Prepared for

The Los Angeles Regional Water Quality Control Board
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Santa Susana Field Laboratory

Site-Wide Stormwater Annual Report

2022/23 Reporting Year

Prepared by

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and

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Abbreviations

CM	Culvert Modification
COC	Constituent of Concern
DMR	Discharge Monitoring Report
DNQ	Detected not Quantified
DOE	Department of Energy
DTSC	Department of Toxic Substances Control
ELV	Expendable Launch Vehicle
ISRA	Interim Source Removal Action
LARWQCB	Los Angeles Regional Water Quality Control Board
LOX	Liquid Oxygen Plant
mg	milligram
ug/L	micrograms per liter
MOU	Memorandum of Understanding
NASA	National Aeronautics and Space Administration
NPDES	National Pollutant Discharge Elimination System
OF	Outfall
PS	Particulate Strength
RMMP	Restoration, Mitigation, and Monitoring Plan
SAP	Sampling and Analysis Plan
SSFL	Santa Susana Field Laboratory
SWPPP	Stormwater Pollution Prevention Plan
SWTS	Stormwater Conveyance and Treatment System
TCDD	Tetrachlorodibenzo-*p*-dioxin
TEQ	Toxic Equivalence
TSS	Total Suspended Solid

Executive Summary

Stormwater discharges from the Santa Susana Field Laboratory (SSFL) are currently regulated by the Los Angeles Regional Water Quality Control Board (LARWQCB) under the *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 requires the Surface Water Expert Panel (SWEP) to conduct annual evaluations of the previous year's Permit limit exceedances and Best Management Practice (BMP) performance, provide new BMP recommendations as needed, and to submit a one-time workplan to outline this process. 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 satisfy the work plan requirement. In addition, in August 2022, the LARWQCB adopted a Memorandum of Understanding[1] (MOU) as a part of a comprehensive framework that establishes specific cleanup protocols and timelines for Boeing, and involves an agreement between Boeing and the Department of Toxic Substances Control (DTSC). The MOU outlines additional responsibilities for the Surface Water Expert Panel including modeling post-cleanup stormwater quality at SSFL outfalls that Boeing areas drain to, establishing background stormwater concentration thresholds, and designing a post-cleanup stormwater monitoring plan within Boeing areas of SSFL.

This 2022/23 Annual Report summarizes the data collected, evaluations performed, and the SWEP's findings and recommendations for the 2022/23 reporting year (July 1, 2022 to June 30, 2023), and follows the 2015 Work Plan. This report summarizes observed rainfall data, stormwater discharges and sampling at the SSFL outfalls, permit limit[2] and benchmark[3] exceedances, potential causes of exceedances, assessment of BMP performance, and recommendations for BMP and monitoring improvements.

A total of 45.9 inches of rainfall was measured in the 2022/23 reporting year, which is the wetest in over 50 years and is far above the long-term average annual rainfall of 17.3 inches[4]. A total of 16 qualifying rain events occurred in 2022/23, where a "rain event" is defined by the Permit as greater than 0.1 inches of rainfall in 24 hours, preceded by at least 72 hours of dry weather. Of the 16 rain events, 11 produced discharges at one or more NPDES outfalls, including Outfalls 001, 002, 008, 009, 010, 011, and 018. No sampleable discharges (and thus no opportunities for permit limit or benchmark exceedances) occurred at Outfalls 003, 004, 005, 006, 007.

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[1] Memorandum of Understanding Establishing the Processes, Methodologies, and Standards for Assessing Stormwater Discharges and Applicable Requirements Following the Boeing Company Soil Cleanup at the Santa Susan Field Laboratory Site

[2] The permit limit is the highest allowable discharge of a pollutant. If the concentration of the pollutant in the monitoring sample is greater than the limit and greater than or equal to the reported Minimum Level (the lowest calibration standard or quantifiable concentration), then the Discharger is out of compliance.

[3] In this permit a "benchmark" is a water quality-based effluent limit that is used to evaluate the performance of best management practices (BMPs) with regard to the removal of pollutants present in the discharge. Exceedance of a benchmark triggers an evaluation of the BMPs implemented at the site.

[4] Data from the Simi Hills – Rocketdyne Lab gauge (Ventura County Watershed Protection District site 249) were used to determine annual rainfall from 1958/59 through 1977/78 and from 1984/85 through 2000/01. Rainfall data from 2001/02 through 2022/23 were recorded at the Area 4 gauge, which was relocated to Area 1 on January 1, 2013), resulting in a combined period of record of 56 years.

In the 2022/23 reporting year, the following exceedances[5] were observed and are discussed in more detail in Section 2.2.1:

- Outfall 001: The 0.3 mg/L iron benchmark was exceeded in four samples at concentrations ranging from 0.83 mg/L to 3.7 mg/L.
- Outfall 002: The 0.3 mg/L iron benchmark was exceeded in three samples at concentrations rainging from 0.86 mg/L to 1.3 mg/L. The 300 ug/L sulfate benchmark was exceeded in one sample at 380 ug/L.
- Outfall 010: The 2.8E-08 µg/L effluent limit for TCDD TEQ (no DNQ) was exceeded in one sample at 4.6E-08 µg/L .
- Outfall 011: The 50 ug/L manganese effluent limit was exceeded in two samples at 61 µg/L and 79 ug/L. The 0.3 mg/L iron effluent limit was exceeded in three samples ranging from 0.78 mg/L to 4.0 mg/L. The 2.8E-08 µg/L TCDD TEQ no DNQ effluent limit was exceeded once at 5.8E-08 µg/L.

Based on multiple lines of evidence, most of the 2022/23 exceedances are believed to be from natural background soils and non-industrial sources (e.g., elevated TCDD TEQ no DNQ in soils near treated wood poles). Only the TCDD TEQ (no DNQ) exceedance at Outfall 011, which occurred during a large storm that caused bypass at the stormwater treatment system, was found to potentially have contributions from impacted soils based on concentrations measured in surface soils in the drainage area. However, on average, the majority of surface soils in potential cleanup areas in this watershed have TCDD TEQ (no DNQ) concentrations similar to background soils, with just the highest percentile concentrations exceeding those of background datasets, on par with soil concentrations near treated wood poles. Where impacted soils could not be ruled out as a source, new BMPs or improvements/repairs are proposed.

Other key findings include the following, which are discussed in more detail in Section 4:

- The passive distributed treatment controls in the Outfall 009 watershed continue to perform well despite many years of operation. Constituent loads are being reduced, through reduction of stormwater concentrations and volumes. Volumes are reduced through moisture retention and evapotranspiration in the treatment controls, and demolition and revegetation ofpavement and buildings. And collectively the controls are working well as evidenced by 100% compliance at Outfall 009 in 2022/23 despite the historically wet season.
- The two active stormwater treatment systems (SWTSs) are performing well, as evidenced by near 100% compliance at Outfalls 011 and 018 when stormwater flows are fully treated (only one exceedance for iron), as well as reductions in concentrations observed between untreated influent and fully treated outfall discharge samples.
- Stormwater quality at the southern buffer area, or Outfalls 001 and 002, are good as evidenced by only exceeding benchmarks for iron (Outfalls 001 and 002) and sulfate (Outfall 002), both of which are not human health-based benchmarks and measured concentrations were found to come from natural background sources.

[5] In October 2023, the SSFL NPDES Permit was renewed and the iron limits and benchmarks were removed since the studies presented by the Surface Water Expert Panel indicate that elevated levels of iron are likely due to high naturally occurring concentrations of these constituents found in the soil, not due to previous industrial activity. Additionally, the limit was based on iron secondary MCLs to protect for aesthetic qualities, specifically color, taste, and odor, but are not health-based limits.

- Stormwater from the small northern outfalls (003-007 and 010) continue to be effectively managed through capture and pumping to Silvernale, with only one storm event that exceeded pumping capacity at 010 despite the historically wet season.
- Boeing and NASA continue to implement SWEP BMP and monitoring recommendations site-wide.
- Concentrations measured in 2022/23, do not change prior stormwater Human Health Risk Assessment (HHRA) conclusions: there are no elevated human health risks from exposure to SSFL stormwater discharge through the exposure pathways that were evaluated.
- For every exceeding constituent, SSFL concentrations were comparable to, or lower than, stormwater concentrations measured at offsite reference watersheds which are undeveloped and/or non-industrial.

Recommendations are discussed in Section 5 and include the following:

- The SWEP continues to recommend accelerated source removal, including the ongoing and proposed Imminent and Substantial Endangerment (ISE) measures at the Former Shooting Range and Area 1 Burn Pit.
- Continued monitoring and maintenance of existing treatment control BMPs.
- To address benchmark and Permit limit exceedances at Outfalls 001, 010, and 011, the SWEP recommends erosion and sediment controls and stormwater capture/conveyance at the Area I Burn Pit; adding pole wattles in 010, and concrete-lining for the Perimeter Pond spillway at OF011 to reduce erosion.
- The SWEP recommends minor changes to the stormwater monitoring program, including QA/QC protocols for compliance samples and refinements to the non-compliance/voluntary sampling, to continue supporting source identification and BMP performance and maintenance needs assessment.

The SWEP will continue to oversee the follow-through on these recommendations into the 2023/24 season. The SWEP will also continue to work on activities required by the recent MOU, which include modeling and planning monitoring of post-cleanup stormwater quality.

The SWEP looks forward to engaging with the public at the next public meeting on November 29, 2023 where these results and recommendations will also be discussed.

1 Introduction

The Santa Susana Field Laboratory (SSFL) occupies approximately 2,850 acres located at the top of Woolsey Canyon Road in the Simi Hills of Ventura County, California. During wet weather, SSFL has the potential to discharge stormwater runoff impacted by constituents from the facility. As such, stormwater discharges from SSFL are currently regulated by the Los Angeles Regional Water Quality Control Board (LARWQCB) under the *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[6] 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 satisfy the work plan requirement specified in the 2015 Permit. As the 2022/23 Annual Report, this document summarizes results and findings of the 2022/23 reporting year (July 1, 2022 to June 30, 2023) and is presented in adherence to commitments outlined in the 2015 Work Plan. Most recently, on October 19, 2023, new public comments were heard and a revised NPDES permit was adopted, without changes to the Expert Panel's charge, and so the 2015 Work Plan remains in effect and without need for update.

On August 11, 2022 the LARWQCB heard public comments and approved a memorandum of understanding[7] (MOU) that clarifies the post-cleanup conditions in which the LARWQCB would consider terminating Boeing's NPDES Permit obligations. The MOU is part of a comprehensive framework that establishes specific cleanup protocols and timelines for Boeing, and involves an agreement between Boeing and the Department of Toxic Substances Control (DTSC). The MOU also outlines additional responsibilities for the Surface Water Expert Panel including modeling stormwater quality at SSFL outfalls that Boeing cleanup areas drain to, establishing background stormwater concentration thresholds, designing a post-cleanup stormwater monitoring plan within Boeing areas of SSFL, and overseeing a post-cleanup stormwater Human Health Risk Assessment. These Panel activities are ongoing but are not the focus of this Annual Report; future reports and plans will be submitted, and made publicly available, to address these MOU activities.

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[6] Most recently the Site was regulated under the *National Pollutant Discharge Elimination System (NPDES) Permit No. CA0001309 for the Boeing Company, SSFL, Canoga Park, CA, Order No. R4-2010-0090* ("2010 Permit") from 2010 to April 1, 2015. The site has been regulated under individual NPDES permits since 1998.

[7] Memorandum of Understanding Establishing the Processes, Methodologies, and Standards for Assessing Stormwater Discharges and Applicable Requirements Following the Boeing Company Soil Cleanup at the Santa Susan Field Laboratory Site

1.1 Background

The SSFL site (the "Site") 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. As shown in Figure 1, the site is divided into four administrative areas (Areas I, II, III, and IV), with undeveloped land area surrounding the Site to the north and south. Administrative Areas I and III are operated by Boeing, who owns the majority of Area I and all of Area III. The federal government owns a 40-acre portion of Area I and the entirety of Area II, both administered by NASA. While Area IV land is Boeing-owned, the Department of Energy (DOE) is responsible for its cleanup. Boeing no longer serves as a DOE contractor; however, Boeing and preceding contractors performed work at the DOE Energy Technology Engineering Center (ETEC) site in Area IV prior to the 1998 Department of Energy remediation contract with Boeing. The DOE owns specific facilities located within an approximately 90-acre portion of Area IV. Industrial operations at the Site have ceased, and current activities include environmental monitoring and sampling, demolition, remediation, and ongoing remedial planning. Undeveloped land and open space at the Site provide wildlife habitat and natural area.

Stormwater discharges from the Site are typically captured and treated at or upstream of outfalls for storms up to the Expert Panel's recommended site-specific design storm, or the 1-year, 24-hour event (2.5 inches of rainfall), which is much larger than the design storms used in most stormwater NPDES permits in California. Outfalls 011 and 018 have had significant stormwater pond storage and "end of pipe" advanced active treatment systems (SWTSs) since 2012 to capitalize on the equalization storage and sedimentation pretreatment provided by existing ponds, while Outfalls 008 and 009 use erosion control, interim source removal, and multiple distributed passive treatment control measures in lieu of outfall-based treatment due to their topography. Outfalls 001 and 002 present exceptions, as stormwater discharges from these outfalls are from undeveloped southern "buffer zone" drainage areas comingled with treated stormwater discharges from Outfalls 011 and 018, respectively. Interim Source Removal Action (ISRA) and Best Management Practices (BMP) programs were implemented at Outfalls 008 and 009 beginning in 2009, with LARWQCB oversight to facilitate Permit compliance through removal of surface soils elevated for NPDES constituents of concern (COCs) and implementation of distributed stormwater treatment controls for prioritized subareas. The 2010 BMP Plan (MWH et al., 2010) was developed under the oversight of the Surface Water Expert Panel ("SWEP" or "Expert Panel") for the Outfall 008 and 009 Watersheds. The 2015 Work Plan subsequently replaced the 2010 BMP Plan as an overall strategy for improving site-wide compliance with NPDES permit requirements and continuing critical public outreach and engagement efforts regarding stormwater subjects.

The Surface Water Expert Panel consists of Dr. Robert Pitt, University of Alabama, emeritus; Dr. Robert Gearheart, California State Polytechnic University, Humboldt; Dr. Michael Stenstrom, University of California, Los Angeles; and Mr. Jonathan Jones, Wright Water Engineers. The Expert Panel continues to oversee stormwater planning and design work at SSFL, providing key input on monitoring and source removal activities, as well as a variety of NPDES Permit compliance topics. The Expert Panel oversees scientific studies related to SSFL stormwater quality and BMP design considerations, reviewed the stormwater Human Health Risk Assessment (HHRA), and engages with the public regarding stormwater activities at SSFL. The original Surface Water Expert Panel objective to improve stormwater at NPDES Outfalls 008 and 009 was expanded in the 2015 Work Plan to include all NPDES Outfalls, as required by the 2015 Permit. The Surface Water Expert Panel also reviews the Quarterly Discharge Monitoring Reports (DMRs) and site-wide construction SWPPPs for demolition and interim source removal projects.

1.2 Site Overview

Outfalls regulated under the 2015 NPDES Permit are listed in Table 1 and depicted in Figure 1. The NPDES Permit states that 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 011 and 018 contribute discharge to Outfalls 001 and 002, respectively. Per the 2015 Permit, injection of treated groundwater is acceptable at Outfall 019, though the discharge of surface water is not planned nor permitted at Outfalls 019 or 020. With the exception of naturally occurring seeps and springs where groundwater is known to comingle with stormwater and could potentially contribute constituents of concern (COCs) to stormwater discharges at the NPDES Outfalls, groundwater considerations are not included in the scope of the Expert Panel. A separate Groundwater Expert Panel at SSFL actively oversees Boeing-related groundwater matters, including groundwater treatment and assessment of naturally occurring seeps and springs.

Stormwater runoff from northern areas of the Site (Outfalls 003 through 007 and 010) is transferred to Silvernale Pond for treatment prior to discharge at Outfall 018. Runoff in excess of the storage and transfer system capacity is treated by flow-through media filters and discharges at Outfalls 003 through 007 and at Outfall 010, which discharge to the Calleguas Creek watershed. Stormwater conveyance and treatment systems (SWTSs) have been in place at Outfalls 011 and 018 since 2012. The SWTSs provide advanced stormwater treatment using ActiFlo coagulation and filtration systems, with stormwater ponds upstream for flow equalization and pretreatment by sedimentation. The SWTS at Outfall 011 has experienced lapses in operation throughout its lifetime, most recently due to damage from the Woolsey Fire, however, it was fully operational in 2022/23. Stormwater runoff from the Outfall 008 and 009 Watersheds is not captured and treated by a central SWTS[8], given the location, size, and adverse terrain of these watersheds, coupled with the inability to store large volumes of stormwater near the outfalls. As described in the 2010 BMP Plan, due to topographical constraints, distributed stormwater treatment and an iterative, adaptive management-based approach are applied within both the Outfall 008 and 009 Watersheds. Stormwater runoff that discharges at Outfall 009 naturally flows to Arroyo Simi and subsequently to Calleguas Creek. Stormwater runoff from Happy Valley at Outfall 008 flows via Dayton Canyon Creek to Chatsworth Creek, which flows south to join Bell Creek southwest of the intersection of Shoup Avenue and Sherman Way. Bell Creek then continues southeast toward its confluence with the Los Angeles River.

Table 1. NPDES Outfall Descriptions

NPDES Outfall[1]	Watershed Area (acres)	Description
001	293 (+303 above OF011)	Downstream of Outfall 011; discharges to Bell Creek
002	360 (+539 above OF018)	Downstream of Outfall 018; discharges to Bell Creek
003	12	Runoff transferred to Silvernale for treatment prior to discharge at Outfall 018[2]
004	6	Runoff transferred to Silvernale for treatment prior to discharge at Outfall 018[2]
005	<1	Runoff transferred to Silvernale for treatment prior to discharge at Outfall 018[2]
006	12	Runoff transferred to Silvernale for treatment prior to discharge at Outfall 018[2]
007	3.0	Runoff transferred to Silvernale for treatment prior to discharge at Outfall 018[2]
008	62	Stormwater from Happy Valley; discharges to Dayton Creek

[8] An exception to this is where a portion of runoff from the Helipad in Area II of the Outfall 009 Watershed is captured and piped to Silvernale Pond for treatment by the Outfall 018 SWTS.

NPDES Outfall[1]	Watershed Area (acres)	Description
009	536	Stormwater from Northern Drainage; discharges to Arroyo Simi
010	5	Runoff transferred to Silvernale for treatment prior to discharge at Outfall 018[2]
011	303	Stormwater and perimeter pond treated by SWTS; discharges to Outfall 001
018	539	Stormwater and R-2 pond, treated by SWTS; discharges to Outfall 002
019	N/A	Injection of treated groundwater (GET System); no surface discharge
020	N/A	Not planned for use; injection of treated groundwater (GET System); no surface discharge

[1]Outfalls 012 through 017 are not included in the 2015 Permit

[2]Stormwater runoff in excess of storage and transfer capacities is treated by media filters at individual outfalls before discharging to tributaries of Calleguas Creek.

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Figure 1. Site Map with Drainages, Drainage Areas, Outfall Locations, and Surface Water Boundaries

1.3 Existing Stormwater Treatment

BMPs have been implemented throughout the Site to treat stormwater prior to discharge, and extensive erosion and sediment control BMPs, revegetation, stabilization of repaved roads, and other soil stabilization activities have also been implemented across the Site. Impervious surfaces such as building roofs and parking lots have been removed and disconnected by reintroducing vegetation and open space between them, effectively restoring the areas to natural conditions. Figure 2 presents the major structural treatment control BMPs implemented at the Site but does not include Site-wide erosion and sediment control BMPs, unpaved road control measures, building demolitions, and paved areas converted by soil scarification and revegetation. Major structural BMPs 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.*, 2015), the 2015 BMP Plan (Haley & Aldrich, 2015), and subsequent Annual Reports. Major structural BMPs include the following, listed by implementation date:

- 2009: Outfall 009 Culvert Modifications (CMs)
- 2010: Outfall 008 ISRA Excavations
- 2011: Outfall 009 Helipad Berms and Pumps
- 2011: Outfall 011 Stormwater Conveyance and Treatment System (SWTS)
- 2011: Outfall 018 Stormwater Conveyance and Treatment System (SWTS)
- 2012: Outfall 009 B-1 Sedimentation Basin and Media Filter
- 2012: Outfall 009 Northern Drainage Restoration Measures
- 2012: Outfall 009 CM-9 Additional Improvements
- 2013: Outfall 009 Lower Parking Lot Sedimentation Basin and Biofilter
- 2013: Outfall 009 ISRA Excavations
- 2013: Outfall 009 ELV Treatment BMP[9]
- 2013: Outfall 009 LOX Sandbag Berms and Slope Drains
- 2015: Outfall 009 B1436 Detention Bioswales
- 2017: Outfall 009 Wattles added around Poles along Roads
- 2017: Outfall 009 Upper Parking Lot Media Filter
- 2017: Outfall 009 Roadway Diversion to CM-3
- 2017: Outfall 009 Administration Area Inlet Filters
- 2017: Outfall 009 Enhanced Erosion Controls in the Former Shooting Range Area
- 2017: Outfall 009 Roadway Diversion to CM-1
- 2018: Outfall 009 CM-1 Reconstruction
- 2019: Outfall 009 Mulch Sack Curb Extension in Lower Parking Lot
- 2019: Area II Utility Pole vegetation clearing and soil base stabilization
- 2020: Outfall 009 ELV and Biofilter Cistern Generators Added
- 2020: Outfall 009 CM-3 Check Dams Added and Media Filter Reconstruction
- 2020: Southern Buffer Zone Utility Pole BMPs
- 2021: Outfall 009 ELV Treatment BMP Media Filter Underdrain Layer Reconstruction

[9] The power supply connection to the ELV treatment BMP was damaged in the Woolsey Fire rendering it inoperable for the 2018/19 season. A generator was installed in September 2019, and the BMP was operational again beginning in 2019/20.

- 2022: R-1 Pond Berm Repair
- 2023: Treated Wood Utility Pole BMP Adjustments

Stormwater from Outfall 011 is pumped to the R-1 Pond for settling and evaporation. The pond also serves as added storage to reduce stormwater discharges. When the runoff exceeds the storage capacity of the pond, stormwater is treated using an advanced SWTS. Treated stormwater is discharged at Outfall 011 and then flows through a natural channel to Outfall 001. Following the November 2018 Woolsey Fire, conveyance pipelines to the Outfall 011 SWTS were damaged and stormwater runoff at Outfall 011 was instead treated only by a flow-through media filter for the 2018/19 water year. The Outfall 011 SWTS was repaired in late 2019 and operational again prior to the first 2019/20 storm event. During the 2021/22 season, a berm on the R-1 Pond was compromised during the peak 24-hr rain event on 1/1/2022, causing the pond to discharge before reaching its capacity under typical operations resulting in stormwater discharge at Outfall 011 that was partially treated by the media filter at the outfall. The berm underwent repair in October 2022, to restore the pond volume to its full capacity.

Stormwater runoff up to the outfall-specific design volumes at Outfalls 003, 004, 005, 006, 007, 009 [10], and 010 is pumped to Silvernale Pond before being treated by the Outfall 018 SWTS alongside stormwater runoff from the local Outfall 018 Watershed. The Outfall 018 SWTS has been shown to be highly effective at reducing both the magnitude and frequency of Permit Limit exceedances (Santa Susana Surface Water Expert Panel and Geosyntec Consultants, 2019).

Distributed BMPs in the Outfall 009 Watershed, including widespread revegetation, erosion and sediment controls, and natural treatment BMPs, have also been shown to be effective at reducing COC concentrations in stormwater. Statistical evaluations of observed influent versus effluent concentrations at BMPs are included in Appendix D; they indicate significant reductions of COC loads in subareas treated by the structural BMPs, with the largest influent-to-effluent reductions achieved for higher influent concentrations. Northern Drainage inspections are performed annually to identify if stabilization efforts are recommended within the Northern Drainage channel, the primary stormwater conveyance in the Outfall 009 Watershed.

Limited runoff has discharged at Outfall 008 since the 2012 completion of ISRA activities that included identification, evaluation, remediation or stabilization, and restoration of areas containing soils contaminated with COCs. Installation of new erosion and sediment controls, revegetation, and unpaved road stabilization also took place in 2012. From 2013 to 2018, a total of just four discharges occurred at Outfall 008, each sampled and analyzed for between 60 and 200 parameters. Three individual parameter results were at concentrations above 2015 Permit Limits, fewer than historic exceedance rates would predict, highlighting pollutant reduction benefits achieved by the ISRA soil removal activities, revegetation and restoration, and implementation of erosion controls targeting sediment-bound COCs. Of the 9 samples collected and analyzed in 2018/19, 11 individual parameter results indicated concentrations above 2015 Permit Limits. Observed increases in runoff volumes and concentrations above Permit Limits in 2018/19 likely resulted from the combination of above average rainfall and decrease in vegetative cover causing increased stormwater flows and turbidity following the Woolsey Fire. No monitoring results were

[10] Stormwater runoff from a small area within the Outfall 009 watershed, the 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.

above 2015 Permit Limits out of the 5 samples collected and analyzed in 2019/20, and far below-average rainfall was recorded in 2020/21 such that no outfalls discharged that year. In the single discharge event in 2021/22, no results were measured above Permit Limits. Of the 10 discharge events during the record high rainfall year of 2022/23, no results were measured above the 2015 Permit Limits.

Sample results collected at distributed structural BMPs have indicated effective BMP performance and further confirmed the water quality improvements achieved by the iterative and adaptive management-based approach that has been employed in these watersheds.

2009: Culvert Modifications

2010: Outfall 008 Watershed ISRA Excavations

2011: Helipad Berms and Pumps

2011: Outfall 011 SWTS

2011: Outfall 018 SWTS

2012: B-1 Sedimentation Basin and Media Filter

2012: Northern Drainage Restoration Measures

2012: CM-9 Additional Improvements (Perforated Pipe, Extended Sedimentation Area and Rip Rap Berm)

2013: Lower Parking Lot Sedimentation Basin and Biofilter

2013: Outfall 009 Watershed ISRA Excavations

2013: ELV Treatment BMP

2013: LOX Sandbag Berms and Slope Drains

2015: B1436 Detention Bioswales

2017: Wattles around Poles along Roads

2017: Upper Parking Lot Media Filter

2017: Roadway Diversion to CM-3

2017: Administration Area Inlet Filter (Filter Basket)

2017: Administration Area Weighted Wattle and Riprap at Culvert Inlet

2017: Enhanced Erosion and Sediment Controls in Former Shooting Range Area

2017: Roadway Diversion to CM-1

2018: CM-1 Reconstruction Including Enlargement

2019: Mulch Sack Curb Extension in Lower Parking Lot

2019: Area II Utility Pole Vegetation Clearing and Soil Base Stabilization

2020: Outfall 009 CM-3 Check Dams Added and Filter Media Reconstruction

2020: Outfall 009 CM-3 Check Dams Added and Media Filter Reconstruction

2020: Southern Buffer Zone Utility Pole BMPs

2020: Outfall 009 ELV and Biofilter Cistern Generators Added

2021: Outfall 009 ELV Treatment BMP Media Filter Reconstruction

2022: R1 Pond Berm Repair

2023: Treated Wood Utility Pole BMP Adjustments

Figure 2. Photos of Example Structural BMPs and Years of Construction

1.4 Permit History

Figure 3 provides a 25-year overview of past SSFL stormwater Permits, Expert Panel involvement, and counts of individual sample results above the 2015 Permit Limits and Benchmarks[11] at regulated Outfalls. The result counts above the 2015 Permit Limits and Benchmarks are not necessarily true exceedances due to some limits being based on annual averages and results prior to 2015 were not subject to the 2015 Permit, however, this provides a static reference point to evaluate conditions over time. Annual frequencies of Permit Limit and Benchmark exceedances are a function of Permit changes, annual rainfall, and implemented treatment control BMPs and stormwater discharge prevention strategies, as well as the natural variability of stormwater quality. Notable milestones presented in Figure 3 include:

- **1998 NPDES Permit:** NPDES Permit No. CA0001309 was issued to regulate wastewater and stormwater discharged from SSFL.
- **2004 NPDES Permit:** The 2004 Permit included new California Toxics Rule (CTR)-based effluent limits and added 11 new compliance monitoring locations. The number of Benchmark and Permit Limits exceedances increased in response to the additional regulatory requirements.
- **2005 Topanga wildfire**: Approximately 97% of SSFL burned, resulting in an increased number of Permit Limit exceedances compared to other reporting years with similar rainfall.

[11] While the discharge of stormwater runoff with constituents in excess of the effluent limitation is prohibited at most outfalls, benchmarks are provided for Outfalls 001 and 002. Benchmarks are defined in the 2015 Permit as "a water quality based effluent limit or a performance based limit that is used to evaluate the performance of best management practices (BMPs) with regard to the removal of pollutants present in the discharge. In this Order, the benchmarks are established based on water quality based effluent limitations. Exceedance of a benchmark triggers an evaluation of the BMPs implemented at the site. The evaluation may determine that the BMPs require augmentation, upgrading, or replacement. If so, the Discharger must develop a plan to implement the required upgrades and report to the Regional Water Board within 60 days of the reported exceedance. The Discharger shall continue monitoring as directed in the Monitoring and Reporting Program during plan development and implementation."

- **2006 NPDES Permit**: The 2004 Permit was revised to include the waste load allocations (WLAs) specified by applicable TMDLs of downstream waterbodies.
- **2007 Cease and Desist Order (CDO):** In the CDO, the RWQCB required the "assembly of a panel to review site conditions, modeled flow, contaminants of concern, and evaluate the BMPs capable of providing treatment to meet the final effluent limits." The CDO also required BMP planning, performance evaluation, and reporting requirements.
- **2010 NPDES Permit:** No major changes to the Permit. The Expert Panel continued to make data-informed recommendations for BMPs in the Outfall 008 and 009 Watersheds, which were then implemented at the Site as described in Section 1.3.
- In **2011**, following the construction of the Outfall 018 SWTS, stormwater from Outfalls 003 through 007 and Outfall 010 was retained in storage tanks and then transferred to Silvernale Pond before being treated by the SWTS, reducing the number of discharges and exceedance occurrences site-wide.
- **2015 NPDES Permit:** Permit expanded the Expert Panel's charge to all regulated SSFL Outfalls. In response, the Panel continues to review Permit Limits and Benchmark exceedances at all Outfalls, making data-driven BMP recommendations on a site-wide basis.
- **2018 Woolsey wildfire:** Approximately 80% of SSFL was impacted by the wildfire, and the Site received above-average rainfall in 2018/19. Because of the post-fire hydrophobicity[12] of the soil and loss of vegetative cover, rain events following the fire produced significantly greater runoff volumes as well as an increase in the number of Permit Limits and Benchmark exceedances compared to rain events of similar size during non-fire years. Stormwater runoff volumes and water quality across the SSFL site returned to typically observed levels the following year.

[12] Soils exhibiting hydrophobicity cause water to collect on the soil surface rather than infiltrate into the ground. Wildfires generally cause soils to temporarily become more hydrophobic, increasing water repellent characteristics of the soil and exacerbating erosion with stormwater runoff in post-fire burn areas.

