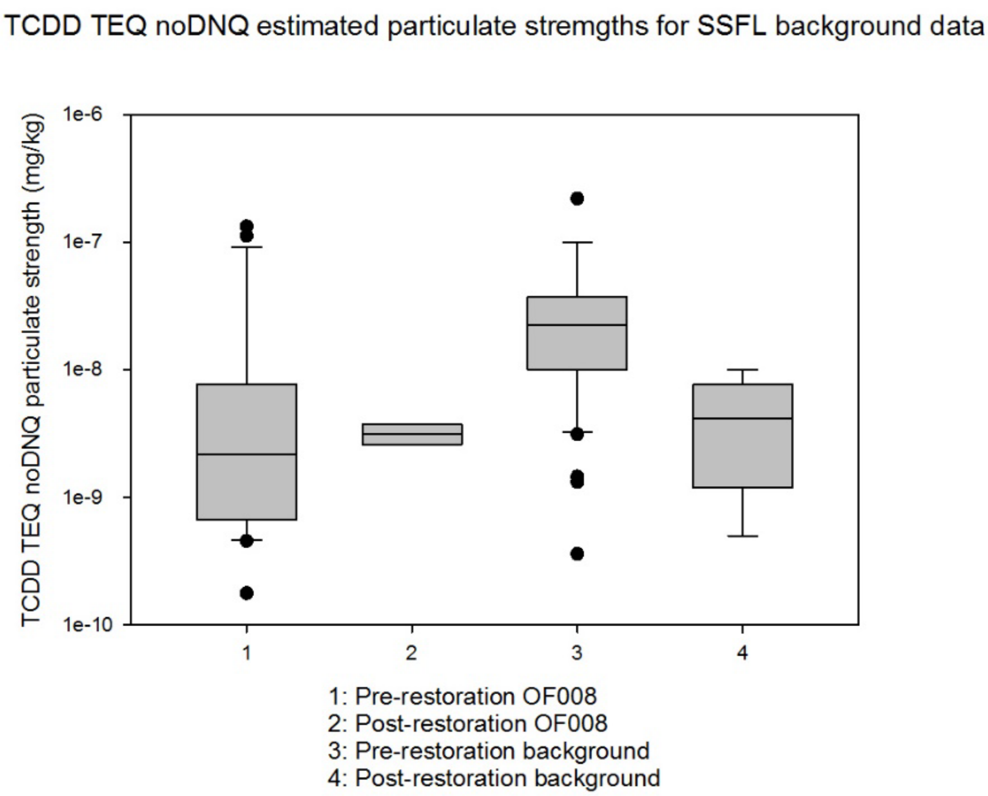

Figure 12. TCDD TEQ (no DNQ) Particulate Strengths Comparison for Site Data

Table 16. TCDD TEQ (no DNQ) Estimated Particulate Strength Comparisons using Kruskal-Wallis One Way Analysis of Variance on Ranks

Group	N	Missing	Median	25%	75%
PreRes OF008 TCDD	21	0	2.17E-09	6.67E-10	7.74E-09
PostRes OF008 TCDD	2	0	3.15E-09	2.6E-09	3.7E-09
PreRes bckgrd TCDD	42	0	2.25E-08	1E-08	3.75E-08
PostRes bckgrd TCDD	5	0	4.17E-09	1.19E-09	7.63E-09
H = 21.921 with 3 degrees of freedom. (P = <0.001)					

The differences in the median values among the treatment groups in Table 16 are greater than would be expected by chance; therefore, there is a statistically significant difference (P = <0.001). To determine which dataset pairs are statistically different, Dunn's all pairwise comparisons were performed as shown in the table below.