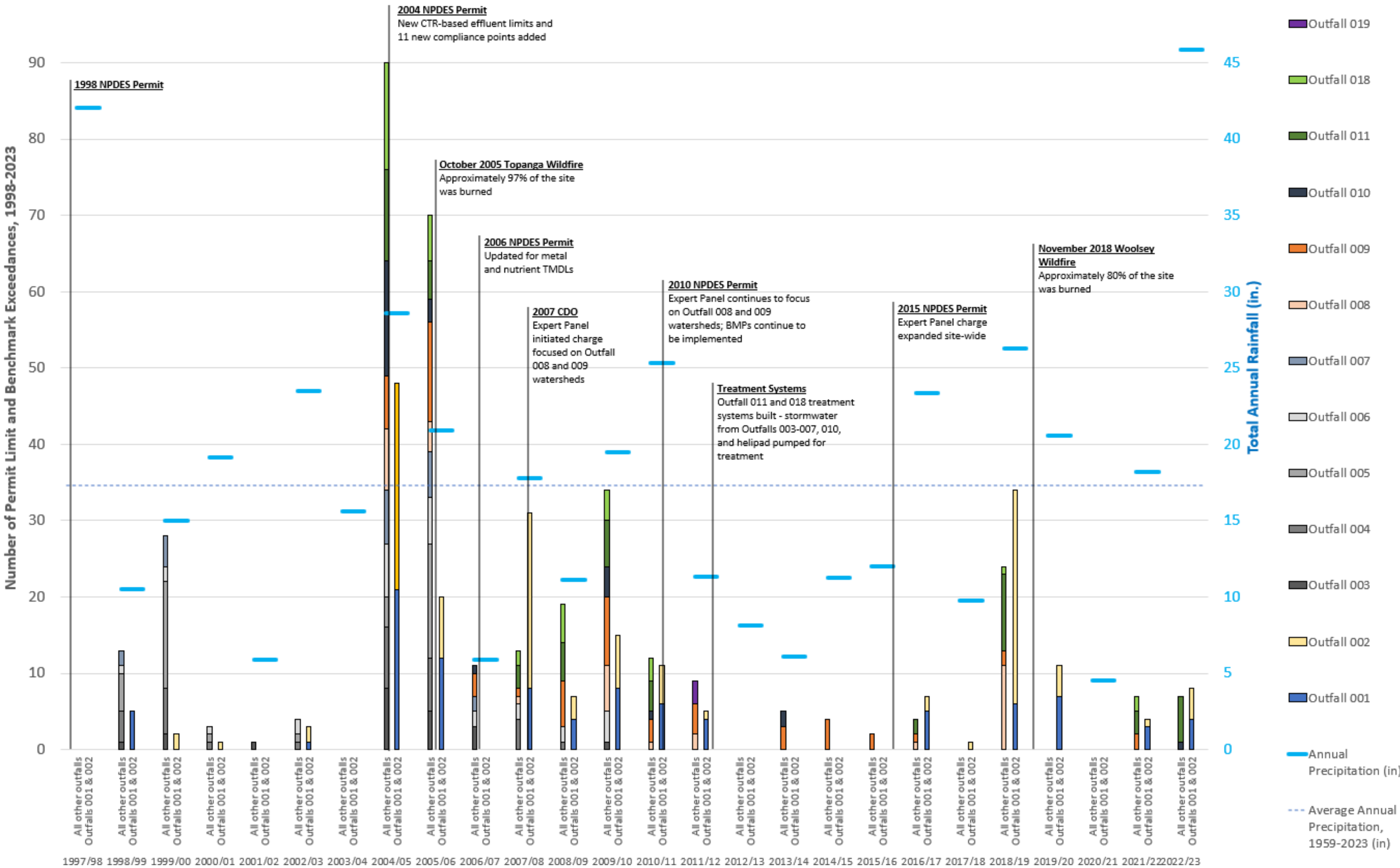

Figure 3. Summary of SSFL Permits, Surface Water Expert Panel Involvement, and Water Quality Compared to 2015 Permit Limits, 1998-2023
(Note: Benchmarks apply at Outfalls 001 and 002; effluent limits apply at all other outfalls)

2 Monitoring Activities

Characteristics of 2022/23 precipitation are presented below, alongside a summary of stormwater sample results from NPDES Permit compliance outfalls and the Outfall 009 Watershed BMP monitoring locations specified in the 2022/23 Sampling and Analysis Plan (Appendix A). Observations from the Northern Drainage assessment and results from the Non-Industrial Sources Special Study are also summarized below.

2.1 2022/23 Rainfall

The long-term average annual rainfall at SSFL from 1959 to 2023 is 17.3 inches[13], occurring primarily in winter storms from September through May. Highly variable periods of above or below average rainfall are common. Little rainfall typically occurs during the April through September dry season. A record total 45.9 inches of rainfall was measured in the 2022/23 reporting year (July 1, 2022 – June 30, 2023). Total prior year rainfall (2021/22) was 18.2 inches. A total of 16 qualifying rain events occurred in 2022/23, where a "rain event" is defined by the Permit as greater than 0.1 inches of rainfall in 24 hours, preceded by at least 72 hours of dry weather. Of the 16 rain events, 11 produced discharge at one or more NPDES outfalls.

Table 2 summarizes historical rainfall totals observed since the submittal of the Surface Water Expert Panel Work Plan in 2010. Seven of the last fourteen years have had above average rainfall (bolded in the table below) and there was a five-year drought from 2011/12-2015/16. Figure 4 illustrates the cumulative rainfall recorded in 2022/23 compared to the previous 6 years and the long-term average annual rainfall.

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

Reporting Year	Annual Rainfall (in)	Percent of Average Annual Rainfall	Number of Qualifying Rain Events
2022/23	**45.9**	**265%**	16
2021/22	**18.2**	**105%**	8
2020/21	4.6	26%	6
2019/20	**20.5**	**118%**	9
2018/19	**26.3**	**152%**	12
2017/18	9.8	57%	4
2016/17	**23.4**	**135%**	14
2015/16	12.0	69%	13
2014/15	11.3	65%	9
2013/14	6.1	35%	5
2012/13	8.1	47%	9
2011/12	11.3	65%	10
2010/11	**23.4**	**135%**	14
2009/10	**19.4**	**112%**	11

[13] Data from the Simi Hills – Rocketdyne Lab gauge (Ventura County Watershed Protection District site 249) were used to determine annual rainfall from 1958/59 through 1977/78 and from 1984/85 through 2000/01. Rainfall data from 2001/02 through 2022/23 were recorded at the Area 4 gauge, which was relocated to Area 1 on January 1, 2013), resulting in a combined period of record of 56 years.

Note: Above average annual rainfall totals are **bolded**.

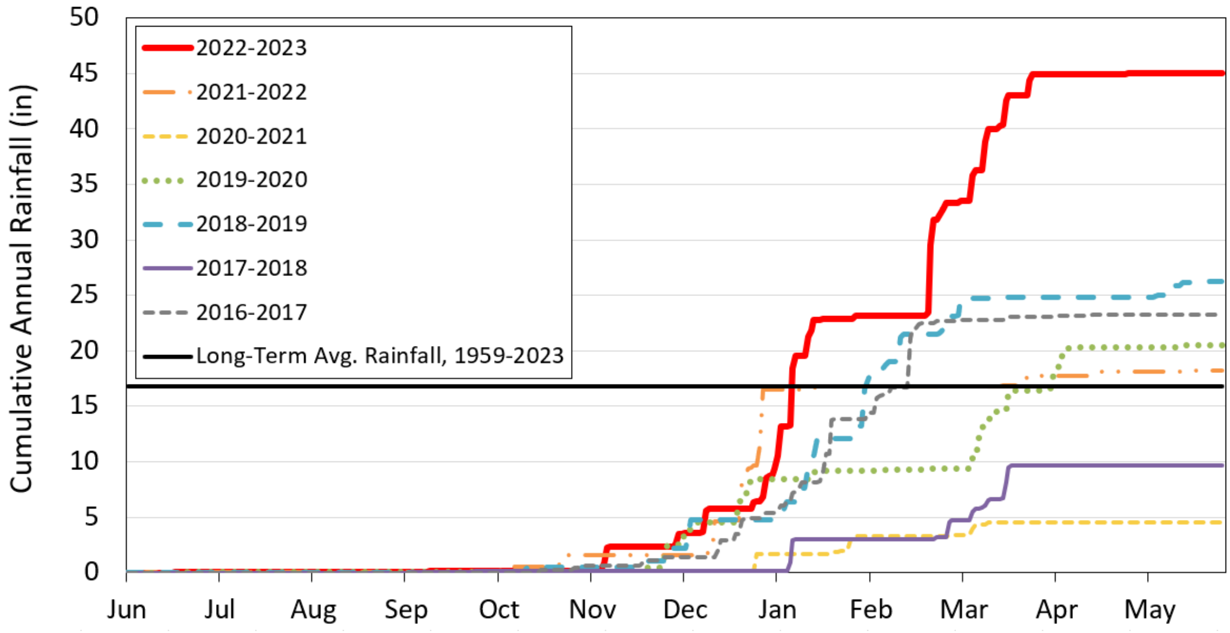

Figure 4. Annual Cumulative Rainfall, 2016-2023

Table 3 summarizes the rain event depths and number of subarea samples collected during each event. The largest rain event of 2022/23 occurred February 23 – March 1, 2023, generating a total of 10.10 inches. The maximum 24-hour rainfall depth during the same storm was 6.51 inches, which is expected to occur once in 25 years based on the point precipitation DDF estimates for SSFL shown in Table 4 (NOAA, 2022). This this is the highest 24-hour rainfall depth observed at the site since the start of the rainfall record in 1958. The next highest historical 24-hour rainfall depth was 6.22 inches, recorded between December 22-31, 2021. The second largest event in 2022/23 occurred December 27, 2022 – January 5, 2023, generating a total of 7.46 inches with a maximum 24-hour rainfall intensity of 3.48 inches which can be expected to occur roughly every 5 years. Overall, these two storms combined measured 17.56 inches of rainfall, or 38% of the total annual rainfall observed in 2022/23 and just over the long-term average annual rainfall.

Table 3. 2022/23 Rain Event and Monitoring Summary[1]

Rain Event	Total Rainfall (in)	Rain Event Duration (hours)	Average Rainfall Intensity During Hours with Rainfall (in/hr)	Maximum 1-hr Rainfall Intensity (in/hr)	Maximum 24-hr Rainfall Depth (in)	24-hr Recurrence Interval	Antecedent Dry Period[2] (days)	BMP Performance Samples	Subarea Monitoring Samples
9/9-10/2022	0.14	32	0.014	0.04	0.14	< 1 year	140	None	None
11/1-2/2022	0.17	5	0.024	0.06	0.17	< 1 year	52	None	None
11/7-9/2022	1.96	53	0.036	0.35	1.57	< 1 year	5	7	1
12/1-5/2022	1.29	95	0.013	0.1	1.03	< 1 year	22	None	None
12/10-12/2022	2.17	38	0.056	0.48	1.95	< 1 year	5	5	1
12/27/2022-1/5/2023	7.46	217	0.030	0.47	3.48	**2-5 year**	15	18	2
1/8-10/2023	6.32	36	0.171	0.59	5.43	**10-25-year**	2	8	2
1/14-16/2023	3.19	49	0.064	0.32	1.76	< 1 year	4	6	2
1/19/2023	0.12	2	0.04	0.06	0.12	< 1 year	3	None	None
1/29-30/2023	0.31	10	0.028	0.10	0.31	< 1 year	10	None	None
2/23-3/1/2023	10.10	144	0.070	0.6	6.51	**25-50 year**	24	3	2
3/5-3/6	0.22	16	0.009	0.07	0.21	< 1 year	4	None	None
3/10-3/15/2023	6.48	130	0.049	0.48	3.60	**2-5 year**	4	3	1
3/19-3/22/2023	3.02	76	0.039	0.23	2.21	< 1 year	4	3	1
3/29-30/2023	1.88	38	0.050	0.34	1.39	< 1 year	7	3	None
5/1-4/2023	0.73	71	--	--	--	--	--	None	None
Non-Event Total[3]	0.29	--	--	--	--	--	--	--	--
Total	45.85	--	--	--	--	--	--	56	12

[1] Total rainfall, event duration, rainfall duration, average rainfall intensity, and maximum 1-hour rainfall intensity were assessed from rainfall data recorded at a calibrated and maintained weather station within Area I.

[2] Antecedent dry period represents the number of days between the start of the rain event and the last recorded rainfall, regardless of whether it qualified as a rain event.

[3] Non-Qualifying Event Total. The following rainfall measured in 2022/23 did not meet the definition of a qualifying rain event per the NPDES Permit: June 1, 2022 (0.01-in), June 17, 2022 (0.01-in), October 15, 2022 (0.01-in), October 23, 2022 (0.01-in), February 5, 2023 (0.03-in), April 12-13, 2023 (0.08-in), May 23, 2023 (0.05-in), June 5-6, 2023 (0.08-in), and June 12, 2023 (0.01-in).

Table 4. NOAA Point Precipitation Depths (inches), Durations, and Frequencies at SSFL

Duration	Average Recurrence Interval					
	1-yr	2-yr	5-yr	10-yr	25-yr	50-yr
1-hour	0.51	0.67	0.87	1.03	1.24	1.41
3-hour	0.95	1.24	1.62	1.92	2.32	2.62
6-hour	1.38	1.8	2.35	2.78	3.36	3.79
12-hour	1.89	2.47	3.21	3.81	4.59	5.18
24-hour (1 day)	2.53	3.33	4.34	5.14	6.20	6.99
48-hour (2 day)	3.14	4.20	5.55	6.63	8.07	9.16
72-hour (3 day)	3.45	4.69	6.32	7.65	9.46	10.9
96-hour (4 day)	3.74	5.14	7.00	8.54	10.7	12.3

[1]Source: Long-term precipitation depth-duration-frequency (DDF) data, NOAA Precipitation Frequency Data Server (PFDS). NOAA Atlas 14, Volume 6, Version 2. Simi Hills-Rocketdyne Lab, Latitude: 34.2353°, Longitude: -118.6759°.

Figure 5 presents observed rainfall intensities throughout the 2022/23 rainy season. The 1-hour rainfall intensities were generally below the 1-year recurrence interval depth, with the exception of one hour during the 2/24/2023 storm event where the intensity was near that of a 2-year event. The 3 and 6-hour duration intensities reached the 2-10-year event depth, while the 12-96-hour durations saw intensities representative of at least 10-year storm events. The 24-hour and 48-hour periods had rainfall intensities exceed the 25-year storm depth. Note that peak runoff occurs when the rainfall duration is equal to the time of concentration of the drainage area. Small drainage areas can therefore have peak runoff rates during relatively short rain durations, while large drainage areas require longer rain durations to produce peak runoff rates.

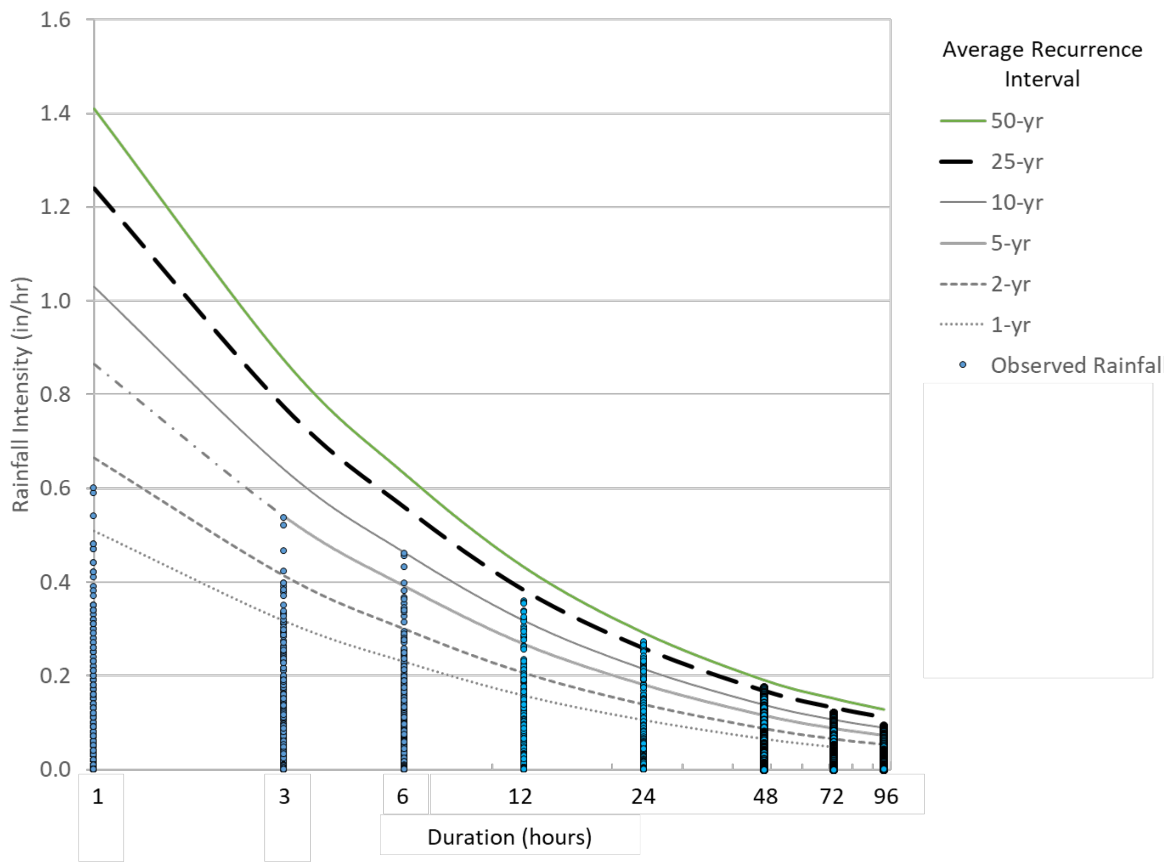

Figure 5. SSFL IDF Curves and Observed 2022/23 Rainfall Intensities

2.2 2022/23 Stormwater Sampling

In the 2022/23 rainy season, 64 samples were collected at NPDES Outfalls 001, 002, 008, 009, 010, 011, and 018. In addition to the compliance samples, 56 BMP performance monitoring samples were collected in the Outfall 009 Watershed, 4 subarea samples were collected in the Outfall 011 Watershed, and 8 subarea samples were collected in the Outfall 001 watershed. A full list of sampling locations and monitoring suites can be found in Appendix A; sampling results are discussed in the following sections. Table 5 summarizes individual 2022/23 rainfall events and lists the NPDES outfalls sampled during each event.

2.2.1 NPDES Outfalls

SSFL Outfall discharges are monitored for water quality compliance according to the 2015 NPDES Permit. This past reporting year, 64 total discharge samples were analyzed from Outfalls 001, 002, 008, 009, 010, 011 and 018[14] combined, as shown in Table 5. Of the 64 stormwater discharge samples analyzed for the

[14] The stormwater from the northern outfalls (Outfalls 003 to 007 and 010) was redirected to the Silvernale treatment system and was therefore monitored as part of the Ourfall 018 discharges. Only Outfall 010 of the northern outfalls had stormwater flows during a single event that exceeded the conveyance capacity to the Silvernale treatment system and therefore had partial flow diacharges which were monitored locally at the Outfall 010 location.

suite of NPDES parameters, there were 8 Benchmark exceedances (at Outfalls 001 and 002) and 7 Permit Limit exceedances (at Outfalls 009, 011, 010 and 018). These exceedances are discussed following Table 5. No sampleable discharge (and thus no opportunities for Permit Limit or Benchmark exceedances) occurred at Outfalls 003, 004, 005, 006, 007, 019, or 020.

Available storage capacities in the Outfall 018 and 011 stormwater ponds were exceeded on 12/30/21, during the largest storm event of the season, which occurred at the end of December 2021 and had a 24-hr storm depth recurrence interval of 25 years. The following summarizes times the BMPs in place at Outfall 011 and Outfall 018 overflowed in the last five years. These dates represent times when the stormwater discharge at these outfalls are partially treated – a mix of stormwater partially treated by settling in the ponds and/or outfall media filter and stormwater fully treated by advanced SWTS. Outfall 011 and 018 BMP overflow events from past years are listed below, with events in 2012-2022 shown in gray. Historically, the systems have overflowed only during exceptionally wet years (2016/17 and 2018/19 received over 130% of average annual rainfall) or during storm events larger than the design storm of 2.5 inches in 24 hours (2018/19 and 2021/22 events). The overflow events that occurred in 2022/23 are consistent with this observed trend.

- Outfall 011 media filter [15] overflowed during the following time frames:
  - 1/22/17 – 1/25-17
  - 2/17/17 until at least 2/25/17 [16]
  - 2/2/19 – 2/7/19 (exceeded 24-hr 1-yr design storm depth)
  - 2/14/19 – 2/19/19 (below 24-hr 1-yr design storm depth)
  - 3/6/19 – 3/11/19 (below 24-hr 1-yr design storm depth)
  - 12/30/21 – 1/1/22 [17] media filter and perimeter pond overflowed (exceeded 24-hr, 1-yr storm)
  - 1/8-10/23 (exceeded 24-hr 1-yr design storm depth)
  - 2/23-3/1/23 (exceeded 24-hr 1-yr design storm depth)
  - 3/10-15/23 (exceeded 24-hr 1-yr design storm depth)
- Outfall 018 R-2A Pond [18] (bold font) and/or Silvernale Pond [19] overflowed (i.e., some flows bypassed the SWTS and the media filter was used to treat bypassed flows) during the following time frames:
  - **1/21/17 – 1/24/17** both R-2A Pond and Silvernale Pond overflowed
  - **2/7/17 – 2/9/17** both R-2A Pond and Silvernale Pond overflowed
  - 2/17/17 – 2/23/17 Silvernale overflowed
  - **2/17/17 – 2/25/17** R-2A Pond overflowed
  - **1/17/19** (below 24-hr 1-yr design storm depth) both R-2A Pond and Silvernale Pond overflowed, OF018 media filter was bypassed since it was burned in and removed after Woolsey Fire

[15] Maximum storage volume of the media filter is approximately 15,000 gallons.
[16] Actual end flow date unknown due to field error with the flow meter and partial data were recorded on paper hard copies. The last date of flow recorded was 2/25/17.
[17] A berm on the R-1 Pond experienced piping and erosion causing the pond to discharge on 1/1/2022 before exceeding its typical maximum storage volume of 3,740,000 gallons.
[18] R-2A Pond has a maximum storage volume is 2,100,000 gallons.
[19] Silvernale Pond has a maximum storage volume is 5,700,000 gallons.

- **2/2/19 – 2/5/19** (exceeded 24-hr 1-yr design storm) both R-2A Pond and Silvernale Pond overflowed, OF018 media filter was bypassed since it was burned in and removed after Woolsey Fire
- 2/11/19 – 2/18/19 (below 24-hr 1-yr design storm depth) Silvernale overflowed
- **12/30/21 – 1/4/22** (exceeded 24-hr, 1-yr storm) R2-A overflowed and 12/30/21 – 1/3/22 Silvernale overflowed
- **12/27-1/5/23** (exceeded 24-hr 1-yr design storm depth) R2-A overflowed
- **1/8-10/23** (exceeded 24-hr 1-yr design storm depth) R2-A overflowed
- **1/14-16/23** (below 24-hr 1-yr design storm depth) R2-A overflowed
- **2/23-3/1/23** (exceeded 24-hr 1-yr design storm depth) R2-A overflowed
- **3/10-15/23** (exceeded 24-hr 1-yr design storm depth) R2-A overflowed

Table 5. NPDES Outfalls –2022/23 Stormwater Discharges and Exceedances

Outfall	Dates of Discharge-Producing Storm Events or SWTS Discharge	Number of Samples Collected (Year Total)	Reported Exceedances					
			Sample Date[e]	Parameter	Unit	Result	Permit Limit or Bench-mark	Threshold Type
001	12/27/2022-1/5/2023 1/8-10/2023 1/14-16/2023 1/19/2023 2/23-3/1/2023 3/3-6/2023[c] 3/5-6/2023 3/10-3/15/2023 3/19-22/2023 3/29-30/2023 4/3-5/2023[a]	11	1/6/2023 1/15/2023 2/26/2023 3/11/2023	Iron Iron Iron Iron	mg/L mg/L mg/L mg/L	0.83 3.6 3.7 1.9	0.3 0.3 0.3 0.3	Benchmark
002	12/27/2022-1/5/2023 1/8-10/2023 1/14-16/2023 1/19/2023 1/29-30/2023 2/23-3/1/2023 3/3-6/2023[c] 3/5-6/2023 3/10-15/2023 3/19-22/2023 3/29-30/2023 5/1-4/2023	14	1/2/2022 1/6/2022 1/15/2023 5/5/2023	Iron Iron Iron Sulfate	mg/L mg/L mg/L ug/L	0.86 0.93 1.3 380	0.3 0.3 0.3 300	Benchmark
008	12/27/2022-1/5/2023 1/8-10/2023 1/14-16/2023 1/19/2023 2/23-3/1/2023 3/3-6/2023[c]	10	No exceedances in 2022/23					

Outfall	Dates of Discharge-Producing Storm Events or SWTS Discharge	Number of Samples Collected (Year Total)	Reported Exceedances					
			Sample Date[e]	Parameter	Unit	Result	Permit Limit or Bench-mark	Threshold Type
	3/5-3/6/2023 3/10-3/15/2023 3/19-3/22/2023 3/29-30/2023							
009	12/27/2022-1/5/2023 1/8-10/2023 1/14-16/2023 1/19/2023 1/29-30/2023 2/23-3/1/2023 3/3-6/2023[c] 3/5-6/2023 3/10-15/2023 3/19-22/2023 3/29-30/2023	11	No exceedances in 2022/23					
010	1/8-10/2023	1	1/11/2023	TCDD TEQ no DNQ	ug/L	4.60E-08	2.80E-08	Permit Limit
011	1/8-10/2023[b] 1/14-16/2023[a] 1/19/2023[a] 2/23-3/1/2023[b] 3/10-15/2023[b] 3/19-22/2023[a] 4/3-5/2023[a]	6	1/10/2023 1/17/2023 2/25/2023 2/25/2023 2/25/2023 3/16/2023	Manganese Iron Iron Manganese TCDD TEQ (no DNQ) Iron	ug/L mg/L mg/L ug/L ug/L mg/L	61 0.78 4.0 79 5.8E-08 3.2	50 0.3 0.3 50 2.8E-08 0.3	Permit Limit
018	12/27/2022-1/5/2023 1/8-10/2023[b] 1/14-16/2023[a] 1/19/2023[a] 2/23-3/1/2023[b] 3/3-6/2023[c] 3/5-6/2023[a] 3/10-15/2023[b] 3/19-22/2023[a] 3/29-30/2023[a] 6/5-8/2023[a]	11	No exceedances in 2022/23					

[a] SWTS-treated discharge
[b] SWTS-treated discharge comingled with untreated runoff
[c] Additional sample collected after 7 days of consecutive discharge
[d] The number of reported exceedances (year total) is based on the sum of the exceedances reported in the quarterly reports

An investigation into the suspected causes of each exceedance is discussed in the following sections with more detail in Appendix C. Potential sources evaluated included onsite surface soils in or near areas of former operations (RFI Areas), pavement solids, treated wood and nearby soils, and offsite background soils were used as an indicator of background soils likely onsite and in comparison to potentially impacted soils onsite (DTSC Characterization Study). Particulate strength (PS) calculations were used to determine if solids concentrations in potential sources are high enough to cause effluent limit or benchmark exceedances in stormwater. PS is the constituent concentration associated with particulate matter in stormwater and is a means to normalize stormwater constituent concentrations by TSS. Of the discharging outfalls, no exceedances were measured at Outfalls 008, 009, or 018. A summary of the exceeding constituents at each outfall are shown in Table 6 below. The Surface Water Expert Panel developed recommendations based on their review of these results with this year's recommendations discussed in Section 5 of this report.

Table 6. Summary of Exceeding Constituents by Outfall

Parameter	Outfall 001	Outfall 002	Outfall 010	Outfall 011	Total*
Iron	4	3	0	3	**10**
Manganese	0	0	0	2	**2**
TCDD TEQ (no DNQ)	0	0	1	1	**2**
Sulfate	0	1	0	0	**1**
Total	**4**	**4**	**1**	**6**	**15**

NR = this parameter does not have a Permit Limit or Benchmark at this outfall
* Note this total reflects exceedances of concentration-based limits at Outfalls 001-018. Mass-based limits at outfalls and offsite Arroyo Simi results were not considered here.

Outfall 001

During the 2022/23 rainy season, there were eleven events (nine qualifying rain events, one 7-day follow up sample, and one Outfall 011 SWTS discharge) that produced discharge at Outfall 001, with a total of four Benchmark exceedances measured. All measured exceedances were for iron and occurred in different samples including within a sample collected during the 12/27/2022-1/5/2023 rain event with a 2-5-year 24-hour recurrence interval, a sample collected during the 1/14-16/2023 rain event with a less than 1-year 24-hour recurrence interval, a sample collected during the 2/23-3/1/2023 rain event with a 25-year 24-hour recurrence interval, and a sample collected during the 3/10-15/2023 rain event with a 2-year 24-hour recurrence interval. Outfall 001 is located in the Southern Buffer Zone and the majority of the watershed was never subject to industrial uses, however, when stormwater discharges at Outfall 011, Outfall 001 can also receive that runoff. Three of the four 2022/23 exceeding samples were collected during a rain event in which Outfall 011 was also discharging, however the first discharging sample of the year (0.83 mg/L on 1/6/2023) was collected without a discharge at Outfall 011, making it representative of conditions only in the Outfall 001 watershed.

A brief discussion of reported exceedances is as follows; for more information, a thorough analysis of the likely causes of exceedances is available in Appendix C:

- **Iron at Outfall 001:** Iron was detected above its daily maximum Benchmark of 0.3 mg/L four times at Outfall 001 at 0.83 mg/L, 3.6 mg/L, 3.7 mg/L, and 1.9 mg/L. The source is believed to be background soils, based on three independent lines of evidence: (1) the uniform spatial pattern indicates that all outfalls likely shared the same diffuse, site-wide source of iron in stormwater; (2) the outfall stormwater particulate strengths were in line with background stormwater samples and best explained by background soils out of all the solid source materials tested (although some iron stormwater particulate strengths – which represent suspended solids that are finer sized than undisturbed soils – are higher than the bulk soil samples, likely due to different soil iron concentrations by particle size); and (3) metal ratios (iron to manganese) support natural background soils as the likely source of iron in the exceeding sample.

Outfall 002

During the 2022/23 rainy season, twelve events (eleven qualifying rain events and one 7-day follow up sample) produced sampleable discharge at Outfall 002, with four Benchmark exceedances. The exceedances occurred in two samples collected during the 12/27/2022-1/5/2023 rain event with a 5-year 12-hour recurrence interval, a sample collected during the 1/14-16/2023 rain event with a less than 1-year 24-hour recurrence interval, and a sample collected during the 5/1-4/2023 rain event with a less than 1-year 24-hour recurrence interval. Outfall 002 is in the Southern Buffer Zone and the majority of the watershed was never subject to industrial uses, however, it also receives runoff from the Outfall 018 watershed when stormwater discharges at Outfall 018. Most discharges at Outfall 018 are fully treated SWTS discharges with the exception of overflow events noted in Section 2.2.1. Three of the exceeding samples at Outfall 002 were collected during periods of pond overflow and SWTS discharge at Outfall 018, representing a mix of treated stormwater from Outfall 018 and and one was collected when Outfall 018 wasn't flowing and is representative of conditions in the Outfall 002 watershed.

A brief discussion of the reported exceedance is as follows; for more information, a thorough analysis of the causes of exceedances is available in Appendix C:

- **Iron at Outfall 002:** Iron was detected above its daily maximum Benchmark of 0.3 mg/L three times at Outfall 002 at 0.86 mg/L, 0.93 mg/L, and 1.3 mg/L. The source is believed to be background soils, based on three independent lines of evidence: (1) the uniform spatial pattern indicates that all outfalls likely shared the same diffuse, site-wide source of iron in stormwater; (2) the outfall stormwater particulate strengths were in line with background stormwater samples and background soils; and (3) metal ratios (iron to manganese) support natural background soils as the likely source of iron in the exceeding sample.
- **Sulfate at Outfall 002:** Sulfate was detected above its daily maximum Benchmark of 300 µg/L at 380 µg/L. The source is believe to be natural seeps influenced by the local geology, based on three independent lines of evidence: (1) The Santa Susana Formation, which is found in just the southwest corner of SSFL, contains shale and shaly sandstone, and shale is known to contain sulfur; 2) high sulfate concentrations have been reported by the Groundwater Expert Panel in seeps above and below Outfall 002 and sulfate concentrations in stormwater samples at the site are typically highest during baseflow periods and late in the wet season when the water table is highest; and 3) sulfate concentrations in offsite background stormwater samples were detected at similar levels also above the permit limit. This supports that the sulfate exceedance at Outfall 002 is from natural sources.

Outfall 010

During the 2022/23 rainy season, one event (a qualifying rain event) produced sampleable discharge at Outfall 010, with one Permit limit exceedance. The exceedances occurred in a sample collected during the 1/8-10/2023 rain event with a 10-year 12- and 24-hour recurrence interval.

A brief discussion of reported exceedances is as follows; for more information, a thorough analysis of the causes of exceedances is available in Appendix C:

- **TCDD TEQ (no DNQ) at Outfall 010:** TCDD TEQ (no DNQ) was calculated to be above the daily maximum limit of 2.8E-08 µg/L once at Outfall 010 at 4.6E-08 µg/L. The source is believed to be pavement solids, soils near treated wood, and possibly other soils (including impacted soils affected by past industrial actities at the site), based on three independent lines of evidence: (1) The spatial patterns indicate a local source contributing to elevated TCDD TEQ (no DNQ) concentrations varied by watershed; (2) A comparison of particulate strengths in stormwater samples and solids concentration in potential source material samples suggests the TCDD TEQ (no DNQ) exceedances in stormwater likely had contributions from pavement solids fines and/or soils near treated wood (pentachlorophenol-treated utility poles); and (3) metal ratios indicate there were contributions from a TCDD TEQ (no DNQ) concentrated source above background. There were few soil samples within the 010 watershed available for evaluation, but their concentrations of TCDD TEQ (no DNQ) were similar to background soils. On the other hand, both pavement solids fines and soils near treated wood have been found to be potent sources of TCDD TEQ (100x exceeding stormwater concentrations) through potential source testing data collected by the Surface Water Expert Panel and Geosyntec. Recommendations to address this exceedance include adding additional soil stabilization and erosion control in Outfall 010 watershed.

Outfall 011

During the 2022/23 rainy season, there were seven events (six qualifying rain events and one 011 SWTS discharge) that produced sampleable discharge at Outfall 011 and a total of six exceedances were measured across four events. Exceedances occurred in the sample collected during the 1/8-10/2023 rain event with a 10-year 24-hour recurrence interval, the sample collected during the 1/14-16/2023 rain event with a less than 1-year recurrence interval, the samples collected during the 2/23-3/1/2023 rain event with a 25-year 24-hour recurrence interval, and the sample collected during the 3/10-15/2023 rain event with a 2-year 24-hour recurrence interval. Three of the four events with exceeding samples were during overflow at Perimeter Pond and are a mix of untreated and treated stormwater.

A brief discussion of reported exceedances is as follows; for more information, a thorough analysis of the causes of exceedances is available in Appendix C:

- **Iron at Outfall 011:** Iron was detected above its daily maximum limit of 0.3 mg/L three times at Outfall 011 at 0.78 mg/L, 4 mg/L, and 3.2 mg/L. The source is believed to be background soils, based on three independent lines of evidence: (1) the uniform spatial pattern indicates that all outfalls likely shared the same diffuse, site-wide source of iron in stormwater; (2) the outfall stormwater particulate strengths were in line with background stormwater samples and best explained by background soils out of all the solid source materials tested (although the iron content of the stormwater particulate strengths – which represent suspended solids that are finer sized than undisturbed soils - are higher than the bulk soil samples, likely due to different soil iron concentrations by particle size); and (3) metal ratios (iron to manganese) support natural background soils as the likely source of iron in the exceeding samples.

- **Manganese at Outfall 011:** Manganese was detected above its daily maximum limit of 50 µg/L twice at Outfall 011 at 61 µg/L, and 79 µg/L. The source is believed to be background soils, based on three independent lines of evidence: (1) the uniform spatial pattern indicates that all outfalls likely shared the same diffuse, site-wide source of manganese in stormwater; (2) the outfall stormwater particulate strengths were in line with background stormwater samples and best explained by background soils out of all the solid source materials tested (although the manganese content of the stormwater particulate strengths – which represent suspended solids that are finer sized than undisturbed soils - are higher than the bulk soil samples, likely due to different soil manganese concentrations by particle size); and (3) metal ratios (manganese to iron) support natural background soils as the likely source of manganese in the exceeding samples. The first exceeding sample (61 µg/L) had an elevated particulate strength for which the source investigation was inconclusive, but likely due to background soils in addition to an unknown source other than impacted soils. The influent and effluent concentrations and permanganate dosing will be more closely monitored during the startup of SWTS operations to reduce the possibility of impacts from the treatment system.

- **TCDD TEQ (no DNQ) at Outfall 011:** TCDD TEQ (no DNQ) was calculated to be above the daily maximum limit of 2.8E-08 µg/L once at Outfall 011 at 5.8E-08 µg/L. The source is believed to be impacted soils, pavement solids, soils near treated wood, and background soils based on three independent lines of evidence: (1) The spatial patterns indicate a local source contributing to elevated TCDD TEQ (no DNQ) concentrations varied by watershed; (2) A comparison of particulate strengths in stormwater samples and solids concentration in potential source material samples suggests the TCDD TEQ (no DNQ) exceedances in stormwater likely had contributions from impacted soils in the 011 watershed, pavement solids fines, and/or soils near treated wood (pentachlorophenol-treated utility poles); and (3) metal ratios indicate TCDD TEQ (no DNQ) ratio to iron were within the 95% confidence interval for background spoils. Recommendations to address this exceedance include the immediate cleanup of the Area 1 Burn Pit and hardening the Perimeter Pond berm to reduce erosion and sediment mobilization.

2.2.2 Treatment BMP Performance Monitoring

Although performance monitoring of BMPs is not a direct NPDES Permit requirement, the Surface Water Expert Panel recommended individual BMPs be monitored to assess their ability to remove stormwater COCs before they reach the NPDES outfalls. At the recommendation of the Panel, the frequency of BMP performance monitoring was temporarily reduced to 2 samples per year after 2016/17 and until additional remediation related activities at the Site were resumed. Such activities had not yet resumed as of the 2022/23 rainy season. After the start of cleanup in the shooting range area sampling frequency in the northern drainage in 009 will be increased. Performance monitoring of the passive treatment BMPs in the Outfall 009 Watershed was conducted throughout the 2022/23 reporting year as outlined in the *2022/232 Rainy Season Sampling and Analysis Plan (SAP) Updates, Best Management Practice (BMP) Monitoring Program* ("2022/23 SAP") (Appendix A to this report) (HAI, 2022). The SAP is updated annually, with the 2023/24 sampling update forthcoming as discussed in Section 5.2.1. In addition to the passive treatment BMP sampling this year, untreated influent samples were collected at the two active SWTSs in Outfall 011 and 018. The results of these influent samples and corresponding treated discharge at the Outfalls are discussed in Section 4.

Where possible, structural BMPs at the Site are designed to treat the Expert Panel's recommended site-specific design storm, or the 24-hour duration, 1-year recurrence interval storm event of 2.53 inches, where sufficient space is available. Rip rap grade control structures were placed strategically within the

24-hour, 1-year design storm depth of 2.53 inches was exceeded at various times during the 2022-23 rain events. Overflow of the CM weir boards was recorded via BMP observations at CM-3 during January 5, 14, and 16, 2023 and at CM-1 on January 5, 2023.

Outfall 009 watershed passive treatment BMP monitoring results are summarized in Table 7 along with copper, lead, mercury, and dioxins results observed above Outfall 009 Permit Limits, noting that BMP monitoring results in excess of Permit Limits are provided solely as a reference for relative water quality since Permit Limits and Benchmarks are only applicable to discharges at NPDES outfalls. Of the 56 BMP performance samples collected in Outfall 009 Watershed subareas (background samples excluded), 29 were influent samples, 9 were intermediate samples, and 18 were effluent samples. Of the BMP subarea influent samples, concentrations of copper, lead, mercury, and dioxins were above Outfall 009 Permit Limits in 0% (0 of 29), 10% (3 of 29), 0% (0 of 29), and 24% (7 of 29) of the results, respectively. Of the treated BMP effluent samples, copper, lead, mercury, and dioxins were above Outfall 009 Permit Limits in 0% (0 of 18), 6% (1 of 18), 0% (0 of 18), and 11% (2 of 18) of the results, respectively, all showing decreases in numbers of values greater than the 2015 NELs after treatment for those constituent having greater concentrations than the NELs in the influent samples.

An annual BMP Performance Analysis is conducted to evaluate performance of existing treatment control BMPs in the Outfall 009 Watershed using statistical, temporal, and other data analysis approaches. Performance monitoring data collected in 2022/23 has been incorporated into the collective BMP Performance Analysis dataset initiated in December 2009.

As in previous years, the Surface Water Expert Panel has overseen and reviewed the 2022/23 BMP performance analysis, evaluating results in consideration of any new BMP or monitoring recommendations that may be beneficial. Initial results were presented to the Expert Panel in a August 1-2, 2023 workgroup meeting. The Expert Panel then reviewed the draft BMP Performance Analysis report in October 2023. Panel recommendations regarding stormwater BMPs and BMP performance monitoring were developed during the reviews and incorporated into the recommendations presented in Sections 5.1 and 5.2 of this Annual Report. The final BMP performance report, *2022/23 BMP Performance Analysis, Santa Susana Field Laboratory* (Santa Susana Surface Water Expert Panel and Geosyntec Consultants, 2022b), is included as Appendix D. Section 4 discusses its key findings.

Table 7. Outfall 009 BMP Performance Stormwater Monitoring Results, 2022/2023 Reporting Year

Sampling Location	BMP	Sample Type	Count of Results Above OF009 Permit Limit[1] / Sample Count			
			Copper (14 µg/L)	Lead (5.2 µg/L)	Mercury (0.13 µg/L)	TCDD TEQ no DNQ (2.8E-8 µg/L)
LPBMP0003	Biofilter	Intermediate	0/2	0/2	0/2	1/2
LPBMP0002	Biofilter	Influent	0/2	0/2	0/2	1/2
LPBMP0004	Biofilter	Effluent	0/2	0/2	0/2	0/2
A2BMP0006	CM-1	Influent	0/2	0/2	0/2	0/2
A2BMP0012	CM-1	Influent	0/2	0/2	0/2	1/2
EVBMP0003	CM-1	Influent	0/2	1/2	0/2	1/2
A2BMP0007	CM-1	Effluent	0/2	0/2	0/2	1/2
LXBMP0010	CM-3	Influent	0/2	1/2	0/2	0/2
LXBMP0011	CM-3	Influent	0/2	0/2	0/2	0/2
LXBMP0012	CM-3	Effluent	0/2	0/2	0/2	0/2
A1BMP0002	CM-9	Influent	0/2	1/2	0/2	0/2
ILBMP0002	CM-9	Influent	0/2	0/2	0/2	0/2
A1BMP0003	CM-9	Effluent	0/2	1/2	0/2	1/2
EVBMP0009	ELV	Intermediate	0/7	0/7	0/7	0/7
EVBMP0007	ELV	Influent	0/7	0/7	0/7	0/7
EVBMP0008	ELV	Effluent	0/7	0/7	0/7	0/7
BGBMP0003	LOX	Background	0/7	0/7	0/7	0/7
B1BMP0009	Upper Lot Media Filter	Influent	0/1	0/1	0/1	1/1
B1BMP0010	Upper Lot Media Filter	Influent	0/1	1/1	0/1	1/1
B1BMP0011	Upper Lot Media Filter	Effluent	0/1	0/1	0/1	0/1
ILBMP0004	Southern Detention Bioswale	Influent	0/2	0/2	0/2	0/2
ILBMP0008	Southern Detention Bioswale	Influent	0/2	0/2	0/2	2/2
ILBMP0005	Southern Detention Bioswale	Effluent	0/2	0/2	0/2	0/2
		BMP Influent	0/29	3/29	0/29	7/29
		BMP Intermediate	0/9	0/9	0/9	1/9
		BMP Effluent	0/18	1/18	0/18	2/18
		Background	0/7	0/7	0/7	0/7
		TOTAL	**0/63**	**4/63**	**0/63**	**10/63**

[1] Provided for reference – Table 7 Permit Limits apply at Outfall 009 only.

2.2.3 Subarea Monitoring

Subarea stormwater sampling is used to identify potential locations for future BMPs. Subarea sampling was originally initiated in the Outfalls 009 watershed but discontinued after 2018/19 in light of the water quality improvements observed in Outfall 009 discharges.

Subarea samples were collected in the Outfall 001 watershed, considered a “buffer zone” watershed to characterize runoff from both natural background areas and potentially impacted areas and facilitate investigations into the causes of repeated Benchmark exceedances in these areas. Eight samples were collected at the Outfall 001 subarea sampling location in 2022/23.

Subarea samples were collected in the Outfall 011 Watershed beginning in 2021/22 to characterize runoff from the Area 1 Burn Pit and inform investigations into the causes of exceedances at Outfall 011. Four samples were collected at the one subarea sampling location in 2022/23.

Subarea monitoring results are summarized in Table 8 below and in more detail in Appendix E.

Table 8. Subarea Stormwater Monitoring Results, 2022/23 Reporting Year

Watershed	Sample Location	Description	Sample Count	Results above NPDES Permit Limit or Benchmark (for reference only, not enforceable at subareas)					
				Cadmium	Copper	Lead	Mercury	TCDD TEQ No DNQ	Zinc
Outfall 001	EPSW001IE01	Potential impacts from CTL-V and A1BP	8	0	3	5	1	5	1
Outfall 011	A1BPSW0001	Potential impacts from Area 1 Burn Pit	4	0	1	1	0	1	0

2.3 Northern Drainage Assessment

Recurring site investigations have been performed annually along the Northern Drainage during the 5 years from 2011/12 to 2016/17, as described in in the *Northern Drainage Restoration, Mitigation, and Monitoring Plan* (RMMP) (Haley & Aldrich, 2011).

Although the RMMP expired in 2017, the voluntary annual stream walk and inspection of in-channel erosion risk areas and sediment control conditions in lower portions of the Outfall 009 Watershed was conducted on May 16, 2023. Six locations were identified for minor maintenance such as rearranging riprap intended for bank toe stabilization and removing accumulated sediment. No additional stabilization measures or maintenance activities were recommended this year.

2.4 Non-Industrial Sources Special Study

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), in part to address periodic lead and dioxins exceedances despite the implementation of numerous BMPs targeting former operational areas in the upper 009 watershed. Given previous findings from the BMP subarea monitoring at SSFL that runoff from paved subareas had significantly higher COC concentrations than that from unpaved subareas, regardless of whether impacted soils were known to be present in the drainage areas, the 2015 Special Study Work Plan posed the following questions as the basis for the Non-Industrial Sources Special Study:

1. Where are the predominant spatial locations within the Outfall 009 Watershed 009 contributing to dioxins and lead in stormwater?
2. What are the predominant sources of constituents in paved subareas -- e.g., either weathered or newly resurfaced pavement material itself, vehicles, treated wood utility poles, the historic shooting range area, and/or atmospheric deposition?

In 2017/18 the Expert Panel also recommended offsite sampling as well as sampling for lead isotopes in the Northern Drainage during 2018/19. The most recent lead and dioxins exceedances observed at Outfall 009 were in February 2017 and December 2018, respectively. The Non-Industrial Sources Special Study was again expanded through 2018/19 Annual Report recommendations for the inclusion of additional parameters and potential sources that could be affecting stormwater quality in the Southern Buffer Zone. Non-Industrial Sources Special Study monitoring activities and subsequent analyses were completed in 2021/22. Over the course of this study, numerous COCs have been found to exceed Permit Limits in stormwater samples collected from the onsite and offsite background and non-industrial locations to date. A summary report is in progress and will be shared in 2023/24.

3 BMP Activities

The following sections summarize the construction and demolition activities conducted at SSFL and BMP activities within each watershed (e.g., new BMPs, inspections, maintenance, etc.) in 2022/23.

3.1 Recent Activities and Maintenance

Maintenance and other activities conducted at SSFL outfalls and BMPs in 2022/23 included BMP repairs and replacements, removal of sediment and debris from outfalls following large storm events, and inspections of existing erosion and sediment controls and vegetation across the site and repairing or supplementing where needed. They are incorporated by reference through the following quarterly NPDES Discharge Monitoring Reports (DMRs).

- The Boeing Company, 2022a. *Third Quarter 2022 NPDES Discharge Monitoring Report, Compliance File CI-6027 and NPDES No. CA0001309, Santa Susana Field Laboratory, Ventura County, California.* November 15.
- The Boeing Company, 2022b. *Fourth Quarter 2022 NPDES Discharge Monitoring Report, Compliance File CI-6027 and NPDES No. CA0001309, Santa Susana Field Laboratory, Ventura County, California.* February 15.
- The Boeing Company, 2023a. *First Quarter 2023 NPDES Discharge Monitoring Report, Compliance File CI-6027 and NPDES No. CA0001309, Santa Susana Field Laboratory, Ventura County, California.* May 15.
- The Boeing Company, 2023b. *Second Quarter 2023 NPDES Discharge Monitoring Report, Compliance File CI-6027 and NPDES No. CA0001309, Santa Susana Field Laboratory, Ventura County, California.* August 15.

As recommended in the 2021/22 SSFL Site-Wide Stormwater Annual Report (Surface Water Expert Panel and Geosyntec, 2022), the following BMP maintenance, improvement, and monitoring actions were taken this past season in addition to ongoing recommendations listed in Section 4:

- Treated wood utility pole BMPs (e.g., wattles and biobags) were shifted 10-ft downgradient from poles on pervious surfaces to better contain pole-impacted soils.
- The R-1 pond berm was repaired.
- System procedures were reviewed to enable a faster startup of the SWTSs to reduce the risk of bypass early in large storm events.
- Removal of 5 unused treated wood utility poles in the Outfall 009 drainage area, and more identified for removal in 2023/24.

4 Summary of Key 2022/23 Findings

The following findings are provided to conclude the analyses referenced above. These findings are the bases of the new BMP and monitoring recommendations that are presented in Section 5.

a. The passive distributed treatment controls in the Outfall 009 Watershed continue to perform well despite many years of operation.

Performance monitoring of the distributed treatment controls in the Outfall 009 Watershed demonstrates continued water quality improvement, which supports NPDES compliance at Outfall 009. Historically, most grouped BMP-COC combinations showed a reduction in the average and maximum concentrations of effluent results as compared to the influent results. Overall, constituent loads are being reduced, both because concentrations are being reduced, and because runoff volumes are being reduced by phased upstream pavement and building removal accompanied by revegetation and stormwater runoff volume reductions in BMPs, mainly through evapotranspiration. The effluent from the administrative area inlet filters and detention bioswales comingles with untreated stormwater runoff from other areas within the upper Outfall 009 watershed and becomes influent to the lower lot biofilter for additional treatment.

Figure 6 and Figure 7 present summaries of influent and effluent monitoring results for dioxins and lead by BMP group[20]. The Outfall 009 Permit Limit is shown for reference only as it is not applicable at these internal BMP influent and effluent monitoring locations.

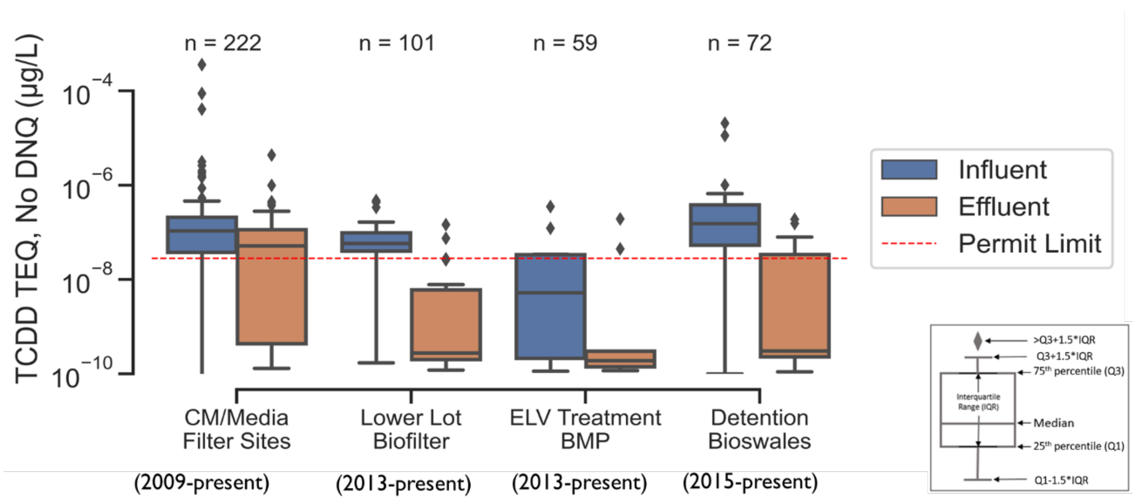

Figure 6. BMP Performance – Influent/Effluent Box Plot for Dioxins, 2009-2023

[20] Box plots identify the medians, interquartile ranges (IQRs) from the 25th-percentile to 75th-percentile values, and the 1.5x quartile values; outliers beyond the 1.5x quartile values are plotted as diamonds.

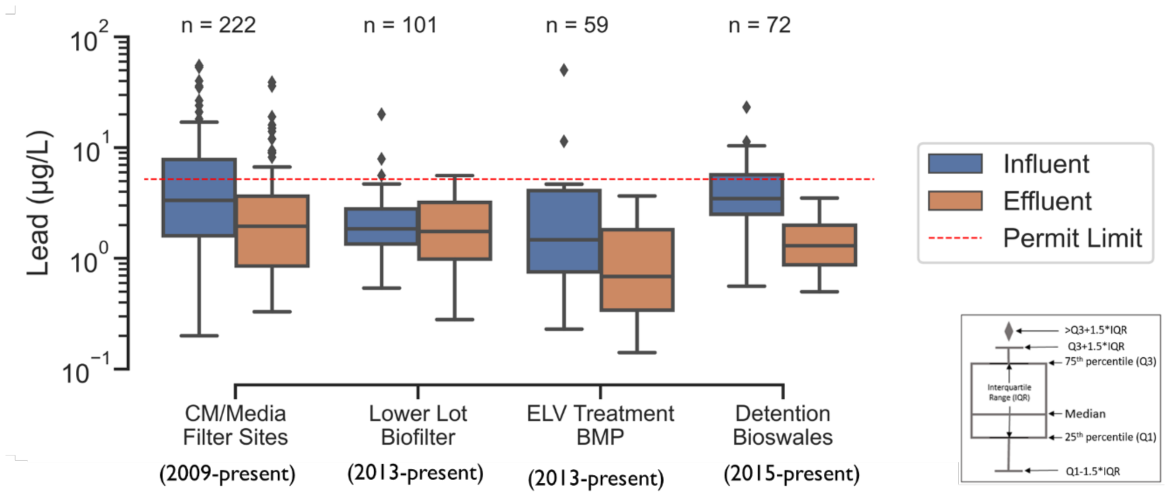

Figure 7. BMP Performance – Influent/Effluent Box Plot for Lead, 2009-2023

b. The two active stormwater treatment systems (SWTSs) are also performing well, as evidenced by compliance results at Outfalls 011 and 018 as well as reductions in concentration observed between untreated SWTS influent and treated Outfall discharge samples.

Untreated stormwater runoff entering the SWTSs was sampled once each at the Outfall 011 and 018 SWTSs and analyzed for the full monitoring suite required at the corresponding NPDES Outfall. Influent sampling at both SWTS is planned to continue in 2023/24 as required in the pending NPDES Permit. Most of the parameter concentrations in the untreated influent samples were below the Permit Limits applicable at the corresponding NPDES Outfall. A summary of SWTS influent results is as follows:

- Iron, manganese, and TCDD TEQ (no DNQ) were detected above the Permit Limit in the influent samples at one or both SWTS
- One result that was detected but not quantified had result above the applicable threshold (0.12 µg/l result vs 0.1 ug/l Permit Limit for mercury)
- Most radionuclides[21] were not detected and those detected were well below Permit Limits

Concentrations as measured in discharge at Outfall 011 and 018 generally indicated reductions from influent concentrations, with the exception of manganese at Outfall 011 (increase from 17 to 61 µg/L), however this was a sample that was mostly untreated bypass of the SWTS. This is summarized for a subset of analytes in Table 9.

[21] Radionuclides analyzed were Gross Alpha, Gross Beta, Combined Radium-226 & Radium-228, Strontium-90, Tritium, Cesium-137, Uranium, and Potassium-40

Table 9. SWTS Influent and Outfall Discharge Comparison (results greater than the permit limit are shown in bold)

Analyte	Units	Daily Maximum Permit Limit	Outfall 018 SWTS Influent Sample 1/3/2023	Outfall 018 Discharge Sample (includes SWTS effluent and untreated bypass) 1/6/2023	Outfall 011 SWTS Influent Sample 1/7/2023	Outfall 011 Discharge Sample (includes SWTS effluent and untreated bypass) 1/10/23
Oil & Grease	mg/L	15	< 0.5	1.3[a]	< 0.5	0.59 J[b]
Mercury	µg/L	0.1	0.014	< 0.12	**0.12 J**	< 0.12
Lead	µg/L	5.2	1.2	< 1	1.6	0.4 J
Iron	mg/L	0.3	**1.3**	0.02	**0.6**	0.2
Manganese	µg/L	50	**71**	17	17	**61**
Perchlorate	µg/L	6.0	< 0.91	< 0.91	< 0.91	< 0.91
Trichloroethene (TCE)	µg/L	5	< 0.17	< 0.17[a]	< 0.17	< 0.17[b]
Gross Alpha	pCi/L	15	< 0.42	< 1.45 J	1.36	< 0.43
Gross Beta	pCi/L	50	3.7	2.1	3.4	1.8
TCDD TEQ (no DNQ)	µg/L	2.8E-08	**4.1E-08**	< 1E-12	1.2E-07	< 1E-12

Note: J indicates the analyte concentration was detected but not quantified due to being between the method detection limit and reporting limit levels. < indicates the analyte was not detected above the method detection limit.

[a] Sample date 1/4/2023

[b] Sample date 1/8/2023

c. Stormwater infiltration in the ponds is minimal.

In response to recent public concerns regarding risks of stormwater infiltration within SSFL's ponds, and any associated transport of stormwater COCs to groundwater, the Surface Water Expert Panel requested water level monitoring and calculation of infiltration rates within the ponds.

Results at SSFL's largest pond, Silvernale Pond located above Outfall 018, showed water levels remained generally constant for extended periods after filling, thereby confirming that this pond is sealed and infiltration is negligible. At the two ponds above Outfall 011, R-1 and Perimeter Ponds, the average calculated infiltration rates were 0.03 inches per hour, which is below the 0.06 inches per hour criteria for the least conductive hydrologic soil group (HSG D), or clay soils. Therefore infiltration was very small at these ponds as well.

The SSFL Groundwater Expert Panel (GWEP) has also extensively evaluated groundwater recharge[22] sitewide. Published GWEP analyses[23] estimate that only 3.8 percent of long-term average rainfall becomes groundwater recharge at SSFL; this is a sum of all sitewide infiltration routes – i.e., on upland soils, in drainage channels, and in ponds.

Taken together, these modeling analyses and field measurements confirm that stormwater infiltration in the ponds is very low at SSFL. Furthermore, the constituents in stormwater that occasionally exceed the NPDES permit's water quality standard-based limits and benchmarks (e.g., iron, manganese, lead, and dioxins) are predominately in particulate form, which minimizes their downward migration as they are filtered and sorbed by sediments and decomposing organic materials in the ponds, and soils in the underlying vadose zone. ***Additionally, no analytes were detected above CA Primary drinking water MCLs in the untreated influent samples collected from Silvernale and R-1 ponds in 2022/23.***

The full pond infiltration study is included in Appendix E.

d. Boeing and NASA continue to implement Surface Water Expert Panel BMP and monitoring recommendations.

As described in Sections 1.3 and 3.2, recommendations from the Surface Expert Panel continue to be implemented at the site in order to continue to improve stormwater quality. A summary of recommendations from the 2021/22 Annual Report and their status to-date are provided in 10 and Table 11.

Table 10. Summary of 2021/22 Surface Water Expert Panel BMP Recommendations

Watershed	Recommendation	Status
Outfall 009	Continue closely observing post-storm ponding at CM-9 for indications of clogging. (note, this should be covered by post-storm inspections)	Completed/ongoing
Outfall 009	Continue annual assessment of geomorphic conditions, check structure and bank toe stabilization maintenance needs, and bank erosion along the Northern Drainage.	Completed/ongoing
Sitewide	Continuing SWEP review of all demolition and cleanup SWPPPs site-wide, including 2023 Boeing ISE projects (Shooting Range and A1BP), incorporating the SWEP's recommended BMPs, and inspecting BMP completion by a construction stormwater BMP expert prior to beginning cleanups – Geo/SWEP comments shared with Stantec and Jacobs in Dec, awaiting revised SWPPP BMP maps	Completed/ongoing
Sitewide	Continuing to monitor the condition of existing erosion and sediment controls and vegetation across the site and repairing or supplementing where needed;	Completed/ongoing

[22] Note that not all water infiltrated in shallow soils and sediments becomes groundwater recharge. Some is lost to soil moisture storage and evapotranspiration loss from soil root zones. Therefore, estimated quantities of infiltration and recharge will not exactly match, and infiltration amounts will typically exceed groundwater recharge amounts.

[23] Manna et al, 2016. *Groundwater recharge assessment in an upland sandstone aquifer of southern California.* Journal of Hydrology, Elsevier. July 2016.

Sitewide	Moving treated wood utility pole BMPs (wattles, biobags) 10 ft from poles on pervious surfaces, prioritizing the downgradient direction, to better contain pole-impacted soils;	Completed
Outfall 011 and 018	Evaluating options to enable a faster startup of SWTSs to reduce risk of bypass at start of big storms	Completed
Watersheds 011 and 018	Conducting a pond infiltration study to measure infiltration rates in Silvernale and R-1 ponds to address questions raised in public comments on the Permit renewal.	Completed/ongong subject to the new 2023 NPDES permit
Watersheds 011 and 018	Modeling design storm scenarios on Watersheds 011 and 018 to evaluate and recommend possible enhanced combined pond storage and treatment flowrate capacity.	In progress[24]
Outfall 011	Capture and treat (eg, CM or sed basin) any stormwater runoff from the A1BP ISE area that doesn't already flow to Perimeter Pond and the OF011 SWTS	In progress
Outfall 011	Repair R-1 pond berm	Completed
Sitewide	Removed additional utility poles	Completed, ongoing

Table 11. Summary of 2021/22 Surface Water Expert Panel Monitoring Recommendations

Program	Recommendation	Status
Stormwater Monitoring	Continue to sample all Outfall 009 BMP performance sites during two events per year.	Completed/ongoing
Stormwater Monitoring	Increase ELV sampling frequency to every storm until the performance of the rebuilt system can be characterized.	Completed/ongoing
Northern Drainage	Restart monitoring at the Northern Drainage sampling location immediately downstream of the shooting range during two events per year and increase to every storm event once the former shooting range area cleanup begins (EPNDSW04).	Completed
Stormwater Monitoring	Discontinue BMP performance monitoring at administrative area inlet filters.	Completed
Stormwater Monitoring	Continue to complete full BMP performance inspection checklists for all BMPs which includes visiting each BMP during every storm event to observe whether there is stormwater discharging and again 72 hours after the end of the rain event to observe if any ponded water remains.	Completed, will optimize
Stormwater Monitoring	Continue to also analyze for the filtered form of each metal when total metals are already being analyzed in Outfall samples as required by the Permit.	Completed/ongoing
Stormwater Monitoring	Continue background and non-industrial subarea monitoring at Sage Ranch (BGBMP0003) and offsite locations during all runoff-producing storm events to evaluate natural background and non-industrial contributions of constituents found in local stormwater.	Completed/ongoing

[24] Pond overflow events this year were during storms exceeding the site design storm, or in one instance a storm that immediately followed a storm exceeding the design storm so the pond began the event near or partially full. Therefore the empirical data already clearly show that the pond storage and SWTS treatment flowrate combinations are effectively larger than the EP's design storm.

Stormwater Monitoring	Continue subarea monitoring to evaluate stormwater constituent contributions from Area 1 Burn Pit in Outfall 001 and Outfall 011 watershed during all runoff-producing storm events (EPSW001IE01 and A1BPSW0001).	Completed/ongoing
Stormwater Monitoring	Discontinue subarea monitoring in Outfall 001 and 002 watersheds (except for EPSW001IE01).	Completed
Stormwater Monitoring	Independently reevaluate laboratory's QAQC plan	In progress
Stormwater Monitoring	Use 3rd party blind standards	In progress
Stormwater Monitoring	Run replicates for all analytes on at least one decaport-split sample to assess analytical variability in stormwater.	In progress

e. **Exceedances measured in 2022/23 do not change prior stormwater Human Health Risk Assessment (HHRA) conclusions that there are not elevated human health risks from exposure to SSFL stormwater discharge.**

The 2022/23 outfall monitoring results were used to assess the cumulative cancer risk and noncancer hazard index associated with potential exposure of recreators to Site constituents of potential concern via surface water discharges[25]. The exposure pathways, number of flow days (based on the average year), and other assumptions used to develop the risk-based concentrations in the 2017 HHRA were retained for this analysis. The same list of constituents of potential concern was also evaluated. As shown in Table 12, at all assessed outfalls, the cumulative cancer risk estimates for recreators are less than the *de minimus* cancer risk level of $1x10^{-6}$ and the cumulative hazard index estimates are less than the target noncancer hazard of 1. Lead concentrations are also below the health-protective concentration of 31.8 ug/L, based on the Cal-EPA Public Health Goal approach adjusted for a recreator. Thus, the HHRA conclusions still hold true, that exposure to SSFL stormwater today does not represent an elevated risk to human health through the exposure pathways that were evaluated, which do *not* include drinking stormwater.