Table 17. TCDD TEQ (no DNQ) Estimated Particulate Strength Comparisons for SSFL data (Dunn's all pairwise comparisons, p values)

	PreRes OF008 TCDD	PostRes OF008 TCDD	PreRes bckgrd TCDD	PostRes bckgrd TCDD
PreRes OF008 TCDD	X	1	<0.001	1
PostRes OF008 TCDD	1	X	0.56	1
PreRes bckgrd TCDD	<0.001	0.56	X	0.091
PostRes bckgrd TCDD	1	1	0.091	X

4 Conclusion

Boeing has implemented dirt road stabilization, hillside erosion controls, revegetation/restoration, and in-channel sediment controls as recommended by the Surface Water Expert Panel to improve stormwater quality at Outfall 008 and comply with the NPDES permit. To evaluate whether the stormwater quality at Outfall 008 has been restored to natural background conditions (i.e., conditions representative of the site prior to the introduction of industrial activities), an analysis was performed to compare historical stormwater runoff results to both natural background concentrations at the SSFL site, as well as to other regional and nationwide open space land use datasets. This analysis included three periods of record, representing interim soil remediation and restoration within the Outfall 008 watershed over time:

- Pre-ISRA (Prior to 12/31/2009)
- Post-ISRA (Between 1/1/2010 and 2/29/2012)
- Post-restoration (3/1/2012 to present)

The post-restoration period represents the most restored condition of the Outfall 008 watershed. However, because only two post-restoration runoff-producing storm events occurred during this time period due to the prolonged regional drought, the following preliminary conclusions are made acknowledging that additional samples are needed for confirmation.

Total lead and copper concentrations at Outfall 008 and local stormwater background sites have periodically exceeded the Permit's WQBELs. After restoration and BMP implementation was completed within the Outfall 008 watershed (i.e., during the post-restoration period), only one of two samples exceeded the WQBELs at Outfall 008 for both copper and lead and zero of two samples exceeded the WQBEL for TCDD TEQ (no DNQ). It is important to note that all copper and lead exceedances would be eliminated if the pending Los Angeles River Site Specific Objectives are approved. In addition, the 2,3,7,8 TCDD congener was not detected at Outfall 008 or background locations, suggesting that un-weathered anthropogenic dioxin contamination may not be present. Historically throughout the entire period of record, for all three COCs, the water concentrations at Outfall 008 were similar to, or above, background concentrations, however this is likely due to elevated TSS levels in the watershed, as Outfall 008 particulate strengths for all three COCs were below or similar to the background particulate strengths. **This result suggests that historic Outfall 008 Permit WQBEL exceedances may be due to elevated levels of natural background soils in stormwater discharges from the watershed.** Elevated TSS levels may be due to the natural geomorphic condition of this steep watershed. In addition, as previously mentioned, the road stabilization, revegetation, other erosion controls, and in-stream sediment controls were implemented at the Site to limit the quantity of soil sediment transported by stormwater to Outfall 008. The apparent downward trend for TSS at Outfall 008 (described below) is an indication that these erosion controls have been successful in limiting soil sediment transport and suggests that if the trend continues, the water quality at Outfall 008 will continue to improve.

Outfall 008 and background concentrations and particulate strengths of copper and lead were generally less than all other open space land use datasets; however, statistically significant differences between pre- and post-restoration periods could not be determined due to the limited data available. For TCDD TEQ (no DNQ), there were no statistically significant differences observed between Outfall 008 and background concentrations. There was an apparent downward trend in TCDD TEQ (no DNQ) estimated particulate strengths, with post-restoration background and Outfall 008 values being similar. The pre-restoration background particulate strengths estimated for TCDD TEQ (no DNQ) were also significantly different (higher) than the pre-restoration Outfall 008 particulate strengths estimated for TCDD TEQ (no DNQ), suggesting that historical exceedances may have been due to elevated levels of natural background soils. Similar to the copper and lead analyses, there were too few data available to compare post-restoration conditions; however, there were apparent differences noted between the Outfall 008 and background data. While there were few statistically significant differences observed for TSS between the SSFL site data (i.e., the pre and post restoration background and outfall 008 watershed sampling locations only), there was an apparent downward trend noted for Outfall 008 TSS concentrations over time. Additional samples representing the post-restoration period will be required for statistical confirmation of this trend, but it suggests that the restoration activities have lowered the TSS concentrations leaving the site through erosion controls and other targeted BMPs.

Therefore, based on the collective weight of evidence, in light of the limited data available, stormwater runoff from the Outfall 008 watershed appears to be trending toward a natural background condition; however, more data are needed to make a conclusive statement. It is recommended that this analysis be updated when new Outfall 008 samples are collected during the coming reporting years.

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