An additional evaluation was performed to assess human health risks through a drinking water pathway. While SSFL stormwater is not directly used for drinking water, some of its surface receiving waters may be designated for municipal supply use (or *potential* municipal supply use) or for recharge to groundwater that may be designated for municipal supply use (which would receive soil aquifer treatment, the process of natural contaminant attenuation that occurs as water passes through the vadose zone). Therefore, many of the SSFL Permit Limits and Benchmarks are based on drinking water-based objectives – i.e., primary Maximum Contaminant Levels (MCLs). In 2022/23 there were two outfall sample results that did not exceed a Permit Limit but did exceed a primary MCL – one aluminum result of 1,200 ug/L on 1/6/2023 at Outfall 008 (greater than the MCL of 1,000 ug/L) and one total asbestos structures (>5 microns) result of 10 MFL on 1/11/2023 at Outfall 010 (greater than the MCL of 7 MFL). **All other sample results, for dozens of constituents at numerous outfalls during one of the wettest years on record, met drinking water standards in SSFL's stormwater.**

[25] Outfall 010 was not assessed in the 2017 HHRA due to a lack of flow data

The community downstream of Outfall 010 is served by Ventura County Waterworks District No. 8, which has the following water supply sources: 1) Imported water from the Calleguas Municipal District (99.2% of supply), 2) treated groundwater from the alluvial Gillibrand Groundwater Subbasin (0.5% of supply, historically used to supplement demands in the summer months), and 3) recycled water (0.3% of supply, historically used for dust control and landscape irrigation at the Simi Valley Landfill) (Kennedy Jenks, 2020). The Simi Groundwater Basin is approximately 2 miles downstream of Outfall 010, with the closest water supply wells over 6 miles to the north. The community downstream of Outfall 008 is served by Los Angeles Department of Water and Power (LADWP), which has the following water supply sources: 1) Imported water (89% of supply, from combination of MWD and Los Angeles Aqueduct), 2) treated groundwater (9% of supply, the majority of which is from the San Fernando Basin), and 3) recycled water (2% of supply) (LADWP, 2020). The San Fernando Basin is approximately 2 miles downstream of Outfall 008, with the closest wellfield, the Tujunga Wellfield, over 14 miles to the east. Both MCL-exceeding parameters are particulate (in the case of asbestos) or particle-associated (in the case of aluminum). Particulates have limited mobility and would be subject to filtration removal through the soil vadose zone during infiltration in downstream creek beds, and therefore have low potential to reach groundwater at similar concentrations.

Table 12. Cumulative Incremental Cancer Risk and Hazard Estimates by Outfall, 2022/23

	Units	Outfall					
		001	002	008	009	011	018
Lower Bound	Cancer Risk	2E-08	9E-08	8E-09	4E-08	1E-08	3E-08
Upper Bound	Cancer Risk	3E-08	2E-07	2E-08	8E-08	2E-08	6E-08
Lower Bound	Hazard	0.003	0.02	0.001	0.002	0.002	0.002
Upper Bound	Hazard	0.007	0.03	0.002	0.004	0.004	0.005

All values are below the *de minimus* cancer risk level of one in a million (1E-06) and noncancer hazard index of 1. Note that for exponential numbers, a larger negative exponent indicates a smaller amount, so 1E-08 is one hundred times smaller than 1E-06.

f. There is no further action required for iron exceedances derived from natural background soils.

Natural background soils were found to be the source of all iron exceedances in 2022/23, based on three independent lines of evidence: the uniform spatial pattern, the outfall stormwater particulate strengths, and the metal ratios all support natural background soils as the likely source of iron in the exceeding samples. The stormwater limit was based on iron secondary MCLs to protect for aesthetic qualities (color, taste, and odor) and are not health-based limits. Iron limits and benchmarks were removed in the NPDES Permit adopted in October 2023, since the studies presented by the Surface Water Expert Panel indicate that elevated levels of iron are likely due to high naturally occurring concentrations of these constituents found in the soil, not due to previous industrial activity. Also, iron is noted as a "naturally occurring, low-toxicity chemical" in the DTSC SRAM for SSFL.[26]

[26] Table 12-2 of Appendix F of the Final Standardized Risk Assessment Methodology, Revision 2 Addendum (SRAM Rev 2 Addendum [2022]), Santa Susana Field Laboratory (SSFL), Ventura County, California.

5 Recommendations

5.1 BMP Recommendations

The following sections outline the site-wide and watershed-specific BMP recommendations, which are designed to address recent exceedances of permit limits and benchmarks or to continue ongoing special studies. Watershed-specific recommendations are not proposed for Outfall 002 because they are covered in site-wide measures (e.g., erosion control).

5.1.1 Site-Wide Recommendations

The Expert Panel recommends continuing to evaluate the need for repairs or implementation of new controls for damaged erosion control through the site, as needed.

5.1.2 Outfall 001 and 011 Watersheds

There were four Benchmark exceedances at Outfall 001 and four Permit Limit exceedances at Outfall 011 in the 2022/23 reporting year. The Expert Panel recommends evaluating the feasibility of the following BMPs in this watershed:

- Erosion and sediment controls and stormwater capture/conveyance at the Area I Burn Pits; and
- Concrete-lining for the Perimeter Pond spillway at OF011, if permitted, to reduce erosion; and
- More efficient permanganate dosing at OF011 to prevent the first flush of manganese, or eliminating manganese-coated sand from filters in treatment train, if possible.

5.1.3 Outfall 009 Watershed

While there were no NPDES exceedances at Outfall 009 in the 2022/23 reporting year, existing BMPs should continue to be observed and repaired as needed based on post-storm observations. It is also recommended that impermeable fabric wrapping be rebuilt or added to all culvert modifications. Erosion and sediment controls and stormwater capture/conveyance at the shooting range should also be reviewed prior to the winter season.

It is recommended to remove sediment accumulated in the ponding area of the CMs. Additionally, it is recommended to rebuild the impermeable fabric wrapping on CM weir boards (such as CM-4 and CM-10). No media replacement needed at this time based on site inspections and monitoring.The Expert Panel recommends continuing to maintain check dams in the Northern Drainage and culvert modifications on Sage Ranch and remove accumulated sediments as needed to preserve their function.

5.1.4 Outfall 010 Watershed

There was one NPDES exeeedance at Outfall 010 for TCDD TEQ (no DNQ), likely caused by contributions from pavement solids fines and/or soils near treated wood (pentachlorophenol-treated utility poles) (see Section 2.1.1). The Expert Panel recommends adding wattles at the treated wood poles and at the base of paved slopes in the OF010 drainage area to reduce dioxin concentrations for events exceeding existing pumping system and flow-through media filter capacity since they are effective for preventing exceedances during all but extreme events.

5.2 Monitoring Recommendations

The sections below outline recommendations made by the Expert Panel with respect to stormwater monitoring of potential and existing BMP subareas, continuation of as-needed inspections along the Northern Drainage, and potential additions to the non-industrial source special study.

5.2.1 Stormwater Monitoring

Informed by the data analyses contained in this report and its appendices, the Expert Panel recommends the following changes to the *2022/232 Sampling and Analysis Plan (SAP) Updates, Best Management Practice (BMP) Monitoring Program* (Haley & Aldrich, 2021) for the 2022/23 stormwater monitoring season:

- Continue to sample 009 BMP performance locations 2x per year (change ELV BMP from every storm to 2x/yr)
    - Perform all 72-hr post-storm observations
    - Maintain record of overflow/bypass events (at a minimum when effluent samples are collected)
- Continue to sample background stormwater subareas during each storm event runoff is observed (continue all events)
    - Onsite: Sage Ranch (Discontinue BGBMP0003, restart BGBMP0004)
    - Offsite: Las Llajas Canyon, Box Canyon, Montgomery Canyon
- Continue to sample the A1BP location where the west side of the burn pit drains toward 001 (EPSW001IE01) and east side that drains toward 011 (A1BPSW0001)
- Confirm new permit limit parameters and TSS are analyzed in SWTS influent, BMP influent & effluent, and background samples.
- Sample Northern Drainage above and below Shooting Range cleanup area (TSS, metals (total and filtered), and dioxin) to assess contribution from shooting range cleanup area; this may be altered pending the requirements of the SWPPP.
- Discontinue CM3 performance sampling.
- Add CM12 performance sampling to see effect of shooting range on this BMP.
- Reduce visual observations at unsampled BMPs to 2 large rain events (more than 1 inch in 24 hours) per year, or one before end of January and one by end of April if no large events.
- Add TSS and dissolved metals to analyte list for SWTS influent samples
- Additional lab QAQC procedures:
    - Stormwater blind standards from independent 3rd party
    - 10-way split on subarea sample, to be analyzed for metals and dioxins

5.2.2 Northern Drainage

As specified in the RMMP, 2016/17 was the last year of required geomorphic monitoring. As such, near-term monitoring and maintenance continues to focus on NPDES compliance needs only. A continued annual assessment of geomorphic conditions, check structure and bank toe stabilization maintenance needs, and bank erosion along this important reach of drainage is recommended.

5.2.3 Non-Industrial Source Special Study

Initial monitoring activities associated with the Non-Industrial Source Special Study are now completed, as specified in Section 2.4. The Expert Panel may reopen the Special Study if new constituents of concern emerge out of the additional monitoring required in the new NPDES permit approved in October 2023.

6 Key Dates and Activities

6.1 Public Involvement

Numerous stakeholder groups and members of the public have expressed interest in stormwater topics at SSFL during past public engagements and Regional Board hearings. To provide progress updates as well as opportunities for feedback from the public, public forum meetings and site tours with the Surface Water Expert Panel have been held periodically from 2011 through the currently ongoing duration of the 2015 Work Plan. Project status reports and submittal documents have been posted on the Boeing project website following completion of major project milestones and in advance of public outreach meetings. Table 13 summarizes public engagement activities since the development of the 2010 BMP Plan (MWH et al., 2010). This year's public meeting was delayed due to all the activity surrounding the permit renewal hearings, so the public meeting is scheduled for November 29, 2023. The annual Surface Water Expert Panel presentation summarizes rainfall and site monitoring activities, BMP performance, results from internal subarea stormwater monitoring, and responses to public questions.

Table 13. Surface Water Expert Panel Public Involvement Activities, 2011-2023

Date	Activity
November 29, 2023 (planned)	Public meeting and SSFL tour
November 17, 2022	Public meeting and SSFL tour
August 19, 2021	Public meeting (virtual)
August 11, 2020	Public meeting (virtual)
July 17 2019	Public meeting and SSFL tour
May 9, 2019	Presentation to LARWQCB
May 25, 2018	Public meeting and SSFL tour
August 17, 2017	DIPCON LA Conference SSFL tour
March 21, 2017	Public meeting and SSFL tour
November 19, 2014	Community Action Group meeting
March 20, 2013	Public meeting and SSFL tour
October 6, 2013	Public meeting and SSFL tour
August 25, 2011	Public meeting
January 22, 2011	Public meeting and SSFL tour

6.2 NPDES Permit and Work Plan

The following milestones are planned for the remainder of the NPDES Permit term.

2023/24 and onward

Future Expert Panel activities will be determined based on requirements of the newly adopted NPDES Permit and the Regional Water Quality Control Board's and Boeing's requests for Expert Panel involvement.

6.3 Memorandum of Understanding (MOU) and Cleanup Activities

The following milestones are planned to support the MOU and cleanup activities.

2023/24 and onward

The Expert Panel will continue to work closely with Regional Board staff and Geosyntec to develop a sitewide stormwater model as described in the Work Plan[27] (Geosyntec, 2022). Following completion of modeling, a post-cleanup subarea stormwater monitoring plan will be developed to sample areas within Boeing areas of SSFL that have been cleaned up. Offsite and onsite background and non-industrial subarea monitoring will continue in order to build the dataset used to calculate background stormwater thresholds that the post-cleanup monitoring samples will be compared against.

Future Expert Panel activities will be determined by the pace of cleanup actions at the site. The Expert Panel will be involved with recommending and evaluating stormwater BMPs during cleanup and disturbed area stabilization, and with revegetation and confirmation monitoring after cleanup.

[27] The Work Plan was included as Attachment D to the MOU.

7 References

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Appendix A: 2022/23 Reporting Year Sampling and Analysis Plan

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

25 October 2023
File No. 0129095-010

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

Mr. Jeffrey Wokurka
The Boeing Company
Santa Susana Field Laboratory
5800 Woolsey Canyon Road
Canoga Park, California 91304

Subject: 2022/2023 Rainy Season Sampling and Analysis Plan (SAP) Updates,
Best Management Practice (BMP) Monitoring Program
Santa Susana Field Laboratory
Canoga Park, California

Dear Mr. Zorba and Mr. Wokurka:

This letter presents the Sampling and Analysis Plan (SAP) updates to the Best Management Practice (BMP) subarea and BMP performance monitoring programs near or within the Outfalls 001, 002, 008, 009, and 011 watersheds at the Santa Susana Field Laboratory (Santa Susana) for the 2022/2023 rainy season, and serves as an addendum to the 2015/2016 and 2016/2017 rainy season SAPs (MWH Americas, Inc. [MWH], 2015; 2016) and the 2017/2018, 2018/2019, 2019/2020, 2020/2021, and 2021/2022 SAPs (Haley & Aldrich, Inc. 2018a; 2018b; 2019; 2020; and 2021). 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 selected structural BMPs (e.g., Lower Lot BMP, B1436 detention bioswales) to assess the effectiveness of the BMPs at promoting sediment settling and improving surface water quality to comply with National Pollutant Discharge Elimination System (NPDES) benchmarks and permit limits at Outfalls 001, 002, 008, 009, and 011.

The updates to the BMP monitoring program SAP for the 2022/2023 rainy season account for field observations of monitoring locations during the 2021/2022 rainy season and an evaluation of surface water sampling data collected to date. These updates are described below. In addition, attached to this letter are 2022/2023 rainy season versions of the SAP tables, figures, and standardized BMP inspection forms. The changes described in this letter were developed with input from, and in accordance with, the recommendations from the Santa Susana Surface Water Expert Panel (Expert Panel) and Geosyntec

Consultants (Geosyntec) and were initially presented in the 2021/2022 Site-wide Stormwater Annual Report (Surface Water Expert Panel and Geosyntec Consultants, 2022).

BMP Monitoring Updates

ANALYTICAL PROGRAM

During the 2022/2023 rainy season, Boeing will implement the following updates to its analytical quality assurance/quality control (QA/QC) program:

- Submit third-party Proficiency Testing (PT) samples from a provider accredited by the American Association for Laboratory Accreditation.
- Collect and submit field duplicate samples at a rate of 1 field duplicate sample per 10 primary samples.
- From one location where a field duplicate was collected, also collect and submit sufficient volume for a laboratory split analysis.
- Request that the analytical laboratory perform replicate analyses for at least one split sample. Field staff will collect the required sample volume for a split sample, and the laboratory will split the sample using the Dekaport Cone Splitter device prior to analysis. The sample selected to perform replicate analyses should be collected from a subarea, not an outfall.
- Review sample container sets and Chain-of-Custody (COC) forms to confirm that all required analyses are performed at each sample location.

CHAIN OF CUSTODY DOCUMENTS

Haley & Aldrich, Inc. (Haley & Aldrich) recommends that COC forms be updated to include a list of individual metals and dioxin congeners to be analyzed for each sample submitted to the analytical laboratory. The list of metals varies based on sample location. Dioxin congeners to be analyzed are listed in Table 1.

OUTFALLS 001, 002, AND 011

Monitoring will be discontinued at Southern Buffer Zone locations with the exception of EPSW001IE01 during the 2022/2023 rainy season, which will be sampled during every rainfall event during the 2022/2023 rainy season. Sampling is required at this location regardless of whether Outfall 001 flows. Samples will not be collected from locations EPSW002BG01, EPSW002IE01, EPSW002IE02, EPSW001PV01, or EPSW001BG01.

Subarea monitoring location A1BPSW0001, which was added in the 2021/2022 rainy season to characterize runoff from the Area 1 Burn Pit (A1BP), will continue to be monitored during every rainfall event during the 2022/2023 rainy season.

OUTFALL 009

BMP performance monitoring at Expendable Launch Vehicle (ELV) Area locations EVBMP0001, EVBMP0007, EVBMP0008, and EVBMP0009 will be performed during every rainfall event during the 2022/2023 rainy season.

Monitoring of location EPNDSW04 will be reinstated during the 2022/2023 rainy season. This location will be monitored twice per year.

Monitoring of location BGBMP0004 will be discontinued during the 2022/2023 rainy season. Location BGBMP0003 will continue to be monitored during every rainfall event during the 2022/2023 rainy season.

Monitoring of Administrative Area Inlet Filter BMPs (ILBMP0009 and ILBMP0010) will be discontinued during the 2022/2023 rainy season.

BMP SAMPLING ACTIVITIES CONTINUING FROM THE 2021/2022 SAP

Monitoring active BMP performance sites within the Outfall 009 watershed will continue to be conducted twice a year, but with new specifications for the timing of each sampling event.

- One sample will be collected during the first discharge-producing rain event.
- The second sample will not be collected until Outfall 009 also flows.

All BMPs do not need to be sampled during the same rain event, but influent and effluent samples from a single BMP must be collected during the same event.

If a lead exceedance is measured at Outfall 009, sampling Northern Drainage subarea monitoring locations or one location downstream of the shooting range will be reevaluated.

The lower lot totalizer reading will be recorded in the post-rain BMP conveyance report.

OFFSITE MONITORING LOCATIONS

The Santa Susana Background Stormwater Sampling Plan, included as an attachment to this document, details the offsite background sampling program. Offsite sample locations and parameters are summarized in Table 1B.

BMP INSPECTIONS AND FORMS

For active BMP sites within the Outfalls 008 and 009 watersheds, the BMP performance inspection checklists will continue to be completed during every rain event exceeding 0.75 inches of rainfall, and once after the rainy season. The BMP Inspection Forms attached to this SAP will be used to document the inspections; these forms include observations, maintenance needs, and corrective actions and were revised in Fall 2022 to reflect current field conditions. As specified on each form, a standardized framed photo should be taken at the same location, facing the same direction, during each inspection.

Seventy-two hours after the end of each rain event exceeding 0.75 inches of rainfall, field crews will also inspect and record maximum ponding levels at locations listed in the Boeing 72 Hours After Rain Event Ponding Inspection Form and NASA 72 Hours After Rain Event Ponding Inspection Form. Both forms are included as attachments to this SAP. The ponding inspection may occur at a time slightly before or after the 72 hours.

CM-9 has approximately one year prior to its expected initial maintenance needs. To check for any indications of clogging during the 2022/2023 rainy season, CM-9 will be closely inspected and observed during each rain event and post-rain period. To assess performance following its recent reconstruction, CM-3 will also be inspected and observed with close attention during each rain event and post-rain period.

Sincerely yours,
HALEY & ALDRICH, INC.

Katherine Miller
Project Manager

Nancy E. Gardiner, CPESC, QSD, QISP
Program Manager

Enclosures:

- References
- Table IA – BMP Monitoring Inspection Locations and Analytical Plan, 2022/2023 Rainy Season – Onsite Locations
- Table IB – BMP Monitoring Inspection Locations and Analytical Plan, 2022/2023 Rainy Season – Offsite Locations
- Table IC – Sample Containers
- Figure 1 – Outfall 009 and 011, BMP Monitoring Locations
- Figure 2 – Outfall 009, B-1 and Lower Lot Areas – Boeing
- Figure 3 – Outfall 009, IEL Area – Boeing
- Figure 4 – Outfall 009, AILF Area – Boeing
- Figure 5 – Outfall 009, CMs South of LOX Area – NASA
- Figure 6 – Outfall 009, A2LF, CM-1, and Helipad Areas – NASA
- Figure 7 – Outfall 009, ELV Area – NASA
- Figure 8 – Outfalls 001 and 002, Potential BMP Monitoring Locations
- Figure 9 – Outfall 001, Potential BMP Subarea
- Figure 10 – Outfall 001, Potential BMP Subarea

Figure 11 – Outfall 011, Area 1 Burn Pit
Figure 12 – Outfall 002, Potential BMP Subarea
Figure 13 – Outfall 002, Potential BMP Subarea
Figure 14 – Outfall 002, Potential BMP Subarea
Figure 15 – Outfall 009, CM-11
BMP Inspection Forms – Outfalls 008, 009 and 011 – Boeing
BMP Inspection Forms – Outfall 009 – NASA
Boeing 72 Hours After Rain Event Ponding Inspection Form
NASA 72 Hours After Rain Event Ponding Inspection Form
Sample Collection Forms
Santa Susana Field Laboratory Background Stormwater Sampling Plan

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TABLES

TABLE IA

BMP MONITORING INSPECTION LOCATIONS AND ANALYTICAL PLAN - ONSITE LOCATIONS
2022/2023 RAINY SEASON
SANTA SUSANA FIELD LABORATORY
CANOGA PARK, CALIFORNIA

Object ID	Sampling Responsibility	Figure Number	Location	Areas Monitored	Purpose	Notes	Sample Frequency[1]	Cd, Cu, Pb, total recoverable (Method 200.8)	Hg, total recoverable (Method 1631E)	Cd, Cu, Pb, total dissolved (Method 200.8)	Hg, total dissolved (Method 1631E)	Dioxins- 17 Congeners[4] (Method 1613B)	Total Suspended Solids (Method 2540D)	Particle Size Distribution (Method ASTM D4462)	Turbidity (Method 180.1)	Method 200.8: As, Cd, Cu, Fe, Mn, Pb, Se Method 200.7: Zn (total recoverable)	Method 200.8: As, Cd, Cu, Fe, Mn, Pb, Se Method 200.7: Zn (total dissolved)	SO4 (Method 300)	Uranium, total recoverable (Method HASL-300 U Mod)	Uranium, total dissolved (Method HASL-300 U Mod)	Potassium-40 and Cesium-137, total recoverable (Method E901.1)	Potassium-40 and Cesium-137, total dissolved (Method E901.1)	Gross Alpha, total recoverable (Method 900.0)	Gross Alpha, total dissolved (Method 900.0)	Gross Beta, total recoverable (Method 900.0)	Gross Beta, total dissolved (Method 900.0)	Total Combined Radium 226 & 228, Sr-90, Tritium (Methods 903.0/903.1, 904, 905, 906.0)	SO4, Fluoride, Nitrate-N, Nitrite-N (Method 300)	Perchlorate (Method 314.0)	Trichloroethene (Method 624.1)	bis (2-ethylhexyl) phthalate (Method 625.1)	Cyanide (SM 4500-CN-E)	Chromium VI, total recoverable (Method 218.6)	Chromium VI, total dissolved (Method 218.6)	Method 200.8: Ag, Al, As, Ba, Be, Cd, Cr, Cu,Fe, Mn, Ni, Pb, Se, Sb, Tl Method 200.7: B, Zn (total recoverable)	Method 200.8: Ag, Al, As, Ba, Be, Cd, Cr, Cu, Fe, Mn, Ni, Pb, Se, Sb, Tl Method 200.7: B, Zn (total dissolved)	Tritium Method 906.0
Sampled by Boeing																																					
A1BMP0002	Boeing	4	A1LF	CM-9, A1LF	US South, Treatment BMP Performance Monitoring	A1LF tributary drainage	Twice a year[2]	X	X	X	X	X	X	X																							
A1BMP0003	Boeing	4	A1LF	CM-9, A1LF, IEL, Area II Road	DS, Treatment BMP Performance Monitoring	CM-9 underdrain	Twice a year[2]	X	X	X	X	X	X	X																							
A1BPSW0001	Boeing	15	A1BP	Impacted Soils Evaluation (A1BP)	Potential BMP Location	At edge of A1BP and access road to Outfall 011	Every Storm[3]		X		X	X	X			X	X	X	X	X	X	X	X	X	X	X											X
B1BMP0009	Boeing	2	B-1	B-1 Upper Parking Lot Media Filter	US North, Treatment BMP Performance Monitoring	Gunite swale conveying road runoff	Twice a year[2]	X	X	X	X	X	X	X																							
B1BMP0010	Boeing	2	B-1	B-1 Upper Parking Lot Media Filter	US South, Treatment BMP Performance Monitoring	Culvert outlet from upper parking lot area	Twice a year[2]	X	X	X	X	X	X	X																							
B1BMP0011	Boeing	2	B-1	B-1 Upper Parking Lot Media Filter	DS, Treatment BMP Performance Monitoring	Underdrains	Twice a year[2]	X	X	X	X	X	X	X																							
BGBMP0003	Boeing	5	Sage Ranch	Background	US, Treatment BMP Performance Monitoring	Sage Ranch near LOX	Every Storm[3]		X		X	X	X	X					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
EPNDSW04	Boeing	5	Sage Ranch	Downstream of Box Culvert	US, Treatment BMP Performance Monitoring	Dirt road crossing at box culvert	Twice a year[2]	X	X	X	X	X	X	X																							
EPSW001IE01	Boeing	9	OF001 Watershed	Impacted Soils Evaluation (A1BP, CTL-V)	Potential BMP Location	At the bottom of the hill to the north of the intersection of the Southern Buffer Zone Road and	Every Storm[3]		X		X	X	X			X	X	X	X	X	X	X	X	X	X	X											X
ILBMP0002	Boeing	4	A1LF	CM-9, IEL, Area II Road	US East, Treatment BMP Performance Monitoring	Culvert inlet off Area II Road	Twice a year[2]	X	X	X	X	X	X	X																							
ILBMP0004	Boeing	3	IEL	B1436 Southern Detention Bioswale	US, Treatment BMP Performance Monitoring	Concrete swale (western) diverting sheetflow into rock crib	Twice a year[2]	X	X	X	X	X	X	X																							
ILBMP0005	Boeing	3	IEL	B1436 Southern Detention Bioswale	DS, Treatment BMP Performance Monitoring	Bioswale underdrain (subsurface 12- inch drain connecting to existing culvert)	Twice a year[2]	X*	X*	X*	X*	X*	X	X																							
ILBMP0008	Boeing	3	IEL	B1436 Southern Detention Bioswale	US, Treatment BMP Performance Monitoring	Concrete swale (eastern) diverting sheetflow into rock crib	Twice a year[2]	X	X	X	X	X	X	X																							
LPBMP0002	Boeing	2	Lower Lot	Lower Lot BMP	US, Treatment BMP Performance Monitoring	Sample port in cistern discharge pipe	Twice a year[2]	X	X	X	X	X	X	X																							
LPBMP0003	Boeing	2	Lower Lot	Lower Lot BMP	Mid-Point, Treatment BMP Performance Monitoring	Sediment Basin outlet box	Twice a year[2]	X	X	X	X	X	X	X																							
LPBMP0004	Boeing	2	Lower Lot	Lower Lot BMP	DS Treatment BMP Performance Monitoring	Discharge from Biofilter effluent pipe	Twice a year[2]	X	X	X	X	X	X	X																							
LXBMP0010	Boeing	5	CM-3	Service Area Road BMP	US, Treatment BMP Performance Monitoring	Outlet pipe south side of road	Twice a year[2]	X	X	X	X	X	X	X																							
LXBMP0011	Boeing	5	CM-3	Background (Service Area Road BMP)	US, Treatment BMP Performance Monitoring	Natural drainage upstream of CM-3	Twice a year[2]		X		X	X	X	X					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
LXBMP0012	Boeing	5	CM-3	Service Area Road BMP	DS, Treatment BMP Performance Monitoring	Underdrains	Twice a year[2]	X	X	X	X	X	X	X																							

TABLE IA

BMP MONITORING INSPECTION LOCATIONS AND ANALYTICAL PLAN - ONSITE LOCATIONS
2022/2023 RAINY SEASON
SANTA SUSANA FIELD LABORATORY
CANOGA PARK, CALIFORNIA

Object ID	Sampling Responsibility	Figure Number	Location	Areas Monitored	Purpose	Notes	Sample Frequency[1]	Cd, Cu, Pb, total recoverable (Method 200.8)	Hg, total recoverable (Method 1631E)	Cd, Cu, Pb, total dissolved (Method 200.8)	Hg, total dissolved (Method 1631E)	Dioxins- 17 Congeners[4] (Method 1613B)	Total Suspended Solids (Method 2540D)	Particle Size Distribution (Method ASTM D4462)	Turbidity (Method 180.1)	Method 200.8: As, Cd, Cu, Fe, Mn, Pb, Se Method 200.7: Zn (total recoverable)	Method 200.8: As, Cd, Cu, Fe, Mn, Pb, Se Method 200.7: Zn (total dissolved)	SO4 (Method 300)	Uranium, total recoverable (Method HASL-300 U Mod)	Uranium, total dissolved (Method HASL-300 U Mod)	Potassium-40 and Cesium-137, total recoverable (Method E901.1)	Potassium-40 and Cesium-137, total dissolved (Method E901.1)	Gross Alpha, total recoverable (Method 900.0)	Gross Alpha, total dissolved (Method 900.0)	Gross Beta, total recoverable (Method 900.0)	Gross Beta, total dissolved (Method 900.0)	Total Combined Radium 226 & 228, Sr-90, Tritium (Methods 903.0/903.1, 904, 905, 906.0)	SO4, Fluoride, Nitrate-N, Nitrite-N (Method 300)	Perchlorate (Method 314.0)	Trichloroethene (Method 624.1)	bis (2-ethylhexyl) phthalate (Method 625.1)	Cyanide (SM 4500-CN-E)	Chromium VI, total recoverable (Method 218.6)	Chromium VI, total dissolved (Method 218.6)	Method 200.8: Ag, Al, As, Ba, Be, Cd, Cr, Cu, Fe, Mn, Ni, Pb, Se, Sb, Tl Method 200.7: B, Zn (total recoverable)	Method 200.8: Ag, Al, As, Ba, Be, Cd, Cr, Cu, Fe, Mn, Ni, Pb, Se, Sb, Tl Method 200.7: B, Zn (total dissolved)	Tritium Method 906.0
Sampled by NASA																																					
A2BMP0006	NASA	7	CM-1	CM-1	US East, Treatment BMP Performance Monitoring	CM-1 eastern tributary drainage	Twice a year[2]	X	X	X	X	X	X	X																							
A2BMP0007	NASA	7	CM-1	CM-1	DS, Treatment BMP Performance Monitoring	CM-1 culvert outlet	Twice a year[2]	X	X	X	X	X	X	X																							
A2BMP0012	NASA	7	CM-1	CM-1, Area II Road	US, Treatment BMP Performance Monitoring	Outlet pipe south side of road	Twice a year[2]	X	X	X	X	X	X	X	X																						
EVBMP0001	NASA	8	ELV	ELV, Helipad	ELV Treatment BMP Overflow Monitoring	Culvert inlet; runoff will only be present when rain events exceed ELV BMP design storm	Every Storm[3]	X	X	X	X	X	X	X	X																						
EVBMP0003	NASA	7	CM-1	CM-1, Area II Road	US West, Treatment BMP Performance Monitoring	Sheetflow along Area II Road upstream of sandbag berm	Twice a year[2]	X	X	X	X	X	X	X																							
EVBMP0007	NASA	8	ELV	ELV Treatment BMP	US, Treatment BMP Performance Monitoring	Sample port in BMP influent pipe prior to "T" connection	Every Storm[3]	X	X	X	X	X	X	X																							
EVBMP0008	NASA	8	ELV	ELV Treatment BMP	DS, Treatment BMP Performance Monitoring	Discharge from media filter tank pipe	Every Storm[3]	X	X	X	X	X	X	X	X																						
EVBMP0009	NASA	8	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	Every Storm[3]	X	X	X	X	X	X	X	X																						

Notes:

[1] All BMPs do not need to be sampled during the same rain event, but influent and effluent samples from a single BMP must be collected during the same event.
[2] One sample should be collected during the ***first discharge event*** *and* *then wait until OF009 flows to take the second sample.*
[3] Sampling is required at every discharge-producing rain event, regardless of whether outfalls flow.
[4] Dioxin congeners to be analyzed are as follows:
2,3,7,8-tetrachlorodibenzo-p-dioxin
1,2,3,7,8-pentachlorodibenzo-p-dioxin
1,2,3,4,7,8-hexachlorodibenzo-p-dioxin
1,2,3,6,7,8-hexachlorodibenzo-p-dioxin
1,2,3,7,8,9- hexachlorodibenzo-p-dioxin
1,2,3,4,6,7,8-heptachlorodibenzo-p-dioxin
1,2,3,4,6,7,8,9-octachlorodibenzo-p-dioxin
2,3,7,8-tetrachlorodibenzofuran
1,2,3,7,8-pentachlorodibenzofuran
2,3,4,7,8- pentachlorodibenzofuran
1,2,3,4,7,8-hexachlorodibenzofuran
1,2,3,6,7,8-hexachlorodibenzofuran
1,2,3,7,8,9-hexachlorodibenzofuran
2,3,4,6,7,8-hexachlorodibenzofuran
1,2,3,4,6,7,8-heptachlorodibenzofuran
1,2,3,4,7,8,9-heptachlorodibenzofuran
1,2,3,4,6,7,8,9-octachlorodibenzofuran

** Collect one equipment blank (EB) per sampling day from the equipment used to sample the B1436 Detention Bioswales downstream monitoring location (under drains).*
Place metals and dioxins analysis on hold; 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 be ILQW0007_yyyymmdd.

Abbreviations:

A1BP = Area 1 Burn Pit
A1LF = A1 Landfill
BG = Background
BMP = Best Management Practice
CM = Culvert Modification
CTL-V = Components Testing Laboratory V
DS = Downstream
ELV = Expendable Launch Vehicle
EP = Expert Panel
IEL = Instrument and Equipment Laboratories
LOX = Liquid Oxygen
OF = Outfall
STL-IV = Systems Test Laboratory IV
SW = Stormwater
US = Upstream
X = Collect & Analyze

TABLE IB
BMP MONITORING INSPECTION LOCATIONS AND ANALYTICAL PLAN - OFFSITE LOCATIONS
2022/2023 RAINY SEASON
SANTA SUSANA FIELD LABORATORY
CANOGA PARK, CALIFORNIA

Location	Sample ID	Location Type	Sampling Responsibility	Watershed Monitored	Primary versus Backup	Notes (*See Santa Susana Field Laboratory Background Stormwater Sampling Plan for detailed maps and photos of sampling locations*)	Sample Frequency[1]	**Hg, total recoverable** (Method 1631E)	**Hg, total dissolved** (Method 1631E)	**Dioxins - 17 Congeners** (Method 1613B)	**Total Suspended Solids** (Method 2540D)	**Particle Size Distribution** (Method ASTM D4462)	**Method 200.8:** Ag, Al, As, Ba, Be, Cd, Cr, Cu,Fe, Mn, Ni, Pb, Se, Sb, Tl **Method 200.7:** B, Zn **(total recoverable)**	**Method 200.8:** Ag, Al, As, Ba, Be, Cd, Cr, Cu, Fe, Mn, Ni, Pb, Se, Sb, Tl **Method 200.7:** B, Zn **(total dissolved)**	**Uranium, total recoverable** (Method HASL-300 U Mod)	**Uranium, total dissolved** (Method HASL-300 U Mod)	**Potassium-40, total recoverable** (Method E901.1)	**Potassium-40, total dissolved** (Method E901.1)	**Cesium-137, total recoverable** (Method E901.1)	**Cesium-137, total dissolved** (Method E901.1)	**Gross Alpha, total recoverable** (Method 900.0)	**Gross Beta, total recoverable** (Method 900.0)	**Gross Alpha, total dissolved** (Method 900.0)	**Gross Beta, total dissolved** (Method 900.0)	**SO4, Fluoride, Nitrate-N, Nitrite-N** (Method 300)	**Perchlorate** (Method 314.0)	**Trichloroethene** (Method 624.1)	**bis (2-ethylhexyl) phthalate** (Method 625.1)	**Cyanide** (SM 4500-CN-E)	**Radium-226** (Method 903)	**Radium-228** (Method 904)	**Strontium-90** (Method 905)	**Tritium** (Method E906.0)	**Chromium VI, total recoverable** (Method 218.6)	**Chromium VI, total dissolved** (Method 218.6)
Las Llajas Canyon	EPBLLC	Primary Background	Boeing	Calleguas Creek	Primary	Park on Evening Sky Drive at the Las Llajas Canyon Trailhead; walk 0.3 miles north to gate on west side of trail. Walk through gate to where a creek crosses a concrete area on the dirt road.	Every Storm[1]	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Montgomery Canyon	EPBMC	Primary Background	Boeing	Calleguas Creek	Primary	Park on Long Canyon Road at the Long Canyon East Trailhead (pull out with No Parking sign). Walk 0.1 miles to the sampling location where the two creeks converge and cross the dirt road.	Every Storm[1]	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Box Canyon	EPBBC	Non-Industrial	Boeing	Los Angeles River	Primary	Park on Valley Circle Boulevard just east of Woolsey Canyon Road. Walk <0.1 miles to the sampling location where a culvert crosses under Valley Circle Boulevard (may need sampling pole or other collection device).	Every Storm[1]	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Chesebro Canyon	EPBCC	Secondary Background	Boeing	Malibu Creek	Backup	Park in the parking lot at Chesebro Canyon Trailhead (closed sunset to 8 am). Walk 0.5 miles to the sampling location, just off the main trail.	Every Storm[2] (if primary location inaccessible or not flowing)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
East Las Virgenes Canyon	EPBLVC	Secondary Background	Boeing	Malibu Creek	Backup	Park at the end of Las Virgenes Road at the Upper Las Virgenes Canyon Open Space Trailhead. Walk 0.4 miles to the sampling location, along a small trail just off the main trail.	Every Storm[2] (if primary location inaccessible or not flowing)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

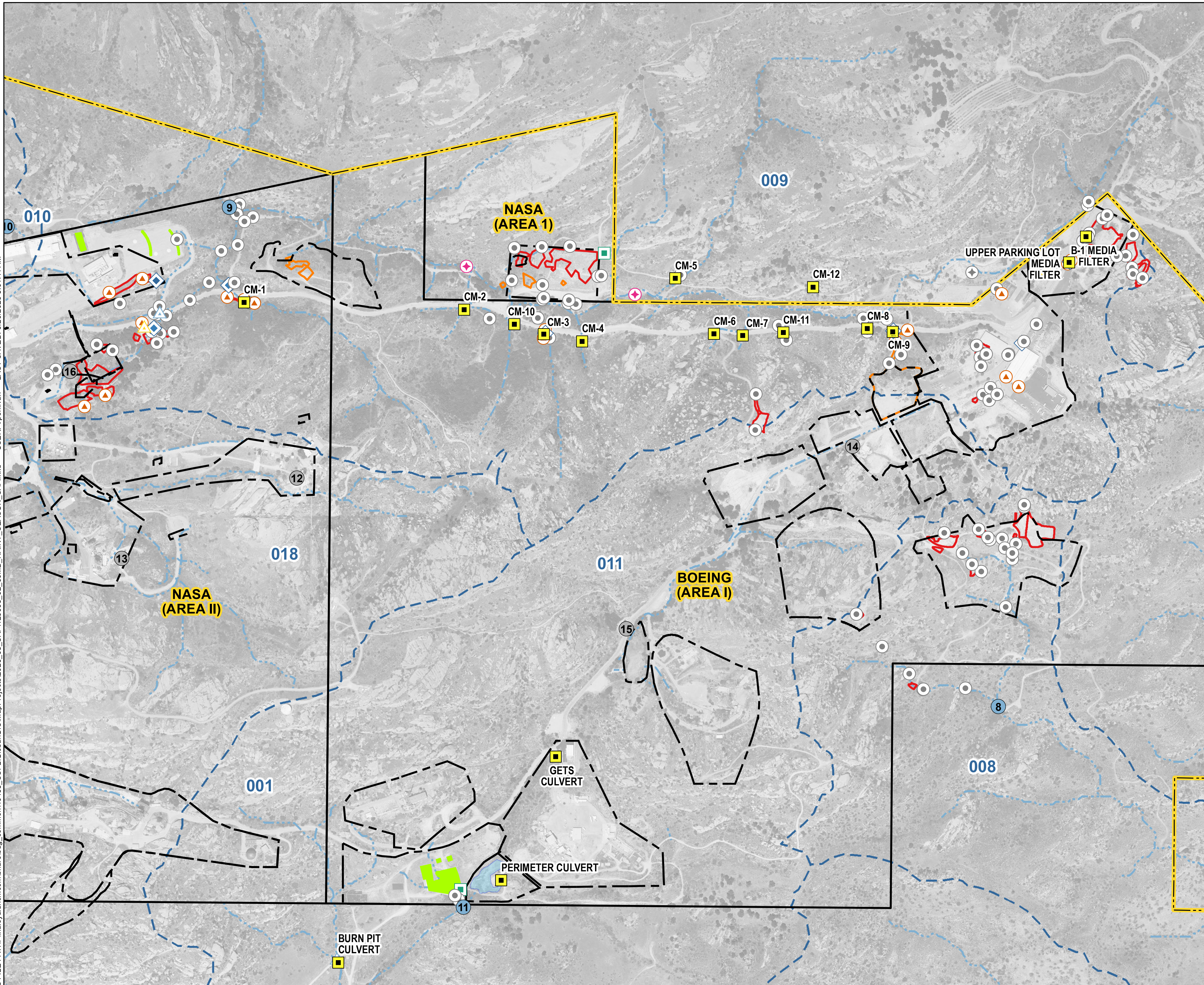
Notes:
[1] *Attempt to sample at every discharge-producing rain event. If sample location is inaccessible or is not flowing, attempt to sample Backup sample locations.*
[2] *Attempt to sample only if any primary sample location is inaccessible or not flowing.*

TABLE IC
SAMPLE CONTAINERS
2022/2023 RAINY SEASON
SANTA SUSANA FIELD LABORATORY
CANOGA PARK, CALIFORNIA

Analyte	Method	# of Bottles	Minimum Bottle Volume	Bottle Type	Preservative	Lab Filter (Yes/No)	Notes
Cd, Cu, Pb, total recoverable	Method 200.8	1	250mL	poly	HNO3	No	
Hg, total recoverable	Method 1631E	1	250mL	Glass	HCl	No	Double-bag sample container prior to shipping.
Cd, Cu, Pb, total dissolved	Method 200.8	1	250mL	poly	none	Yes	
Hg, total dissolved	Method 1631E	1	250mL	Glass	none	Yes	Double-bag sample container prior to shipping.
Dioxins- 17 Congeners	Method 1613B	2	1 L	Glass Amber	none	No	
Total Suspended Solids	Method 2540D	1	1 L	poly	none	No	
Particle Size Distribution	Method ASTM D4462	1	1 L	poly	none	No	
Turbidity	Method 180.1	1	125mL	poly	none	No	
As, Cd, Cu, Fe, Mn, Pb, Se, Zn (total recoverable)	Method 200.8/Method 200.7	1	250mL	poly	HNO3	No	
As, Cd, Cu, Fe, Mn, Pb, Se, Zn (total dissolved)	Method 200.8/Method 200.7	1	250mL	poly	none	Yes	
SO4	Method 300	1	250mL	poly	none	No	
Gross Alpha, total recoverable*	Method 900.0	1	1 L	poly	none	No	
Gross Alpha, total dissolved*	Method 900.0	1	1 L	poly	none	No	
Gross Beta, total recoverable*	Method 900.0	1	1 L	poly	none	No	Share with Total Gross Alpha bottle
Gross Beta, total dissolved*	Method 900.0	1	1 L	poly	none	No	Share with Dissolved Gross Alpha Bottle
SO4, Fluoride, Nitrate-N, Nitrite-N	Method 300	1	250mL	poly	none	No	
Perchlorate	Method 314.0	1	250mL	poly	none	No	
Trichloroethene	Method 624.1	3	40mL	VOA	HCL	No	
bis (2-ethylhexyl) phthalate	Method 625.1	2	1L	Glass Amber	none	No	
Cyanide	SM 4500-CN-E	1	500mL	poly	NaOH	No	
Total Combined Radium 226 & 22, Sr-90, Tritium*	Methods 903.0/903.1, 904, 905, 906.0	4	1 L	poly	none	No	
Chromium VI, total recoverable	Method 218.6	1	250mL	poly	none	No	
Chromium VI, total dissolved	Method 218.6	1	250mL	poly	none	Yes	
Ag, As, Ba, Be, Cd, Cr, Cu, Fe, Mn, Ni, Pb, Se, Sb, Tl, B, Zn (total recoverable)	Method 200.8/Method 200.7	1	250mL	poly	HNO3	No	
Ag, As, Ba, Be, Cd, Cr, Cu, Fe, Mn, Ni, Pb, Se, Sb, Tl, B, Zn (total dissolved)	Method 200.8/Method 200.7	1	250mL	poly	none	Yes	
Radium-226*	Method 903	2	1L	poly	none	No	
Radium-228*	Method 904						
Strontium-90*	Method 905	2	1L	poly	none	No	
Tritium	Method E906.0						
Ag, Al, As, Ba, Be, Cd, Cr, Cu,Fe, Mn, Ni, Pb, Se, Sb, Tl, B, Zn **(total recoverable)**	Method 200.8/Method 200.7	1	250mL	poly	HNO3	No	
Ag, Al, As, Ba, Be, Cd, Cr, Cu,Fe, Mn, Ni, Pb, Se, Sb, Tl, B, Zn **(total dissolved)**	Method 200.8/Method 200.7	1	250mL	poly	none	Yes	
Uranium, total recoverable*	Method HASL-300 U Mod	1	1L	poly	none	No	
Uranium, total dissolved*	Method HASL-300 U Mod	1	1L	poly	none	Yes	
Potassium-40, total recoverable*	Method E901.1	1	1L	poly	none	No	
Potassium-40, total dissolved*	Method E901.1	1	1L	poly	none	Yes	
Cesium-137, total recoverable*	Method E901.1	1	1L	poly	none	No	Share with total K-40 bottle.
Cesium-137, total dissolved*	Method E901.1	1	1L	poly	none	Yes	Share with dissolved K-40 bottle.

* - If total suite of radionuclides are collected at a sample location, all radionuclides can be combined into a 2.5-gallon cube.

FIGURES



LEGEND

- CULVERT MODIFICATION (CM)
- UPSTREAM BMP PERFORMANCE MONITORING LOCATION
- DOWNSTREAM BMP PERFORMANCE MONITORING LOCATION
- MIDPOINT BMP PERFORMANCE MONITORING LOCATION
- PREVIOUS BMP PERFORMANCE MONITORING LOCATION
- ALTERNATE BMP PERFORMANCE MONITORING LOCATION
- POTENTIAL BMP PERFORMANCE MONITORING LOCATION
- ACTIVE NPDES OUTFALL
- FORMER NPDES OUTFALL
- DRAINAGE
- SURFACE WATER DIVIDE
- EROSION CONTROL FABRIC/LINER
- SURFACE WATER POND
- ISRA EXCAVATION BOUNDARY
- FORMER ISRA EXCAVATION BOUNDARY
- STUDY AREA
- ADMINISTRATIVE AREA BOUNDARY
- SSFL PROPERTY BOUNDARY

NOTES

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
2. SAP = SAMPLING AND ANALYSIS PLAN
3. BMP = BEST MANAGEMENT PRACTICE
4. AERIAL IMAGERY SOURCE: CIRGIS

N

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SCALE IN FEET

HALEY ALDRICH

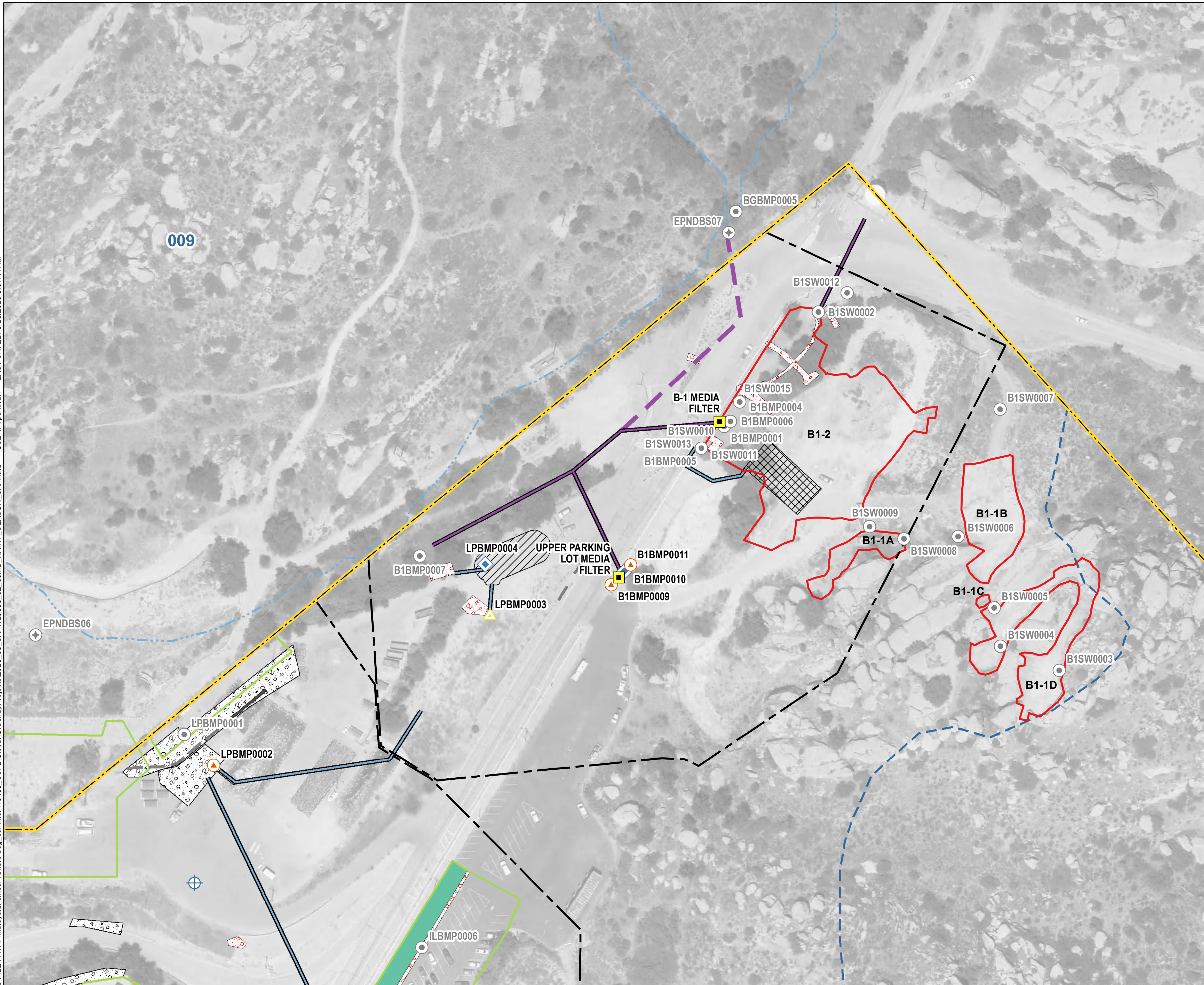
2022/2023 RAINY SEASON MAP
BMP MONITORING PROGRAM
THE BOEING COMPANY
VENTURA COUNTY, CALIFORNIA

OUTFALL 009 AND 011
BMP MONITORING LOCATIONS

SEPTEMBER 2023

FIGURE 1

GIS FILE PATH: \\haleyaldrich.com\share\sdg_common\40458_SSFL\Global\GIS\MapProjects\2023_08_SAP\129095_02_00MB_RAINY_SEASON_SAP.mxd — USER: Vpehlivan — LAST SAVED: 9/26/2023 8:01:11 AM



LEGEND

- CULVERT MODIFICATION (CM)
- UPSTREAM BMP PERFORMANCE MONITORING LOCATION
- DOWNSTREAM BMP PERFORMANCE MONITORING LOCATION
- MIDPOINT BMP PERFORMANCE MONITORING LOCATION
- PREVIOUS BMP PERFORMANCE MONITORING LOCATION
- 24" STORM DRAIN
- DRAINAGE
- SURFACE WATER DIVIDE
- CONVEYANCE PIPELINE
- ASPHALT CURB
- ROLLING AC BERM
- STORM DRAIN (ESTIMATED SUBSURFACE TRACE)
- STORM DRAIN INFERRED
- ASPHALT/CONCRETE REMOVAL AREA
- DETENTION BIOSWALE
- ENGINEERED NATURAL TREATMENT SYSTEM
- GRAVEL
- RIP RAP
- SEDIMENTAION BASIN
- ISRA EXCAVATION BOUNDARY
- STUDY AREA
- ADMINISTRATIVE AREA BOUNDARY
- SSFL PROPERTY BOUNDARY

NOTES

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
2. SAP = SAMPLING AND ANALYSIS PLAN
3. BMP = BEST MANAGEMENT PRACTICE
4. AERIAL IMAGERY SOURCE: CIRGIS

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SCALE IN FEET

HALEY ALDRICH

2022/2023 RAINY SEASON MAP
BMP MONITORING PROGRAM
THE BOEING COMPANY
VENTURA COUNTY, CALIFORNIA

OUTFALL 009
B-1 AND LOWER PARKING LOT AREAS - BOEING

SEPTEMBER 2023

FIGURE 2

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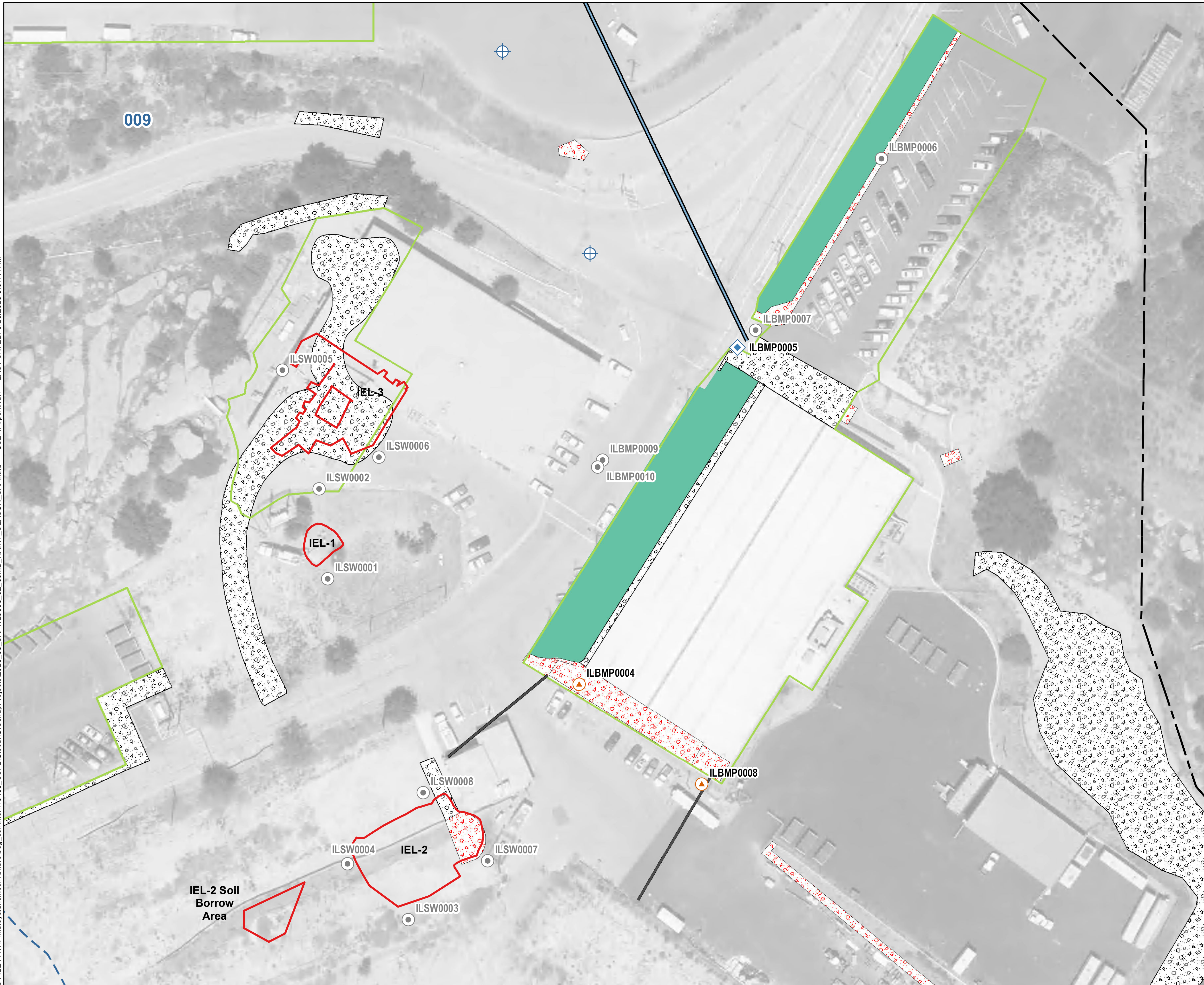


LEGEND

- UPSTREAM BMP PERFORMANCE MONITORING LOCATION
- DOWNSTREAM BMP PERFORMANCE MONITORING LOCATION
- PREVIOUS BMP PERFORMANCE MONITORING LOCATION
- 24" STORM DRAIN
- SURFACE WATER DIVIDE
- CONVEYANCE PIPELINE
- ROLLING AC BERM
- ASPHALT/CONCRETE REMOVAL AREA
- DETENTION BIOSWALE
- GRAVEL
- RIP RAP
- ISRA EXCAVATION BOUNDARY
- STUDY AREA
- ADMINISTRATIVE AREA BOUNDARY
- SSFL PROPERTY BOUNDARY

NOTES

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
2. SAP = SAMPLING AND ANALYSIS PLAN
3. BMP = BEST MANAGEMENT PRACTICE
4. AERIAL IMAGERY SOURCE: CIRGIS

HALEY ALDRICH

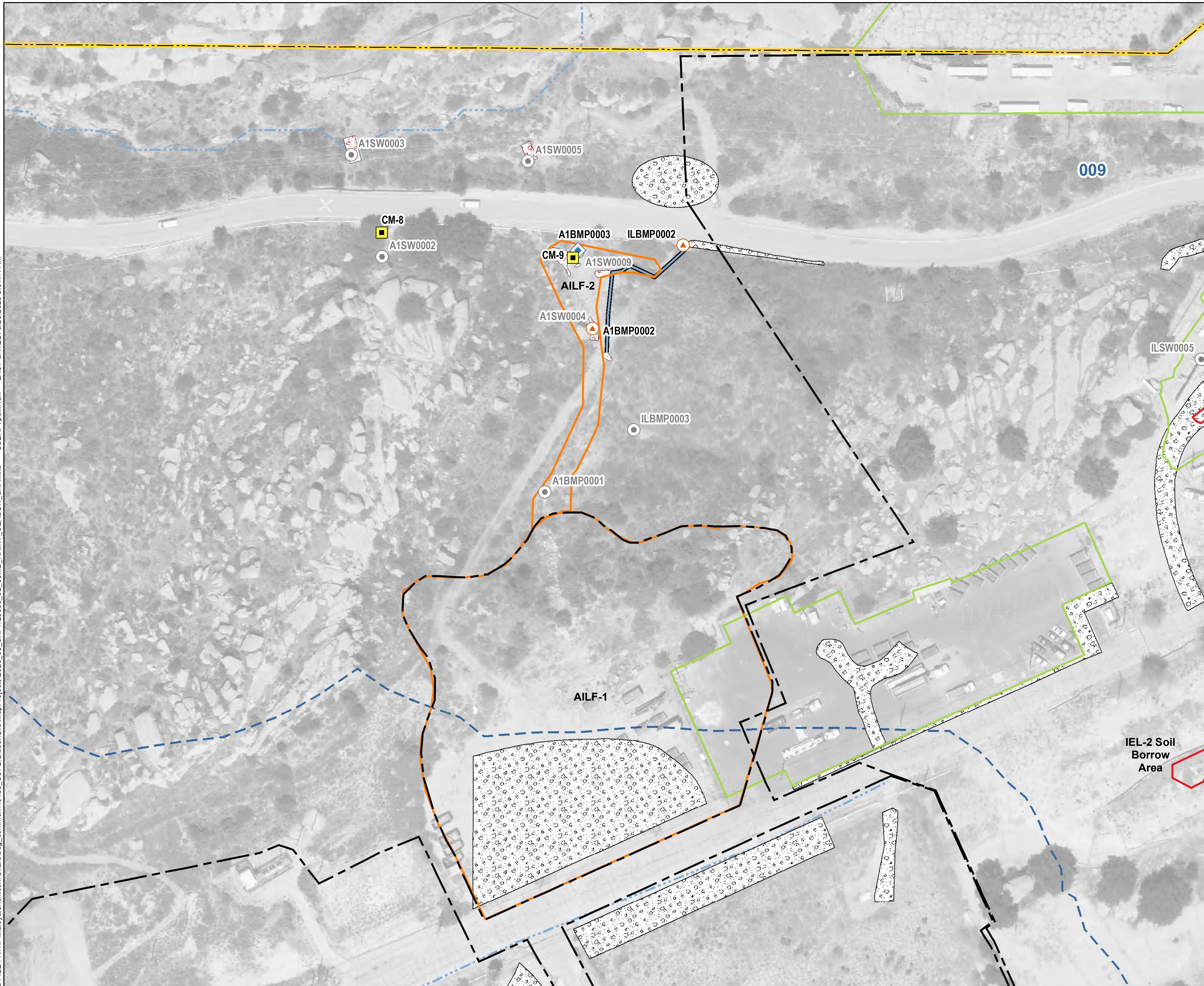
2022/2023 RAINY SEASON MAP
BMP MONITORING PROGRAM
THE BOEING COMPANY
VENTURA COUNTY, CALIFORNIA

OUTFALL 009
IEL AREA - BOEING

SEPTEMBER 2023

FIGURE 3

GIS FILE PATH: \\haleyaldrich.com\share\sdg_common\40458_SSFL\Global\GIS\MapProjects\2023_08_SAP\129095_02_00MB_RAINY_SEASON_SAP.mxd — USER: Vpehlivan — LAST SAVED: 9/26/2023 8:01:11 AM



LEGEND

- CULVERT MODIFICATION (CM)
- UPSTREAM BMP PERFORMANCE MONITORING LOCATION
- DOWNSTREAM BMP PERFORMANCE MONITORING LOCATION
- PREVIOUS BMP PERFORMANCE MONITORING LOCATION
- DRAINAGE
- SURFACE WATER DIVIDE
- CONVEYANCE PIPELINE
- ASPHALT/CONCRETE REMOVAL AREA
- GRAVEL
- RIP RAP
- ISRA EXCAVATION BOUNDARY
- FORMER ISRA EXCAVATION BOUNDARY
- STUDY AREA
- ADMINISTRATIVE AREA BOUNDARY
- SSFL PROPERTY BOUNDARY

NOTES

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
2. SAP = SAMPLING AND ANALYSIS PLAN
3. BMP = BEST MANAGEMENT PRACTICE
4. AERIAL IMAGERY SOURCE: CIRGIS

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SCALE IN FEET

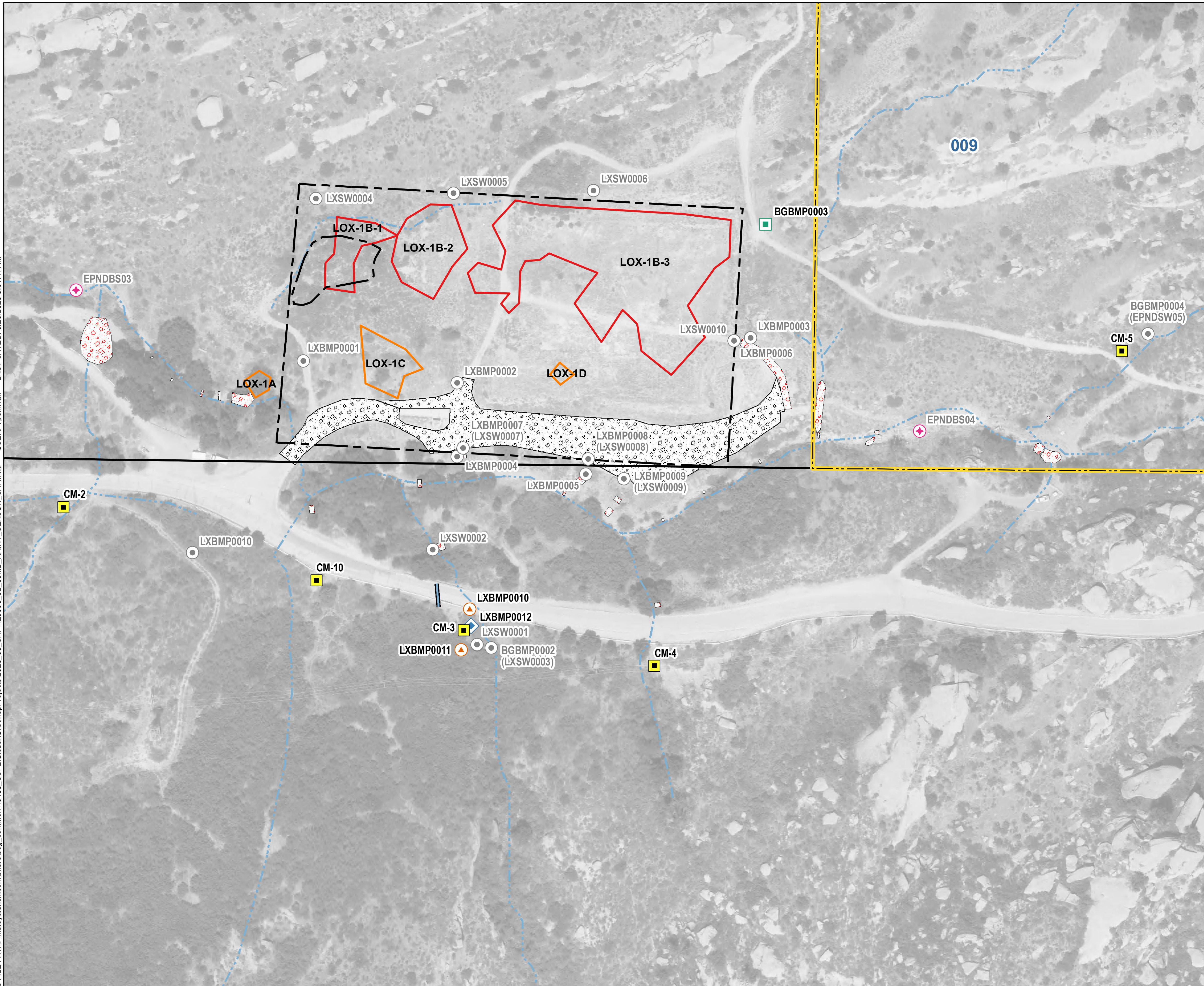
HALEY ALDRICH

2022/2023 RAINY SEASON MAP
BMP MONITORING PROGRAM
THE BOEING COMPANY
VENTURA COUNTY, CALIFORNIA

OUTFALL 009
AILF AREA - BOEING

SEPTEMBER 2023

FIGURE 4



LEGEND

- CULVERT MODIFICATION (CM)
- UPSTREAM BMP PERFORMANCE MONITORING LOCATION
- DOWNSTREAM BMP PERFORMANCE MONITORING LOCATION
- PREVIOUS BMP PERFORMANCE MONITORING LOCATION
- ALTERNATE BMP PERFORMANCE MONITORING LOCATION
- DRAINAGE
- CONVEYANCE PIPELINE
- GRAVEL
- RIP RAP
- ISRA EXCAVATION BOUNDARY
- FORMER ISRA EXCAVATION BOUNDARY
- STUDY AREA
- ADMINISTRATIVE AREA BOUNDARY
- SSFL PROPERTY BOUNDARY

NOTES

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
2. SAP = SAMPLING AND ANALYSIS PLAN
3. BMP = BEST MANAGEMENT PRACTICE
4. AERIAL IMAGERY SOURCE: CIRGIS

N

0 150 300
SCALE IN FEET

HALEY ALDRICH

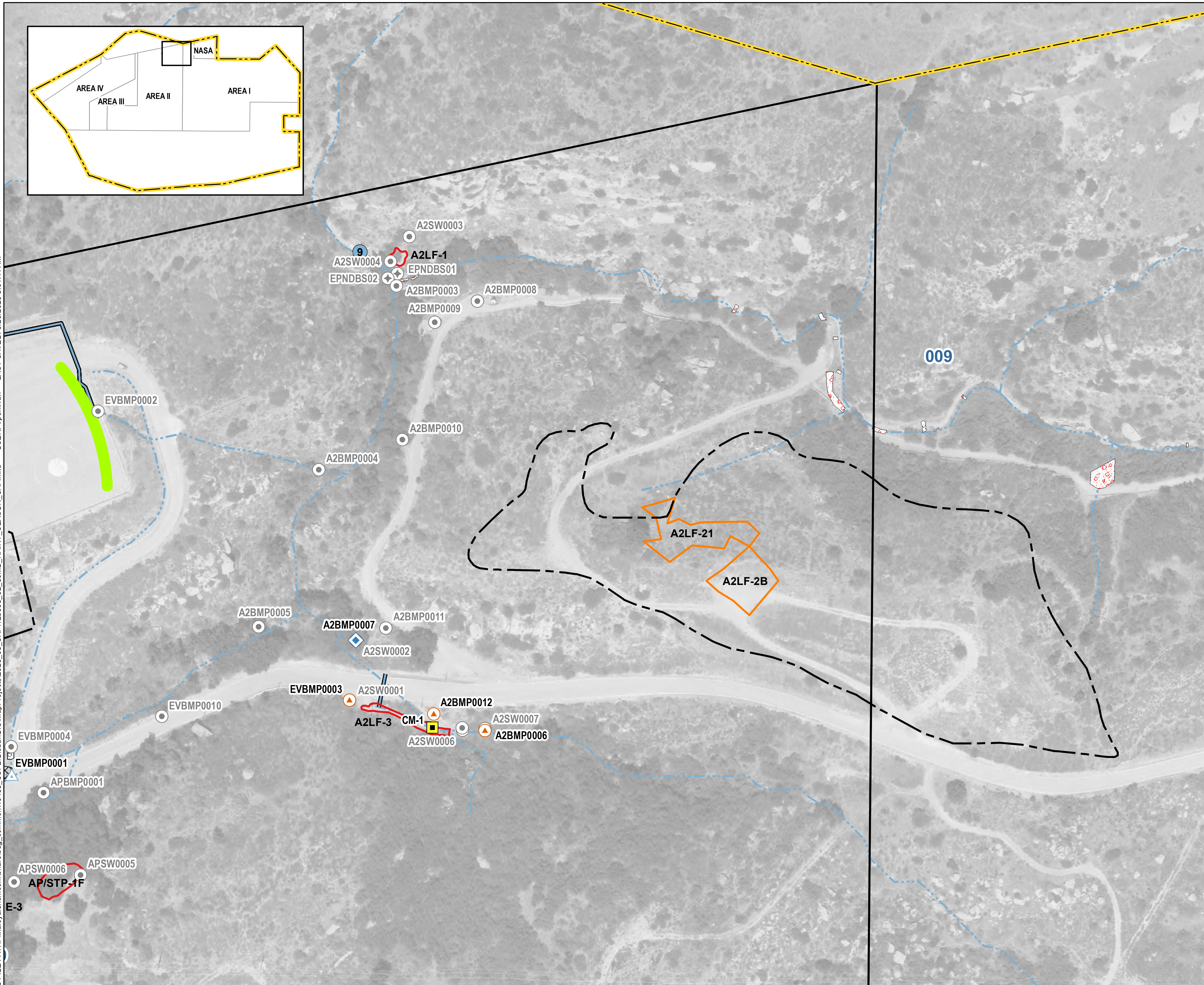
2022/2023 RAINY SEASON MAP
BMP MONITORING PROGRAM
THE BOEING COMPANY
VENTURA COUNTY, CALIFORNIA

OUTFALL 009
CMS SOUTH OF LOX AREA - NASA

SEPTEMBER 2023

FIGURE 5

GIS FILE PATH: \\haleyaldrich.com\share\sdg_common\40458_SSFL\Global\GIS\MapProjects\2023_08_SAP\129095_02_00MB_RAINY_SEASON_SAP.mxd — USER: Vpehlivan — LAST SAVED: 9/26/2023 8:01:11 AM



LEGEND

- CULVERT MODIFICATION (CM)
- UPSTREAM BMP PERFORMANCE MONITORING LOCATION
- DOWNSTREAM BMP PERFORMANCE MONITORING LOCATION
- PREVIOUS BMP PERFORMANCE MONITORING LOCATION
- POTENTIAL BMP PERFORMANCE MONITORING LOCATION
- ACTIVE NPDES OUTFALL
- DRAINAGE
- CONVEYANCE PIPELINE
- EROSION CONTROL FABRIC/LINER
- GRAVEL
- RIP RAP
- SEDIMENTAION BASIN
- ISRA EXCAVATION BOUNDARY
- FORMER ISRA EXCAVATION BOUNDARY
- STUDY AREA
- ADMINISTRATIVE AREA BOUNDARY
- SSFL PROPERTY BOUNDARY

NOTES

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3. BMP = BEST MANAGEMENT PRACTICE
4. AERIAL IMAGERY SOURCE: CIRGIS

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SCALE IN FEET

HALEY ALDRICH

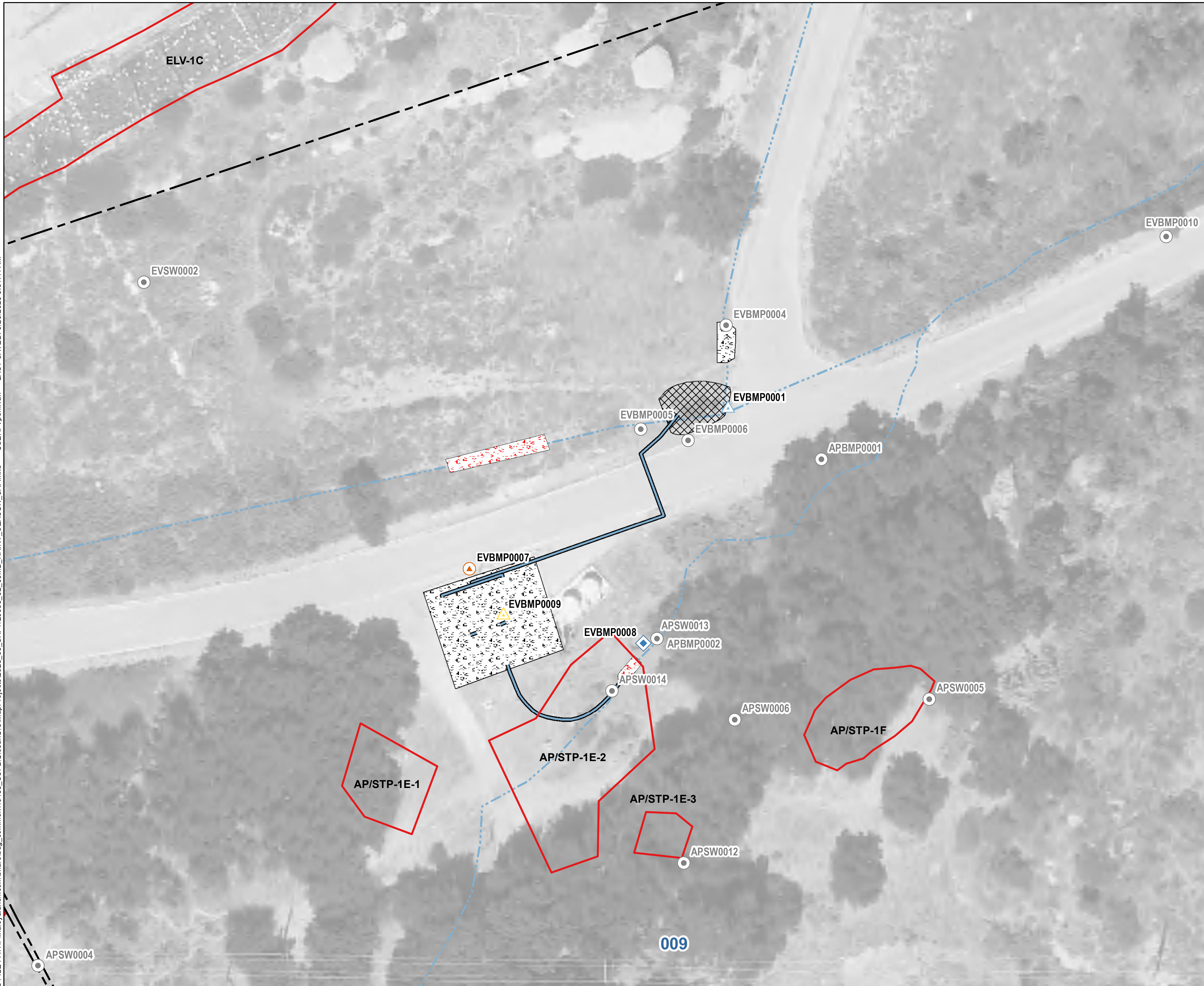
2022/2023 RAINY SEASON MAP
BMP MONITORING PROGRAM
THE BOEING COMPANY
VENTURA COUNTY, CALIFORNIA

OUTFALL 009
A2LF, CM-1, AND HELIPAD
AREAS - NASA

SEPTEMBER 2023

FIGURE 6

GIS FILE PATH: \\haleyaldrich.com\share\sdg_common\40458_SSFL\Global\GIS\MapProjects\2023_08_SAP\129095_02_00MB_RAINY_SEASON_SAP.mxd — USER: Vpehlivan — LAST SAVED: 9/26/2023 8:01:11 AM



LEGEND

- UPSTREAM BMP PERFORMANCE MONITORING LOCATION
- DOWNSTREAM BMP PERFORMANCE MONITORING LOCATION
- MIDPOINT BMP PERFORMANCE MONITORING LOCATION
- PREVIOUS BMP PERFORMANCE MONITORING LOCATION
- POTENTIAL BMP PERFORMANCE MONITORING LOCATION
- DRAINAGE
- CONVEYANCE PIPELINE
- GRAVEL
- RIP RAP
- SEDIMENTAION BASIN
- ISRA EXCAVATION BOUNDARY
- STUDY AREA
- ADMINISTRATIVE AREA BOUNDARY
- SSFL PROPERTY BOUNDARY

NOTES

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2. SAP = SAMPLING AND ANALYSIS PLAN
3. BMP = BEST MANAGEMENT PRACTICE
4. AERIAL IMAGERY SOURCE: CIRGIS

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SCALE IN FEET

HALEY ALDRICH

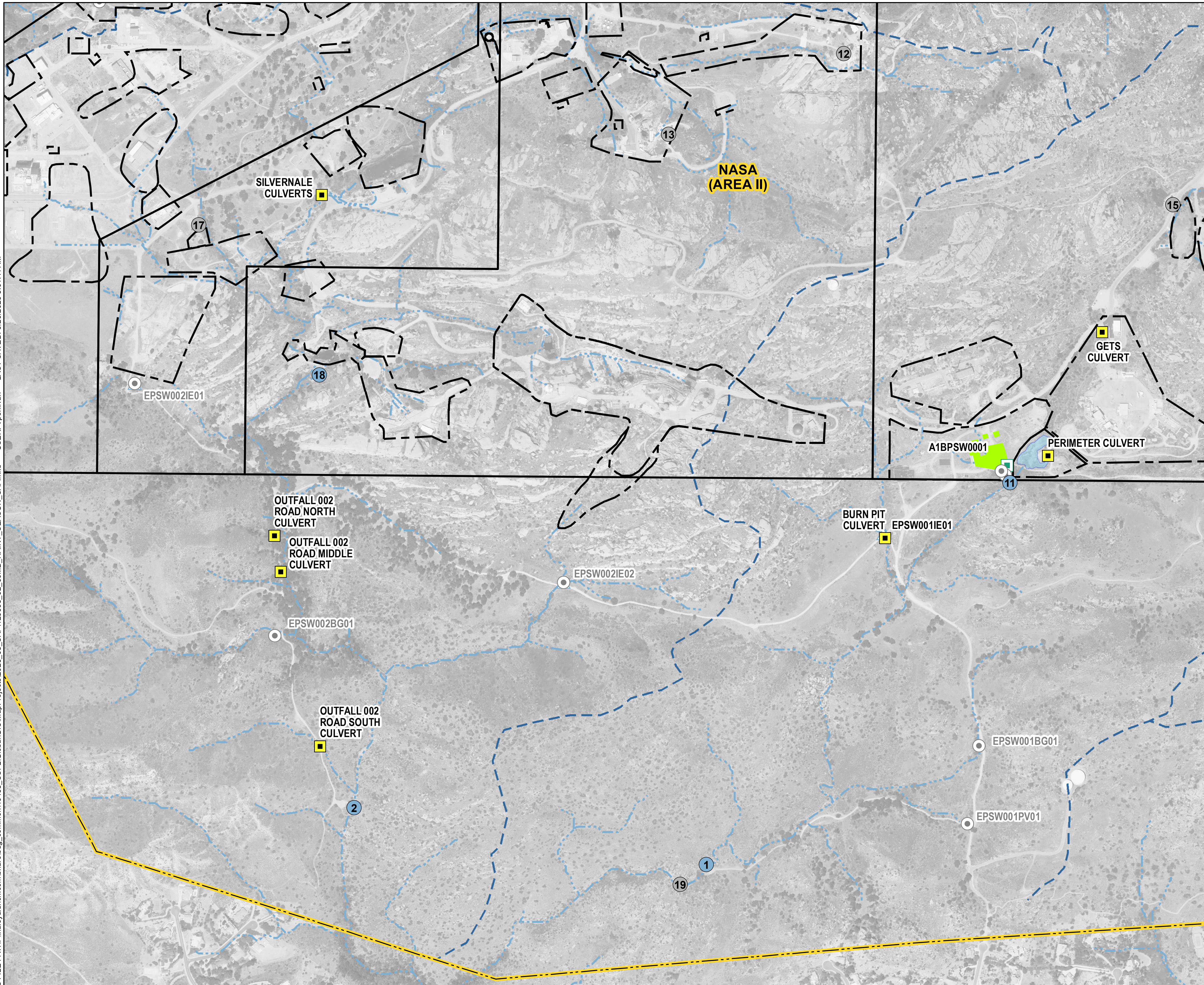
2022/2023 RAINY SEASON MAP
BMP MONITORING PROGRAM
THE BOEING COMPANY
VENTURA COUNTY, CALIFORNIA

OUTFALL 009
ELV AREA - NASA

SEPTEMBER 2023

FIGURE 7

GIS FILE PATH: \\haleyaldrich.com\share\sdg_common\40458_SSFL\Global\GIS\MapProjects\2023_08_SAP\129095_02_00MB_RAINY_SEASON_SAP.mxd — USER: Vpehlivan — LAST SAVED: 9/26/2023 8:01:11 AM



LEGEND

- CULVERT MODIFICATION (CM)
- PREVIOUS BMP PERFORMANCE MONITORING LOCATION
- ALTERNATE BMP PERFORMANCE MONITORING LOCATION
- POTENTIAL BMP PERFORMANCE MONITORING LOCATION
- ACTIVE NPDES OUTFALL
- FORMER NPDES OUTFALL
- DRAINAGE
- SURFACE WATER DIVIDE
- EROSION CONTROL FABRIC/LINER
- SURFACE WATER POND
- STUDY AREA
- ADMINISTRATIVE AREA BOUNDARY
- SSFL PROPERTY BOUNDARY

NOTES

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
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3. BMP = BEST MANAGEMENT PRACTICE
4. AERIAL IMAGERY SOURCE: CIRGIS

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SCALE IN FEET

HALEY ALDRICH

2022/2023 RAINY SEASON MAP
BMP MONITORING PROGRAM
THE BOEING COMPANY
VENTURA COUNTY, CALIFORNIA

OUTFALLS 001 AND 002
POTENTIAL BMP MONITORING LOCATIONS

SEPTEMBER 2023

FIGURE 8

LEGEND

- PREVIOUS BMP PERFORMANCE MONITORING LOCATION
- DRAINAGE
- SSFL PROPERTY BOUNDARY

NOTES

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
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3. BMP = BEST MANAGEMENT PRACTICE
4. AERIAL IMAGERY SOURCE: CIRGIS

HALEY ALDRICH

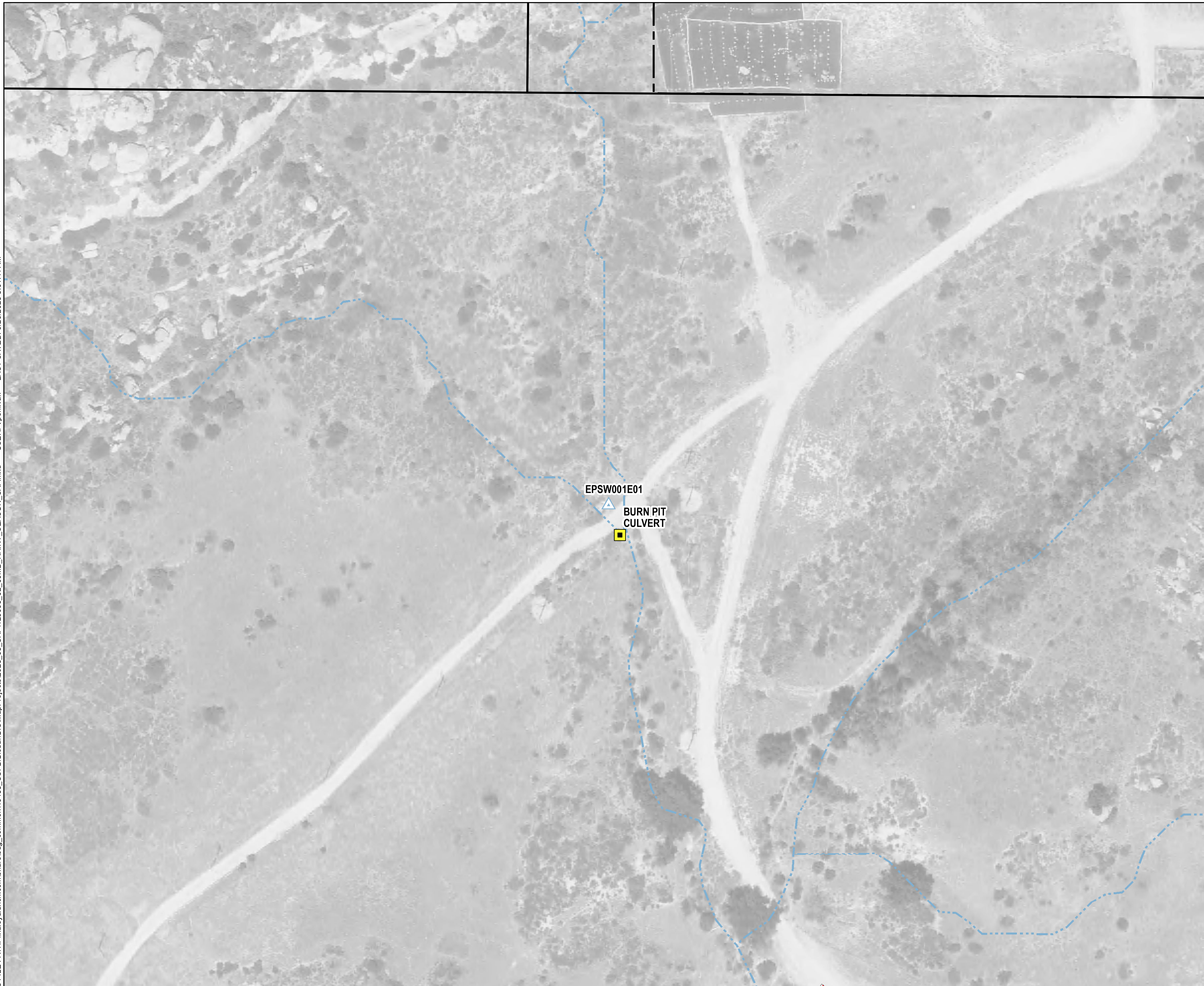
2022/2023 RAINY SEASON MAP
BMP MONITORING PROGRAM
THE BOEING COMPANY
VENTURA COUNTY, CALIFORNIA

OUTFALL 001
POTENTIAL BMP SUBAREA

SEPTEMBER 2023

FIGURE 9

GIS FILE PATH: \\haleyaldrich.com\share\sdg_common\40458_SSFL\Global\GIS\MapProjects\2023_08_SAP\129095_02_00MB_RAINY_SEASON_SAP.mxd — USER: Vpehlivan — LAST SAVED: 9/26/2023 8:01:11 AM



LEGEND

- CULVERT MODIFICATION (CM)
- POTENTIAL BMP PERFORMANCE MONITORING LOCATION
- DRAINAGE
- RIP RAP
- STUDY AREA
- ADMINISTRATIVE AREA BOUNDARY
- SSFL PROPERTY BOUNDARY

NOTES

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
2. SAP = SAMPLING AND ANALYSIS PLAN
3. BMP = BEST MANAGEMENT PRACTICE
4. AERIAL IMAGERY SOURCE: CIRGIS

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SCALE IN FEET

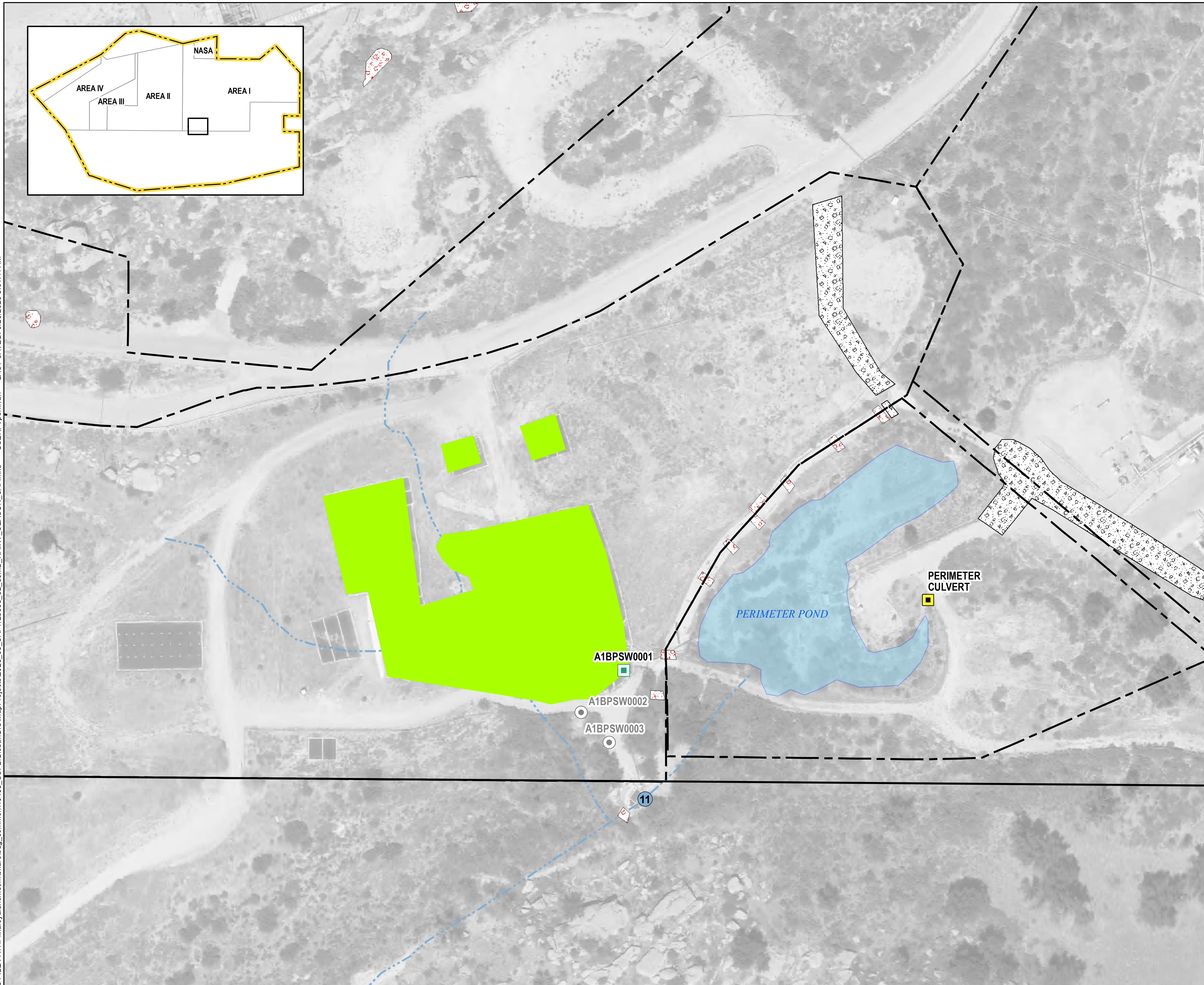
HALEY ALDRICH

2022/2023 RAINY SEASON MAP
BMP MONITORING PROGRAM
THE BOEING COMPANY
VENTURA COUNTY, CALIFORNIA

OUTFALL 001
POTENTIAL BMP SUBAREA

SEPTEMBER 2023

FIGURE 10



LEGEND

- CULVERT MODIFICATION (CM)
- PREVIOUS BMP PERFORMANCE MONITORING LOCATION
- ALTERNATE BMP PERFORMANCE MONITORING LOCATION
- ACTIVE NPDES OUTFALL
- DRAINAGE
- EROSION CONTROL FABRIC/LINER
- GRAVEL
- RIP RAP
- SURFACE WATER POND
- STUDY AREA
- ADMINISTRATIVE AREA BOUNDARY
- SSFL PROPERTY BOUNDARY

NOTES

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
2. SAP = SAMPLING AND ANALYSIS PLAN
3. BMP = BEST MANAGEMENT PRACTICE
4. AERIAL IMAGERY SOURCE: CIRGIS

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SCALE IN FEET

HALEY ALDRICH

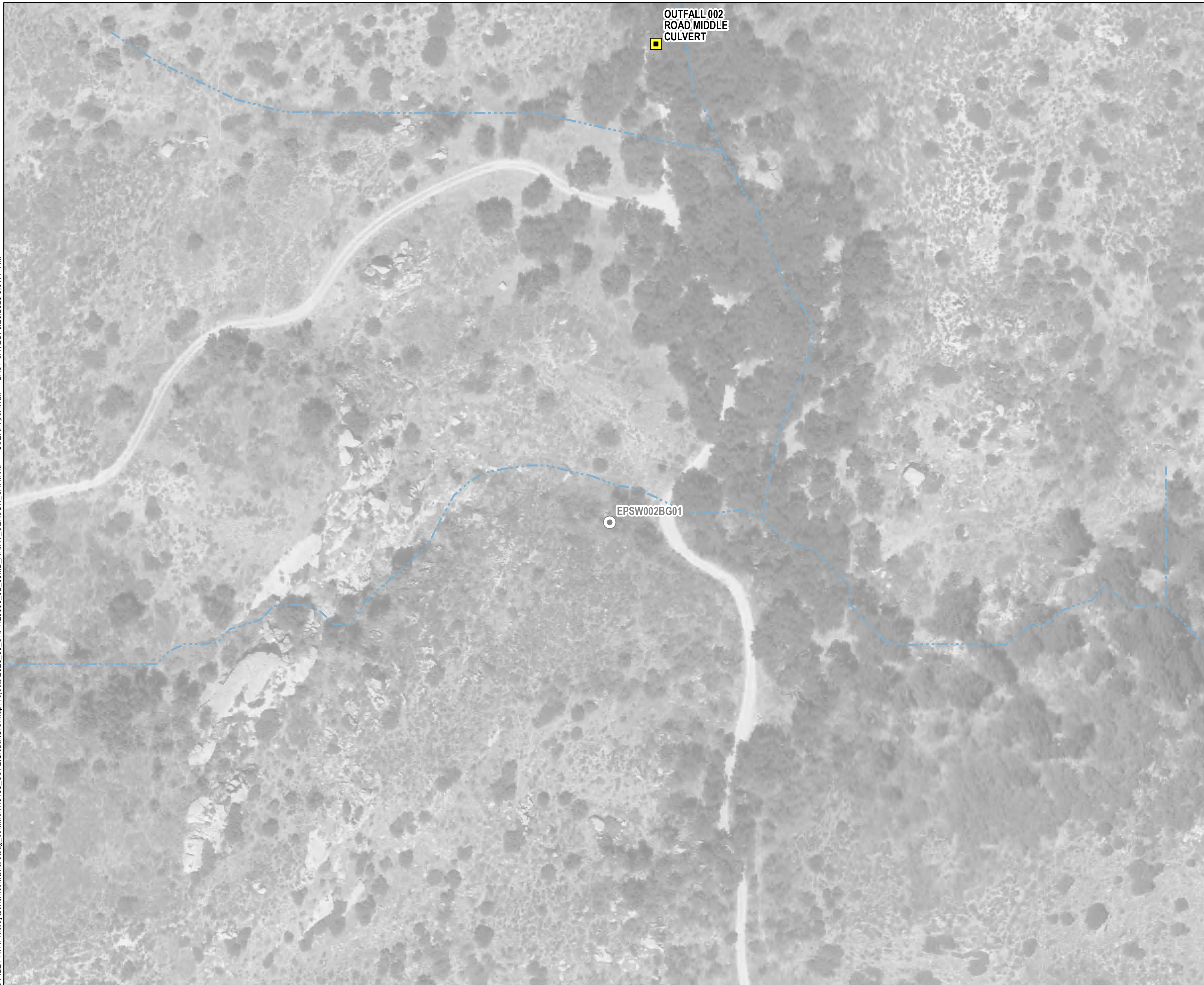
2022/2023 RAINY SEASON MAP
BMP MONITORING PROGRAM
THE BOEING COMPANY
VENTURA COUNTY, CALIFORNIA

OUTFALL 011
AREA 1 BURN PIT

SEPTEMBER 2023

FIGURE 11

GIS FILE PATH: \\haleyaldrich.com\share\sdg_common\40458_SSFL\Global\GIS\MapProjects\2023_08_SAP\129095_02_00MB_RAINY_SEASON_SAP.mxd — USER: Vpehlivan — LAST SAVED: 9/26/2023 8:01:11 AM



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LEGEND

- CULVERT MODIFICATION (CM)
- PREVIOUS BMP PERFORMANCE MONITORING LOCATION
- DRAINAGE
- SSFL PROPERTY BOUNDARY

NOTES

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
2. SAP = SAMPLING AND ANALYSIS PLAN
3. BMP = BEST MANAGEMENT PRACTICE
4. AERIAL IMAGERY SOURCE: CIRGIS

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SCALE IN FEET

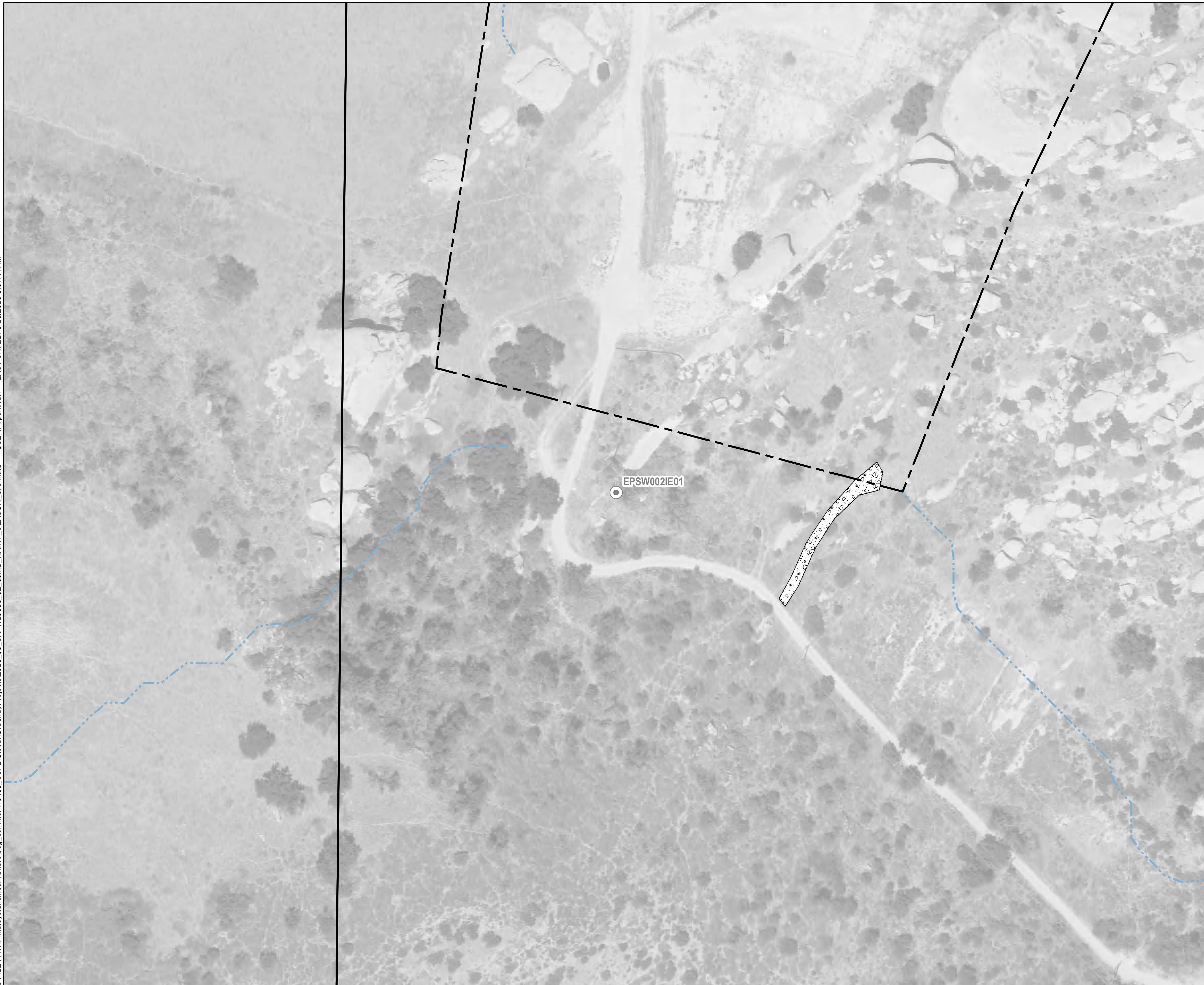
HALEY ALDRICH

2022/2023 RAINY SEASON MAP
BMP MONITORING PROGRAM
THE BOEING COMPANY
VENTURA COUNTY, CALIFORNIA

OUTFALL 002
POTENTIAL BMP SUBAREA

SEPTEMBER 2023

FIGURE 12



LEGEND

- PREVIOUS BMP PERFORMANCE MONITORING LOCATION
- DRAINAGE
- GRAVEL
- STUDY AREA
- ADMINISTRATIVE AREA BOUNDARY
- SSFL PROPERTY BOUNDARY

NOTES

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
2. SAP = SAMPLING AND ANALYSIS PLAN
3. BMP = BEST MANAGEMENT PRACTICE
4. AERIAL IMAGERY SOURCE: CIRGIS

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SCALE IN FEET

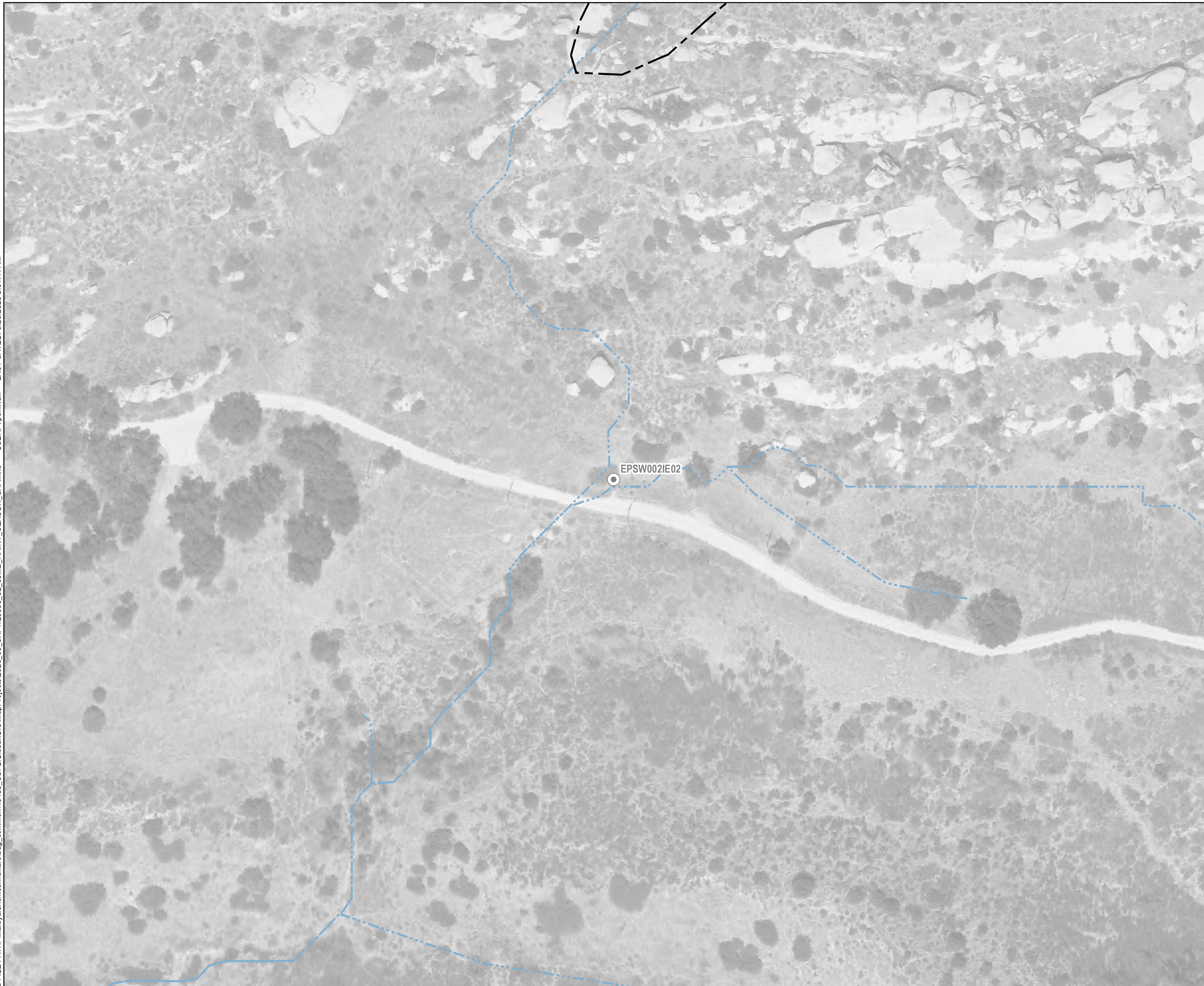
HALEY ALDRICH

2022/2023 RAINY SEASON MAP
BMP MONITORING PROGRAM
THE BOEING COMPANY
VENTURA COUNTY, CALIFORNIA

OUTFALL 002
POTENTIAL BMP SUBAREA

SEPTEMBER 2023

FIGURE 13



LEGEND

- PREVIOUS BMP PERFORMANCE MONITORING LOCATION
- DRAINAGE
- STUDY AREA
- SSFL PROPERTY BOUNDARY

NOTES

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
2. SAP = SAMPLING AND ANALYSIS PLAN
3. BMP = BEST MANAGEMENT PRACTICE
4. AERIAL IMAGERY SOURCE: CIRGIS

N

0 100 200
SCALE IN FEET

HALEY ALDRICH

2022/2023 RAINY SEASON MAP
BMP MONITORING PROGRAM
THE BOEING COMPANY
VENTURA COUNTY, CALIFORNIA

OUTFALL 002
POTENTIAL BMP SUBAREA

SEPTEMBER 2023

FIGURE 14

GIS FILE PATH: \\haleyaldrich.com\share\sdg_common\40458_SSFL\Global\GIS\MapProjects\2023_08_SAP\129095_02_00MB_RAINY_SEASON_SAP.mxd — USER: Vpehlivan — LAST SAVED: 9/26/2023 8:01:11 AM

LEGEND

- CULVERT MODIFICATION (CM)
- DRAINAGE
- RIP RAP
- ADMINISTRATIVE AREA BOUNDARY
- SSFL PROPERTY BOUNDARY

NOTES

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
2. SAP = SAMPLING AND ANALYSIS PLAN
3. BMP = BEST MANAGEMENT PRACTICE
4. AERIAL IMAGERY SOURCE: CIRGIS

N

0 50 100
SCALE IN FEET

HALEY ALDRICH

2022/2023 RAINY SEASON MAP
BMP MONITORING PROGRAM
THE BOEING COMPANY
VENTURA COUNTY, CALIFORNIA

OUTFALL 009
CM-11

SEPTEMBER 2023

FIGURE 15

GIS FILE PATH: \\haleyaldrich.com\share\sdg_common\40458_SSFL\Global\GIS\MapProjects\2023_08_SAP\129095_02_00MB_RAINY_SEASON_SAP.mxd — USER: Vpehlivan — LAST SAVED: 9/26/2023 8:01:11 AM

ATTACHMENTS

Boeing

Happy Valley - Road Leading Down to Lower BMP Area

BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

Happy Valley - Road Leading Down to Lower BMP Area

Inspection Status: **Conducted/Not Conducted**

Inspection Checklist Questions:	*Inspection Answers:*
During Rain Event Inspection	
Any odors, suspended materials, floating material, etc. observed?	No/Yes/NA with comment
Are erosion/sediment controls in good condition?	No/Yes/NA with comment
Is the road leading down to BMP area free of erosion?	No/Yes/NA with comment
Are rip rap berms free of sediment/debris?	No/Yes/NA with comment
Are upstream areas free of erosion or sediment?	No/Yes/NA with comment

Corrective action identified during this inspection event: No/Yes/NA with comment

General Comments:

Signature

Boeing

Happy Valley - Road Leading Down to Lower BMP Area

BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

Insert photo here

Photo LBMP-1: Overview of HVS Lower BMP Area (from top of road east)

Insert photo here

Photo LBMP-2: Overview of HVS Lower BMP Area (from top of road west)

General Comments:

Signature

Boeing

OF008
BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

OF008 Inspection Status: **Conducted/Not Conducted**

Inspection Checklist Questions:	*Inspection Answers:*
During Rain Event Inspection	
Any odors, suspended materials, floating material, etc. observed?	No/Yes/NA with comment
Are erosion/sediment controls in good condition?	No/Yes/NA with comment
Are upstream areas free of erosion or sediment?	No/Yes/NA with comment

Corrective action identified during this inspection event: No/Yes/NA with comments

General Comments:

Signature

Boeing

OF008

BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

Insert photo here

Photo OF008-1: HVS Drainage and Tributary Drainage Overview (looking north)

Insert photo here

Photo OF008-2: Outfall 008 Overview

Insert photo here

Photo OF008-3: Tributary Drainage Check Dams

General Comments:

Signature

Boeing

OF009 ADMINISTRATION BUILDING AREA

BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

OF009 Administration Building Area Inspection Status: **Conducted/Not Conducted**

Inspection Checklist Questions:	*Inspection Answers:*
During Rain Event Inspection	
Any odors, suspended materials, floating material, etc. observed?	No/Yes/NA with comment
Is any short-circuiting present around the lip of the filter basket?	No/Yes/NA with comment

Corrective action identified during this inspection event: No/Yes/NA with comment

General Comments:

Signature

Boeing

OF009 ADMINISTRATION BUILDING AREA

BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

Insert photo here

Photo OF009-1: Filter Basket Overview

General Comments:

Signature

Boeing

OF009 Lower Parking Lot

BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

General Comments:

Signature

Boeing

OF009 Lower Parking Lot

BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

Insert photo here

Photo LPL-1: Cistern area

Insert photo here

Photo LPL-2: Looking down into low flow diversion structure

Insert photo here

Photo LPL-3: Grated inlet and concrete curb

Insert photo here

Photo LPL-4: Wooden retaining wall

General Comments:

Signature

Boeing

OF009 Lower Parking Lot

BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

Insert photo here

Photo 3: LPBMP0002: Lower Lot Area, Upstream BMP; Sample Port in Cistern Discharge Pipe

Insert photo here

Photo 4: LPBMP0003: Lower Lot Area, Mid-Point Lower Lot BMP; Sediment Basin Outlet Box

Insert photo here

Photo 5: LPBMP0004: Lower Lot Area, Downstream Lower Lot Treatment BMP; Discharge from Biofilter Effluent Pipe

General Comments:

Signature

Boeing

OF009 Sediment Basin

BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

OF009 Sediment Basin Inspection Status: **Conducted/Not Conducted**

Inspection Checklist Questions:	*Inspection Answers:*
During Rain Event Inspection	
Any odors, suspended materials, floating material, etc. observed?	No/Yes/NA with comment
Are erosion/sediment controls in good condition?	No/Yes/NA with comment
Is there overflow into the lower lot?	No/Yes/NA with comment
If above is YES, please record a video.	N/A

Corrective action identified during this inspection event: No/Yes/NA with comment

General Notes:

Signature

Boeing

OF009 Sediment Basin

BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

Insert photo here

Photo SB-1: Sediment Basin Overview

Insert photo here

Photo SB-2: Inside Sediment Basin Riser Structure

General Notes:

Signature

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

OF009 BIOFILTER Inspection Status: **Conducted/Not Conducted**

Inspection Checklist Questions:	*Inspection Answers:*
During Rain Event Inspection	
Any odors, suspended materials, floating material, etc. observed?	No/Yes/NA with comment
Are erosion/sediment controls in good condition?	No/Yes/NA with comment
Are upstream areas free of erosion or sediment?	No/Yes/NA with comment
Is there flow overtopping the riser structure?	No/Yes/NA with comment
If above is YES, does the underdrain appear to be constricted?	No/Yes/NA with comment
If above is YES, please record a video.	N/A
Is there flow in the riser structure?	No/Yes/NA with comment

Corrective action identified during this inspection event: No/Yes/NA with comment

General Notes:

Signature

Boeing

OF009 BIOFILTER

BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

Insert photo here

Photo BF-1: Sediment Basin Discharge Pipe

Insert photo here

Photo BF-2: Biofilter Overview

Insert photo here

Photo BF-3: Biofilter Discharge Pipe

Insert photo here

Photo BF-4: Biofilter Outlet Structure

General Notes:

Signature

Boeing

OF009 CM-9 A1LF Area

BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

OF009 CM-9 AILF Area *Inspection Checklist Questions:*	Inspection Status: **Conducted/Not Conducted** *Inspection Answers:*
During Rain Event Inspection	
Any odors, suspended materials, floating material, etc. observed?	No/Yes/NA with comment
Are erosion/sediment controls in good condition?	No/Yes/NA with comment
Are upstream areas free of erosion or sediment?	No/Yes/NA with comment
Is there flow overtopping the weir board?	No/Yes/NA with comment
If above is YES, does the underdrain appear to be constricted?	No/Yes/NA with comment
If above is YES, please record a video.	N/A
Is the upstream perforated pipeline draining properly?	No/Yes/NA with comment
Is the culvert basin clear of unwanted sediment/debris?	No/Yes/NA with comment
If above is NO, note approximate depth	Depth
Is the inlet swale along Area II Road clear of unwanted sediment/debris?	No/Yes/NA with comment
Is rip rap berm clear of unwanted sediment/debris?	No/Yes/NA with comment
Is any water observed coming out of landfill slope?	No/Yes/NA with comment

Corrective action identified during this inspection event: No/Yes/NA with comment

General Notes:

Signature

Boeing

OF009 CM-9 A1LF Area

BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

Insert photo here

Photo CM9-1: Asphalt Swale Inlet from Area 2 Road – ILBMP0002

Insert photo here

Photo CM9-2a: CM-9 Basin Overview (Upstream)

Insert photo here

Photo CM9-2b:
CM-9 Basin Overview (Towards Weir Boards)

Insert photo here

Photo CM9-3a: Along Perforated Pipeline (upstream)

General Notes:

Signature

Boeing

OF009 CM-9 A1LF Area

BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

Insert photo here

Photo CM9-3b: Along Perforated Pipeline (downstream)

Insert photo here

Photo CM9-4a: Rip Rap Berm (upstream)

Insert photo here

Photo CM9-4b: Rip Rap Berm (downstream)

Insert photo here

Photo 6: A1BMP0002: CM-9 Area, Upstream (South), CM-9 BMPs

General Notes:

Signature

Boeing

OF009 CM-9 A1LF Area

BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

Insert photo here

Photo 7: A1BMP0003: CM-9 Area, Downstream, CM-9 BMPs; CM-9 Underdrains

Insert photo here

Photo 8: ILBMP0002: CM-9 Area, Upstream (East), CM-9 BMPs; Culvert Inlet Off Area II Road

General Notes:

Signature

Boeing

OF009 B-1 Retention Basin

BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

OF009 B-1 Retention Basin Inspection Status: **Conducted/Not Conducted**

Inspection Checklist Questions:	*Inspection Answers:*
During Rain Event Inspection	
Any odors, suspended materials, floating material, etc. observed?	No/Yes/NA with comment
Are erosion/sediment controls in good condition?	No/Yes/NA with comment
Are upstream areas free of erosion or sediment?	No/Yes/NA with comment
Is the retention basin clear of unwanted sediment/debris?	No/Yes/NA with comment
Is the perimeter of the basin free of erosion?	No/Yes/NA with comment

Corrective action identified during this inspection event: No/Yes/NA with comment

General Notes:

Signature

Boeing

OF009 B-1 Retention Basin

BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

Insert photo here

Photo B1RB-1: B-1 Retention Overview

Insert photo here

Photo B1RB-2: Close-up of Riser Structure in Retention Basin

General Notes:

Signature

Boeing

OF009 Upper Lot Media Filter
BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

OF009 Upper Lot Media Filter Inspection Status: **Conducted/Not Conducted**

Inspection Checklist Questions:	*Inspection Answers:*
During Rain Event Inspection	
Any odors, suspended materials, floating material, etc. observed?	No/Yes/NA with comment
Are erosion/sediment controls in good condition?	No/Yes/NA with comment
Are upstream areas free of erosion or sediment?	No/Yes/NA with comment
Is there flow overtopping the box?	No/Yes/NA with comment
If above is YES, does the underdrain appear to be constricted?	No/Yes/NA with comment
If above is YES, please record a video.	N/A
Is hillside free of erosion?	No/Yes/NA with comment
Is the asphalt/Gunite Swale going towards Upper Lot Media Filter clear of unwanted sediment/debris?	No/Yes/NA with comment
Note % flow from each underdrain	%

Corrective action identified during this inspection event: No/Yes/NA with comment

General Notes:

Signature

Boeing

OF009 Upper Lot Media Filter

BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

Insert photo here

Photo ULMF-1: Upper Lot Media Filter Overview

Insert photo here

Photo ULMF-2: Upper Lot Retention Basin Discharge Pipe (inside of the riser structure)

Insert photo here

Photo ULMF-3: ULMF Area, Gunite Swale Conveying Road Runoff

Insert photo here

Photo 9: B1BMP0009: B-1 Area, Gunite Swale Conveying Road Runoff

General Notes:

Signature

Boeing

OF009 Upper Lot Media Filter

BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

Insert photo here

Photo 10: B1BMP0010: B-1 Area, Culvert Outlet from Upper Parking Lot Area

Insert photo here

Photo 11: B1BMP0011: B-1 Area, Underdrains

General Notes:

Signature

Boeing

OF009 Detention Bioswales

BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

OF009 Detention Bioswales Inspection Status: **Conducted/Not Conducted**

Inspection Checklist Questions:	*Inspection Answers:*
During Rain Event Inspection	
Any odors, suspended materials, floating material, etc. observed?	No/Yes/NA with comment
Are erosion/sediment controls in good condition?	No/Yes/NA with comment
Are upstream areas free of erosion or sediment?	No/Yes/NA with comment
Is rip rap swale clear of unwanted sediment/debris?	No/Yes/NA with comment
Are vegetated swales in good condition?	No/Yes/NA with comment
Note % flow from northern underdrain	%
Note % flow from southern underdrain	%

Corrective action identified during this inspection event: No/Yes/NA with comment

General Notes:

Signature

Boeing

OF009 Detention Bioswales

BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

Insert photo here

Photo B1DB-1: Northern B1436 Bioswale Overview (from the north end)

Insert photo here

Photo B1DB-2: Northern B1436 Bioswale Overview (from the south end)

Insert photo here

Photo B1DB-3: Southern B1436 Bioswale Overview (from the north end)

Insert photo here

Photo B1DB-4: Southern B1436 Bioswale Overview (from the south end)

General Notes:

Signature

Boeing

OF009 Detention Bioswales

BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

Insert photo here

Photo B1DB-5: Western Swale Inlet to Southern B1436 Bioswale

Insert photo here

Photo B1DB-6: Eastern Swale Inlet to Southern B1436 Bioswale

Insert photo here

Photo 12: ILBMP0004: Upstream, B1436 Southern Detention Bioswale (Concrete Swale Diverting Sheet Flow into Rock Crib – West)

Insert photo here

Photo 13: ILBMP0008: Upstream, B1436 Southern Detention Bioswale (Concrete Swale Diverting Sheet Flow into Rock Crib – East)

General Notes:

Signature

Boeing

OF009 Detention Bioswales

BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

Insert photo here

Photo 14: ILBMP0005: Downstream, B1436 Southern Detention Bioswale; 12-inch Underdrain

General Notes:

Signature

Boeing

OF009 CM-8
BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

OF009 CM-8 Inspection Status: **Conducted/Not Conducted**

Inspection Checklist Questions:	*Inspection Answers:*
During Rain Event Inspection	
Any odors, suspended materials, floating material, etc. observed?	No/Yes/NA with comment
Are erosion/sediment controls in good condition?	No/Yes/NA with comment
Are upstream areas free of erosion or sediment?	No/Yes/NA with comment
Is the culvert basin clear of unwanted sediment/debris?	No/Yes/NA with comment
If above is NO, note approximate depth	Depth
Is there flow overtopping the weir boards?	No/Yes/NA with comment
If above is YES, does the underdrain appear to be constricted?	No/Yes/NA with comment
If above is YES, please record a video.	N/A

Corrective action identified during this inspection event: No/Yes/NA with comment

General Notes:

Signature

Boeing

OF009 CM-8
BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

Insert photo here

Photo CM8-1a: CM-8 Basin Overview (Upstream)

Insert photo here

Photo CM8-1b: CM-8 Basin Overview (Towards Weir Boards)

Insert photo here

Photo 15: A1SW0002: CM-8 upstream, before treatment. Influent sample only.

General Notes:

Signature

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

OF009 CM-11 Inspection Status: **Conducted/Not Conducted**

Inspection Checklist Questions:	*Inspection Answers:*
During Rain Event Inspection	
Any odors, suspended materials, floating material, etc. observed?	No/Yes/NA with comment
Are erosion/sediment controls in good condition?	No/Yes/NA with comment
Are upstream areas free of erosion or sediment?	No/Yes/NA with comment
Is the culvert basin clear of unwanted sediment/debris?	No/Yes/NA with comment
If above is NO, note approximate depth	Depth
Is there flow overtopping the weir boards?	No/Yes/NA with comment
If above is YES, does the underdrain appear to be constricted?	No/Yes/NA with comment
If above is YES, please record a video.	N/A

Corrective action identified during this inspection event: No/Yes/NA with comment

General Notes:

Signature

Boeing

OF009 CM-11

BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

Insert photo here

Photo CM11-1a: CM-11 Basin Overview (Upstream)

Insert photo here

Photo CM11-1b: CM-11 Basin Overview (Towards Weir Boards)

Insert photo here

Photo 16: A1SW0006: CM-11 upstream, before treatment. Influent sample only.

General Notes:

Signature

Boeing

OF009 CM-7

BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

OF009 CM-7 Inspection Status: **Conducted/Not Conducted**

Inspection Checklist Questions:	*Inspection Answers:*
During Rain Event Inspection	
Any odors, suspended materials, floating material, etc. observed?	No/Yes/NA with comment
Are erosion/sediment controls in good condition?	No/Yes/NA with comment
Are upstream areas free of erosion or sediment?	No/Yes/NA with comment
Are the upstream swales clear of unwanted sediment/debris?	No/Yes/NA with comment

Corrective action identified during this inspection event: No/Yes/NA with comment

General Notes:

Signature

Boeing

OF009 CM-7

BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

Insert photo here

Photo CM7-1: CM-7 Upstream

General Notes:

Signature

Boeing

OF009 CM-6

BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

OF009 CM-6 Inspection Status: **Conducted/Not Conducted**

Inspection Checklist Questions:	*Inspection Answers:*
During Rain Event Inspection	
Any odors, suspended materials, floating material, etc. observed?	No/Yes/NA with comment
Are erosion/sediment controls in good condition?	No/Yes/NA with comment
Are upstream areas free of erosion or sediment?	No/Yes/NA with comment
Is the culvert basin clear of unwanted sediment/debris?	No/Yes/NA with comment
If above is NO, note approximate depth	Depth
Is there flow overtopping the weir boards?	No/Yes/NA with comment
If above is YES, does the underdrain appear to be constricted?	No/Yes/NA with comment
If above is YES, please record a video.	N/A

Corrective action identified during this inspection event: No/Yes/NA with comment

General Notes:

Signature

Boeing

OF009 CM-6

BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

Insert photo here

Photo CM6-1a: CM-6 Basin Overview (Upstream)

Insert photo here

Photo CM6-1b: CM-6 Basin Overview (Towards Weir Boards)

General Notes:

Signature

Boeing

OF009 CM-12 Sage Ranch

BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

OF009 CM-5 Sage Ranch Inspection Status: **Conducted/Not Conducted**

Inspection Checklist Questions:	*Inspection Answers:*
During Rain Event Inspection	
Any odors, suspended materials, floating material, etc. observed?	No/Yes/NA with comment
Are erosion/sediment controls in good condition?	No/Yes/NA with comment
Are upstream areas free of erosion or sediment?	No/Yes/NA with comment
Is the culvert basin clear of unwanted sediment/debris?	No/Yes/NA with comment
If above is NO, note approximate depth	Depth
Is there flow overtopping the weir boards?	No/Yes/NA with comment
If above is YES, does the underdrain appear to be constricted?	No/Yes/NA with comment
If above is YES, please record a video.	N/A

Corrective action identified during this inspection event: No/Yes/NA with comment

General Notes:

Signature

Boeing

OF009 CM-12 Sage Ranch

BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

Insert photo here

Photo CM5-1a: CM-5 Basin Overview (Upstream)

Insert photo here

Photo CM5-1b: CM-5 Basin Overview (Towards Weir Boards)

Insert photo here

Photo 17: BGBMP0003: Near LOX by Sage Ranch Loop Trail

Insert photo here

Photo 18: BGBMP0004: CM-5 tributary drainage East of LOX

General Notes:

Signature

Boeing

OF009 CM-12 Sage Ranch

BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

Insert photo here

Photo 19: EPNDSW04: CM-5 tributary drainage Southeast of LOX

General Notes:

Signature

Boeing

OF009 CM-12 Sage Ranch
BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

OF009 CM-12 Sage Ranch Inspection Status: **Conducted/Not Conducted**

Inspection Checklist Questions:	*Inspection Answers:*
During Rain Event Inspection	
Any odors, suspended materials, floating material, etc. observed?	No/Yes/NA with comment
Are erosion/sediment controls in good condition?	No/Yes/NA with comment
Are upstream areas free of erosion or sediment?	No/Yes/NA with comment
Is the culvert basin clear of unwanted sediment/debris?	No/Yes/NA with comment
If above is NO, note approximate depth	Depth
Is there flow overtopping the weir boards?	No/Yes/NA with comment
If above is YES, does the underdrain appear to be constricted?	No/Yes/NA with comment
If above is YES, please record a video.	N/A

Corrective action identified during this inspection event: No/Yes/NA with comment

General Notes:

Signature

Boeing

OF009 CM-12 Sage Ranch

BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

Insert photo here

Photo CM12-1a: CM-12 Basin Overview (Upstream)

Insert photo here

Photo CM12-1b: CM-12 Basin Overview (Towards Weir Boards)

General Notes:

Signature

Boeing

OF009 CM-4

BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

OF009 CM-4 Inspection Status: **Conducted/Not Conducted**

Inspection Checklist Questions:	*Inspection Answers:*
During Rain Event Inspection	
Any odors, suspended materials, floating material, etc. observed?	No/Yes/NA with comment
Are erosion/sediment controls in good condition?	No/Yes/NA with comment
Are upstream areas free of erosion or sediment?	No/Yes/NA with comment
Is the culvert basin clear of unwanted sediment/debris?	No/Yes/NA with comment
If above is NO, note approximate depth	Depth
Is there flow overtopping the weir boards?	No/Yes/NA with comment
If above is YES, does the underdrain appear to be constricted?	No/Yes/NA with comment
If above is YES, please record a video.	N/A

Corrective action identified during this inspection event: No/Yes/NA with comment

General Notes:

Signature

Boeing

OF009 CM-4

BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

Insert photo here	*Insert photo here*
Photo CM4-1a: CM-4 Basin Overview (Upstream)	**Photo CM4-1b: CM-4 Basin Overview (Towards Weir Boards)**

General Notes:

Signature

Boeing

OF009 CM-3

BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

OF009 CM-3 Inspection Status: **Conducted/Not Conducted**

Inspection Checklist Questions:	*Inspection Answers:*
During Rain Event Inspection	
Any odors, suspended materials, floating material, etc. observed?	No/Yes/NA with comment
Are erosion/sediment controls in good condition?	No/Yes/NA with comment
Are upstream areas free of erosion or sediment?	No/Yes/NA with comment
Is the culvert basin clear of unwanted sediment/debris?	No/Yes/NA with comment
If above is NO, note approximate depth	Depth
Is there flow overtopping the weir boards?	No/Yes/NA with comment
If above is YES, does the underdrain appear to be constricted?	No/Yes/NA with comment
If above is YES, please record a video.	N/A
Is the drop inlet on the north side of the road clogged or otherwise obstructed?	No/Yes/NA with comment
Is there erosion at the diversion pipe outlet?	No/Yes/NA with comment

Corrective action identified during this inspection event: No/Yes/NA with comment

General Notes:

Signature

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

Insert photo here

Photo CM3-1a: CM-3 Basin Overview (Upstream)

Insert photo here

Photo CM3-1b: CM-3 Basin Overview (Towards Weir Boards)

Insert photo here

Photo CM3-2: CM-3 Roadway Inlet

Insert photo here

Photo CM3-3: CM-3 Diversion Outlet

General Notes:

Signature

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

Insert photo here

Photo 19: LXBMP0010: CM-3 Area, upstream of Service Area Road BMP; Outlet on South Side of Road

Insert photo here

Photo 20: LXBMP0011: CM-3 Area, Upstream of Service Area Road BMP, Natural Drainage Upstream of CM-3

Insert photo here

Photo 21: LXBMP0012: CM-3 Area, Downstream of Service Area Road BMP, Underdrains

General Notes:

Signature

Boeing

OF009 CM-10

BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

OF009 CM-10 Inspection Status: **Conducted/Not Conducted**

Inspection Checklist Questions:	*Inspection Answers:*
During Rain Event Inspection	
Any odors, suspended materials, floating material, etc. observed?	No/Yes/NA with comment
Are erosion/sediment controls in good condition?	No/Yes/NA with comment
Are upstream areas free of erosion or sediment?	No/Yes/NA with comment
Is there flow overtopping the weir boards?	No/Yes/NA with comment
If above is YES, does the underdrain appear to be constricted?	No/Yes/NA with comment
If above is YES, please record a video.	N/A
Is there sediment accumulation in the culvert basin?	No/Yes/NA with comment
If above is YES, record approximate depth.	Depth

Corrective action identified during this inspection event: No/Yes/NA with comment

General Notes:

Signature

Boeing

OF009 CM-10

BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

Insert photo here

Photo CM10-1a: CM-10 Basin Overview (Upstream)

Insert photo here

Photo CM10-1b: CM-10 Basin Overview (Towards Weir Boards)

General Notes:

Signature

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

OF009 CM-2 Inspection Status: **Conducted/Not Conducted**

Inspection Checklist Questions:	*Inspection Answers:*
During Rain Event Inspection	
Any odors, suspended materials, floating material, etc. observed?	No/Yes/NA with comment
Are erosion/sediment controls in good condition?	No/Yes/NA with comment
Are upstream areas free of erosion or sediment?	No/Yes/NA with comment
Is there sediment accumulation in the culvert basin?	No/Yes/NA with comment
If above is YES, record approximate depth.	Depth
Is there flow overtopping the weir boards?	No/Yes/NA with comment
If above is YES, does the underdrain appear to be constricted?	No/Yes/NA with comment
If above is YES, please record a video.	N/A

Corrective action identified during this inspection event: No/Yes/NA with comment

General Notes:

Signature

Boeing

OF009 CM-2

BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

Insert photo here

Insert photo here

Photo CM2-1a: CM-2 Basin Overview (Upstream)

Photo CM2-1b: CM-2 Basin Overview (Towards Weir Boards)

General Notes:

Signature

Boeing

OF011 A1BP

BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

OF011 A1BP Inspection Status: **Conducted/Not Conducted**

Inspection Checklist Questions:	*Inspection Answers:*
During Rain Event Inspection	
Any odors, suspended materials, floating material, etc. observed?	No/Yes/NA with comment
Are erosion/sediment controls in good condition?	No/Yes/NA with comment

Corrective action identified during this inspection event: No/Yes/NA with comment

General Notes:

Signature

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

Insert photo here

Photo 22: A1BPSW0001: Along the edge of A1BP and access road to Outfall 011.

General Notes:

Signature

Boeing

OF001 Watershed

BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

Insert photo here

Photo 23: EPSW001IE01 At the bottom of the hill to the north of the intersection of the Southern Buffer Zone Road and Outfall 001 Road.

General Notes:

Signature

Boeing

OF002 Watershed

BMP Performance Inspection Checklist

Client	**The Boeing Company**	Inspection Date	
Project Name	**Santa Susana**	Inspector Name	
County	**Ventura County**	Inspector Company	
State	**California**	Project Manager	
Inspection Type(s)	**Stormwater Inspection**	Precip. Present	

Insert photo here

Photo 24: EPSW002IE01 At STLV-IV. Immediately past the gates to the southeast; adjacent to the new telephone pole.

General Notes:

Signature

BMP Visual Inspection Form – OF009 NASA

Date/Time of Inspection ______________________

Inspector's Name/Title ______________________ **Signature** ______________________

Weather and Observations		
Precipitation present during inspection?	☐ Yes	☐ No

LOX Area BMPs

Photo #		Photo Location:	LOX Berm Overview (West End)
Photo #		Photo Location:	LOX Berm Overview (East End)
Photo #		Photo Location:	Northern Drainage Overview Where Slope Drains Discharge
Photo #		Additional Photo(s):	

During Rain Event Inspection	Yes	No	N/A	Comments/Corrective Action:
Any odors, suspended material, floating material, etc. observed?				
Are erosion/sediment controls in good condition?				
Are slope drains in good condition?				
Is the gravel bag berm in good condition?				
Are upstream areas free of erosion or sediment? If no, note location and description under comments.				

72 Hours After the End of the Rain Event Inspection	Yes	No	N/A	Comments/Corrective Action:
Any odors, suspended material, floating material, etc. observed?				
Are slope drains in good condition?				
Is the gravel bag berm in good condition?				
Are upstream areas free of erosion or sediment? If no, note location and description under comments.				
Other ______________				

BMP Visual Inspection Form – OF009 NASA

Sandbag Berm – Near LOX Area

Photo # ____________ Photo Location: ____________

Photo # ____________ Photo Location: ____________

Photo # ____________ Photo Location: ____________

Photo # ____________ Additional Photo(s): ____________

During Rain Event Inspection	Yes	No	N/A	Comments/Corrective Action:
Any odors, suspended material, floating material, etc. observed?				
Are the sandbags in good condition?				
Is area behind sandbag berm free of debris/sediment buildup?				
Are upstream areas free of erosion or sediment? If no, note location and description under comments.				

72 Hours After the End of the Rain Event Inspection	Yes	No	N/A	Comments/Corrective Action:
Any odors, suspended material, floating material, etc. observed?				
Are slope drains in good condition?				
Are the sandbags in good condition?				
Is area behind sandbag berm free of debris/sediment buildup?				
Are upstream areas free of erosion or sediment? If no, note location and description under comments.				
Other ____________				

BMP Visual Inspection Form – OF009 NASA

CM-1 Area

Photo #	Photo Location:	
Photo #	Photo Location:	CM-1 Basin Overview (Upstream and Towards Weir Boards)
Photo #	Photo Location:	CM-1 Underdrains
Photo #	Photo Location:	CM-1 Discharge Pipe
Photo #	Photo Location:	Rip Rap Berm Northwest of CM-1
Photo #	Photo Location:	Stormwater Diversion to CM-1

During Rain Event Inspection	Yes	No	N/A	Comments/Corrective Action:
Any odors, suspended materials, floating material, etc. observed?				
Are erosion/sediment controls in good condition?				
Is there flow overtopping the weir boards? If yes, does the underdrain appear to be constricted? If yes, please record a video.				
Are underdrains in good condition? Note approximate % flow from each underdrain under comments.				
Is there sediment accumulation in the culvert basin? If yes, record approximate depth under comments.				
Any excessive ponding in front of sandbags at NW entrance?				
Are upstream areas free of erosion or sediment? If no, note location and description under comments.				
Is the drop inlet on the north side of the road clogged or otherwise obstructed?				
Is there erosion at the diversion pipe outlet?				

BMP Visual Inspection Form – OF009 NASA

CM-1 Area				
72 Hours After the End of the Rain Event Inspection	Yes	No	N/A	Comments/Corrective Action:
Any odors, suspended materials, floating material, etc. observed?				
Are erosion/sediment controls in good condition?				
Is a recent high-water mark visible on weir boards? If yes, record depth from top of weir boards.				
Is water ponded in front of weir boards? If yes, record depth from top of weir boards.				
Is weir board filter fabric in good condition?				
Is there sediment accumulation in the culvert basin? If yes, record approximate depth under comments.				
Are upstream areas free of erosion or sediment? If no, note location and description under comments.				
Is the drop inlet on the north side of the road clogged or otherwise obstructed?				
Is there erosion at the diversion pipe outlet?				
Other ______				

BMP Visual Inspection Form – OF009 NASA

ELV Treatment BMP & ELV Channel

Photo #		Photo Location:	ELV Channel (Up- and Downstream)
Photo #		Photo Location:	ELV Settling Basin (looking towards intake pipe)
Photo #		Photo Location:	ELV Settling Basin (looking towards overflow bypass and culvert inlet)
Photo #		Photo Location:	ELV Treatment BMP Discharge Pipe
Photo #		Photo Location:	ELV Treatment BMP Tank Array Overview
Photo #		Additional Photo(s):	

During Rain Event Inspection / 72 Hours After the End of the Rain Event Inspection	Yes	No	N/A	Comments/Corrective Action:
Are erosion/sediment controls in good condition?				
Is ELV channel rip rap in good condition?				
Are fiber rolls and jute matting in good condition?				
Is influent screen free of debris (no clogging)?				
Is basin intake pipe in good condition?				
Is the settling basin in good condition?				
Is tank array and associated piping in good condition?				
Is effluent pipe in good condition?				
Are upstream areas free of erosion or sediment? If no, note location and description under comments.				
Other ______________				

BMP Visual Inspection Form – OF009 NASA

Sandbag Berm – Near ELV Treatment BMP

Photo #		Photo Location:	
Photo #		Photo Location:	
Photo #		Photo Location:	
Photo #		Additional Photo(s):	

	Yes	No	N/A	Comments/Corrective Action:
<u>During Rain Event Inspection</u>				
Are the sandbags in good condition?				
Is area behind sandbag berm free of debris/sediment buildup?				
Are upstream areas free of erosion or sediment? If no, note location and description under comments.				
<u>72 Hours After the End of the Rain Event Inspection</u>				
Are the sandbags in good condition?				
Is area behind sandbag berm free of debris/sediment buildup?				
Are upstream areas free of erosion or sediment? If no, note location and description under comments.				
Is water ponded in front of sandbags? If yes, record depth from top of weir boards.				
Other ________				

BMP Visual Inspection Form – OF009 NASA

Helipad Area BMPs

Photo #		Photo Location:	Helipad Berm Overview (Eastern Berm)
Photo #		Photo Location:	Helipad Berm Overview (Western Berm)
Photo #		Photo Location:	Culvert Inlet Passing Beneath Helipad Road
Photo #		Photo Location:	
Photo #		Additional Photo(s):	

During Rain Event Inspection	Yes	No	N/A	Comments/Corrective Action:
Are the Helipad Berms in good condition?				
Are upstream areas free of erosion or sediment? If no, note location and description under comments.				
Is area behind Helipad Berms free of debris/sediment buildup?				
Is parking lot free of excessive debris/sediment?				
Is water overtopping the Helipad Berm? If yes, note which berm(s) are being overtopped. If yes, please record a video.				
72 Hours After the End of the Rain Event Inspection				
Are the Helipad Berms in good condition?				
Are upstream areas free of erosion or sediment? If no, note location and description under comments.				
Is area behind Helipad Berms free of debris/sediment buildup?				
Is parking lot free of excessive debris/sediment?				
Other ______				

BMP Visual Inspection Form – OF009 NASA

Additional Notes/Observations

Boeing 72 Hours After Rain Event Ponding Inspection Form

Perform inspection after each storm exceeding 0.75 inches of rain.

Date/Time of Inspection ______________________

Inspector's Name/Title ______________________ **Signature** ______________________

Culvert Modification	Ponding? Yes	Ponding? No	Depth (feet)
CM-2			
CM-3			
CM-4			
CM-5			
CM-6			
CM-8			
CM-9			
CM-10			
CM-11			
CM-12			
SEDIMENT BASIN			
BIOFILTER			
UPPER LOT MEDIA FILTER			
NORTHERN DETENTION BIOSWALE			
SOUTHERN DETENTION BIOSWALE			
ADMIN AREA FILTER BASKET			

NASA 72 Hours After Rain Event Ponding Inspection Form

Perform inspection after each storm exceeding 0.75 inches of rain.

Date/Time of Inspection ______________________

Inspector's Name/Title ______________________ **Signature** ______________________

Culvert Modification	Ponding? Yes	Ponding? No	Depth (feet)
CM-1			
ELV			

Surface Water Monitoring Inspection and Sample Collection Form
PERFORMANCE MONITORING and BMP MONITORING PROGRAMS

Sampling Responsibility: NASA
Inspector/Sampler:
Date:
Outfall/Watershed 009

Weather:
Rain Event Start Date/Time:

	Sample Tracking Information						Sample Field Measurements				Leaf Test					Sample Observations
	ISRA Area(s) & Location	Sample Frequency	Qualitative Flow Observations*	Photo Number(s)	Object ID	Sample ID (Object ID_yyyymmdd)	Sample/Observation Time	Conductivity (mS or uS)	pH	Temperature (°C)	Turbidity (NTU)	Distance (ft)	Time (s)	Speed (ft/s)	Water Depth (in)	Notes (color, odor, sheen, foam, biological material, nearby erosion, etc.)
ELV TREATMENT BMP AND HELIPAD	Culvert inlet; runoff will only be present when rain events exceed ELV BMP design storm	Every Storm			EVBMP0001	EVBMP0001_										
	Sample port in BMP influent pipe prior to "T" connection	Every Storm			EVBMP0007	EVBMP0007_										
	Discharge from media filter tank pipe	Every Storm			EVBMP0008	EVBMP0008_										
	Composite of samples from eastern and western sample ports between settling tanks and media filter	Every Storm			EVBMP0009	EVBMP0009_										

Notes:

***Qualitative Flow Observations:**

No Flow
Low Flow: Trickle or minor amount of flow.
Moderate Flow: Water is flowing normally, no significant erosion or turbid water.
High Flow: Significant water flow/velocity, slope erosion.

NPDES Permit Limits:

Temperature < 86 °F

pH 6.5 - 8.5

ALL RECEIVING AND SAMPLE COLLECTION BOTTLES MUST BE PRE- RINSED 3 TIMES WITH SOURCE WATER, PRIOR TO COLLECTION OF THE SAMPLE.

EXCEPTION IS THE HNO3 (NITRIC) PRESERVED POLY BOTTLES - DO NOT PRE-RINSE THE HNO3 PRESERVED POLY'S

Additional Observations:

Surface Water Monitoring Inspection and Sample Collection Form
PERFORMANCE MONITORING and BMP MONITORING PROGRAMS

Sampling Responsibility: NASA
Inspector/Sampler:
Date:
Outfall/Watershed 009

Weather:
Rain Event Start Date/Time:

	Sample Tracking Information						Sample Field Measurements				Leaf Test					Sample Observations
	ISRA Area(s) & Location	Sample Frequency	Qualitative Flow Observations*	Photo Number(s)	Object ID	Sample ID (Object ID_yyyymmdd)	Sample/Observation Time	Conductivity (mS or uS)	pH	Temperature (°C)	Turbidity (NTU)	Distance (ft)	Time (s)	Speed (ft/s)	Water Depth (in)	Notes (color, odor, sheen, foam, biological material, nearby erosion, etc.)
CM-1 AND AREA II ROAD	Sheetflow along Area II Road upstream of sandbag berm	Twice a year			EVBMP0003	EVBMP0003_										
	CM-1 eastern tributary drainage	Twice a year			A2BMP0006	A2BMP0006_										
	CM-1 culvert outlet	Twice a year			A2BMP0007	A2BMP0007_										
	Outlet pipe south side of road	Twice a year			A2BMP0012	A2BMP0012_										

Notes:

***Qualitative Flow Observations:**

No Flow
Low Flow: Trickle or minor amount of flow.
Moderate Flow: Water is flowing normally, no significant erosion or turbid water.
High Flow: Significant water flow/velocity, slope erosion.

NPDES Permit Limits:

Temperature < 86 °F

pH 6.5 - 8.5

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EXCEPTION IS THE HNO3 (NITRIC) PRESERVED POLY BOTTLES - DO NOT PRE-RINSE THE HNO3 PRESERVED POLY'S

Additional Observations:

Surface Water Monitoring Inspection and Sample Collection Form
PERFORMANCE MONITORING and BMP MONITORING PROGRAMS

Sampling Responsibility: Boeing

Inspector/Sampler:

Date:

Outfall/Watershed 009

Weather:

Rain Event Start Date/Time:

	Sample Tracking Information							Sample Field Measurements				Leaf Test				Sample Observations
	ISRA Area(s) & Location	Sample Frequency	Qualitative Flow Observations*	Photo Number(s)	Object ID	Sample ID (Object ID_yyyymmdd)	Sample/Observation Time	Conductivity (mS or uS)	pH	Temperature (°C)	Turbidity (NTU)	Distance (ft)	Time (s)	Speed (ft/s)	Water Depth (in)	Notes (color, odor, sheen, foam, biological material, nearby erosion, etc.)
B-1 AREA	Gunite swale conveying road runoff	Twice a year			B1BMP0009	B1BMP0009_										
B-1 AREA	Culvert outlet from upper parking lot area	Twice a year			B1BMP0010	B1BMP0010_										
B-1 AREA	Underdrains	Twice a year			B1BMP0011	B1BMP0011_										
B1436 DETENTION BIOSWALES	Upstream, B1436 southern detention bioswale (concrete swale diverting sheet flow into rock crib - west)	Twice a year			ILBMP0004	ILBMP0004_										
B1436 DETENTION BIOSWALES	Downstream, B1436 southern detention bioswale; 12-inch underdrain	Twice a year			ILBMP0005	ILBMP0005_										
B1436 DETENTION BIOSWALES	Upstream, B1436 southern detention bioswale (concrete swale diverting sheet flow into rock crib - east)	Twice a year			ILBMP0008	ILBMP0008_										

Printed on 11/15/2022

Surface Water Monitoring Inspection and Sample Collection Form
PERFORMANCE MONITORING and BMP MONITORING PROGRAMS

Sampling Responsibility: Boeing

Inspector/Sampler: ____________

Date: ____________

Outfall/Watershed: 009

Weather: ____________

Rain Event Start Date/Time: ____________

	Sample Tracking Information							Sample Field Measurements				Leaf Test				Sample Observations
	ISRA Area(s) & Location	Sample Frequency	Qualitative Flow Observations*	Photo Number(s)	Object ID	Sample ID (Object ID_yyyymmdd)	Sample/Observation Time	Conductivity (mS or uS)	pH	Temperature (°C)	Turbidity (NTU)	Distance (ft)	Time (s)	Speed (ft/s)	Water Depth (in)	Notes (color, odor, sheen, foam, biological material, nearby erosion, etc.)
LOWER LOT AND ADMINISTRATION BUILDING AREA	Upstream Lower Lot Treatment BMP; sample port in cistern discharge pipeline	Twice a year			LPBMP0002	LPBMP0002_										
	Mid-Point Lower Lot BMP; Sediment Basin outlet box	Twice a year			LPBMP0003	LPBMP0003_										
	Downstream Lower Lot Treatment BMP; discharge from Biofilter effluent pipe	Twice a year			LPBMP0004	LPBMP0004_										
CM-9 Area	Upstream (South), CM-9 BMPs	Twice a year			A1BMP0002	A1BMP0002_										
	Downstream, CM-9 BMPs; CM-9 underdrains	Twice a year			A1BMP0003	A1BMP0003_										
	Upstream (East), CM-9 BMPs; culvert inlet off Area II Road	Twice a year			ILBMP0002	ILBMP0002_										
Sage Ranch	Sage Ranch location - just east of LOX	Every storm			BGBMP0003	BGBMP0003_										
	Sage Ranch location - Downstream of box culvert	Twice a year			EPNDSW04	EPNDSW04_										

Surface Water Monitoring Inspection and Sample Collection Form
PERFORMANCE MONITORING and BMP MONITORING PROGRAMS

Sampling Responsibility: Boeing

Inspector/Sampler:

Date:

Outfall/Watershed 009

Weather:

Rain Event Start Date/Time:

	Sample Tracking Information							Sample Field Measurements				Leaf Test				Sample Observations
	ISRA Area(s) & Location	Sample Frequency	Qualitative Flow Observations*	Photo Number(s)	Object ID	Sample ID (Object ID_yyyymmdd)	Sample/Observation Time	Conductivity (mS or uS)	pH	Temperature (°C)	Turbidity (NTU)	Distance (ft)	Time (s)	Speed (ft/s)	Water Depth (in)	Notes (color, odor, sheen, foam, biological material, nearby erosion, etc.)
CM-3 AREA	Upstream of Service Area Road BMP, outlet pipe on south side of road	Twice a year			LXBMP0010	LXBMP0010_										
CM-3 AREA	Upstream of Service Area Road BMP, natural drainage upstream of CM-3	Twice a year			LXBMP0011	LXBMP0011_										
CM-3 AREA	Downstream of Service Area Road BMP, underdrains	Twice a year			LXBMP0012	LXBMP0012_										

Notes:

***Qualitative Flow Observations:**

No Flow
Low Flow: Trickle or minor amount of flow.
Moderate Flow: Water is flowing normally, no significant erosion or turbid water.
High Flow: Significant water flow/velocity, slope erosion.

NPDES Permit Limits:

Temperature < 86 °F

pH 6.5 - 8.5

ALL RECEIVING AND SAMPLE COLLECTION BOTTLES MUST BE PRE-RINSED 3 TIMES WITH SOURCE WATER, PRIOR TO COLLECTION OF THE SAMPLE.

EXCEPTION IS THE HNO3 (NITRIC) PRESERVED POLY BOTTLES - DO NOT PRE-RINSE THE HNO3 PRESERVED POLY'S

NOTE: COLLECT TWO FIELD DUPLICATE SAMPLES FROM ANY LOCATIONS WITH SUFFICIENT FLOW.

Additional Observations:

Surface Water Monitoring Inspection and Sample Collection Form
PERFORMANCE MONITORING and BMP MONITORING PROGRAMS

Sampling Responsibility: Boeing

Inspector/Sampler:

Date:

Outfall/Watershed 001, 002, and 011

Weather:

Rain Event Start Date/Time:

	Sample Tracking Information							Sample Field Measurements				Leaf Test				Sample Observations
	ISRA Area(s) & Location	Sample Frequency	Qualitative Flow Observations*	Photo Number(s)	Object ID	Sample ID (Object ID_yyyymmdd)	Sample/Observation Time	Conductivity (mS or uS)	pH	Temperature (°C)	Turbidity (NTU)	Distance (ft)	Time (s)	Speed (ft/s)	Water Depth (in)	Notes (color, odor, sheen, foam, biological material, nearby erosion, etc.)
Outfall 001	Potential BMP location, Outfall 001 watershed (at the bottom of the hill to the north of the intersection of the Southern Buffer Zone Road and Outfall 01 Road).	Every storm			EPSW001IE01	EPSW001IE01_										
Outfall 011	Outfall 011 Burn Pit runoff On felt liner by HDPe pipe	Every storm			A1BPSW0001	A1BPSW0001_										

Notes:

*__Qualitative Flow Observations:__

No Flow

Low Flow: Trickle or minor amount of flow.

Moderate Flow: Water is flowing normally, no significant erosion or turbid water.

High Flow: Significant water flow/velocity, slope erosion.

__NPDES Permit Limits:__

Temperature < 86 °F

pH 6.5 - 8.5

ALL RECEIVING AND SAMPLE COLLECTION BOTTLES MUST BE __PRE-RINSED 3 TIMES__ WITH SOURCE WATER, PRIOR TO COLLECTION OF THE SAMPLE.

EXCEPTION IS THE HNO3 (NITRIC) PRESERVED POLY BOTTLES - __DO NOT PRE-RINSE THE HNO3 PRESERVED POLY'S__

NOTE: COLLECT FIELD DUPLICATE FROM EITHER LOCATION EVERY STORM.

Additional Observations:

Geosyntec consultants

924 Anacapa Street, Suite 4A
Santa Barbara, CA 93101
PH 805.897.3800
www.geosyntec.com

MEMORANDUM

Date: December 10, 2021

To: Stormwater Sampling Team

From: SSFL Surface Water Expert Panel, Geosyntec Consultants

Subject: Santa Susana Field Laboratory Background Stormwater Sampling Plan

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Monitoring Locations

One non-industrial subwatershed (Box Canyon) and two natural background subwatersheds (Las Llajas and Montgomery Canyons) were selected as primary locations for sampling, and two subwatersheds (Chesebro and East Las Virgenes Canyons) were selected as backup locations to be sampled if the primary locations cannot be accessed or are not flowing at the time of sampling. Figure 1 shows the location of each subwatershed and monitoring location relative to SSFL. GPS coordinates for the selected downstream monitoring locations are shown in Table 1. Maps showing access points and monitoring locations are included in Attachment A.

Table 1. Subwatershed Characteristics

Sample Location Type	Name	Watershed	Sample Location (latitude, longitude)	Drainage Area (acres)
Primary Background	Las Llajas Canyon	Calleguas Creek	34.300070°, -118.681550°	4,020
	Montgomery Canyon	Calleguas Creek	34.235774°, -118.784127°	908
Non-Industrial	Box Canyon	Los Angeles River	34.234664°, -118.642553°	694
Secondary Background	*Chesebro Canyon*	*Malibu Creek*	*34.159300°, -118.725314°*	*1,814*
	East Las Virgenes Canyon	*Malibu Creek*	*34.171851°, -118.701614°*	*1,454*

Sampling and Analysis

Samples will be collected using grab sampling techniques and may be collected from runoff up to 12 hours after the end of a rainfall event. Sampling will only be conducted during daylight hours and may be aborted if unsafe conditions exist (e.g., lightning, flooding). Sample bottles will be labeled with the date, time, unique sample ID, and sampler's initials, at a minimum. A clean pair of disposable gloves (e.g., nitrile) will be worn by the sampler at each sample location. Samples will be collected from the bank of the stream either directly into the sample bottles or using a clean secondary bottle that is not reused between locations. If necessary, a sampling pole or other technique may be used to allow safe sample collection.

Parameters that will be analyzed for each sample are shown in **Error! Reference source not found.**. A total of 14 bottles will be collected for each sampling location. One field blank and one field duplicate will be prepared for each sampling event where at least one location is sampled. **Thus, five sets of sample bottles will be required for each sampling event (two background locations, one non-industrial location, one field duplicate, and one field blank).** Sample bottles will be immediately placed on ice after collection and shipped overnight or via courier to Eurofins Test America in Irvine, CA.

Analytical Parameters

The parameters listed in in Attachment B will be analyzed by Eurofins Test America according to the methods and within the holding times listed. Calculations will also be made to determine Nitrate + Nitrite as N, Radium-226 + Radium-228, TCDD TEQ, and TCDD TEQ (No DNQ) concentrations.

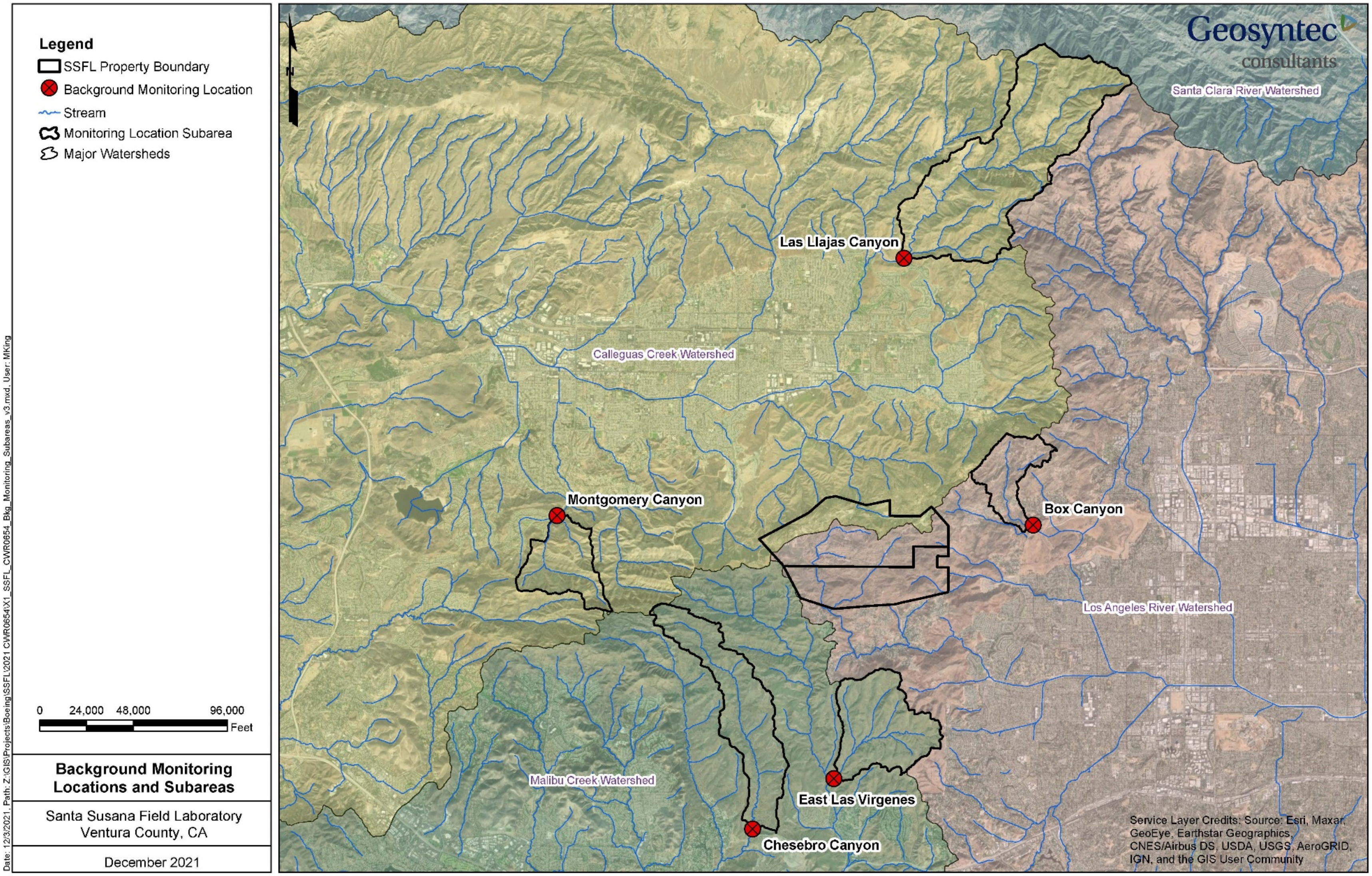


Figure 1. Offsite Background Stormwater Monitoring Subwatersheds

ATTACHMENT A: MONITORING LOCATIONS AND ACCESS POINTS

Las Llajas Canyon
Legend
Access
Creek
Sampling Location
Trail
Sampling Location
Las Llajas Canyon Rd
Cherokee Cir
Evening Sky Dr
Access
Evening Sky Dr
Google Earth
N
700 ft

Las Llajas Canyon – Primary Natural Background Sampling Location:

- Park on Evening Sky Drive at the Las Llajas Canyon Trailhead
- Walk 0.3 miles to the sampling location, through gate, to where the creek crosses a concrete area on the dirt road

Figure 1. Las Llajas Canyon Trail at Trailhead

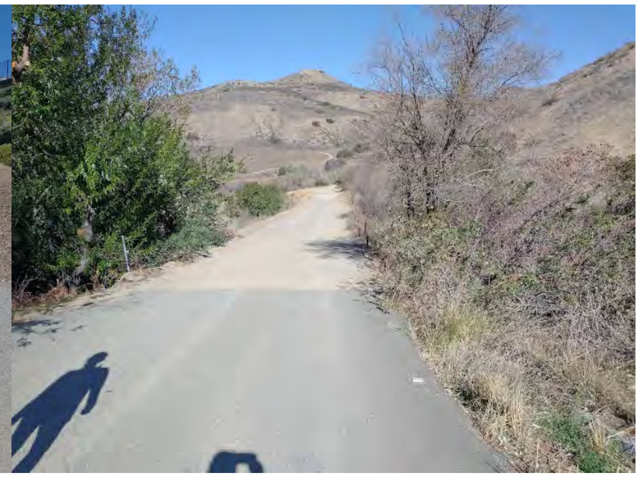


Figure 2. Las Llajas Canyon Trail

Figure 3. Sampling Location

Figure 4. Gate on Las Llajas Canyon Trail

Montgomery Canyon
Legend
Access
Creek
Sampling Location
Trail
Brooks Rd
Long Canyon Rd
Access
Sampling Location
Montgomery Trail
Long Canyon E
Google Earth
N
300 ft

Montgomery Canyon – Primary Natural Background Sampling Location:

- Park on Long Canyon Road at the Long Canyon East Trailhead (pull out w/ no parking sign)
- Walk 0.1 miles to the sampling location where the two creeks converge and cross the dirt road

Figure 5. Long Canyon East Trailhead

Figure 6. Sampling Location

Figure 7. Looking Downstream at Sampling Location


Box Canyon
Legend
Access
Creek
Sampling Location
Trail
Access
Sampling Location
STOP
STOP
Valley Circle Blvd
Google Earth
N
200 ft

Box Canyon – Non-Industrial Sampling Location:

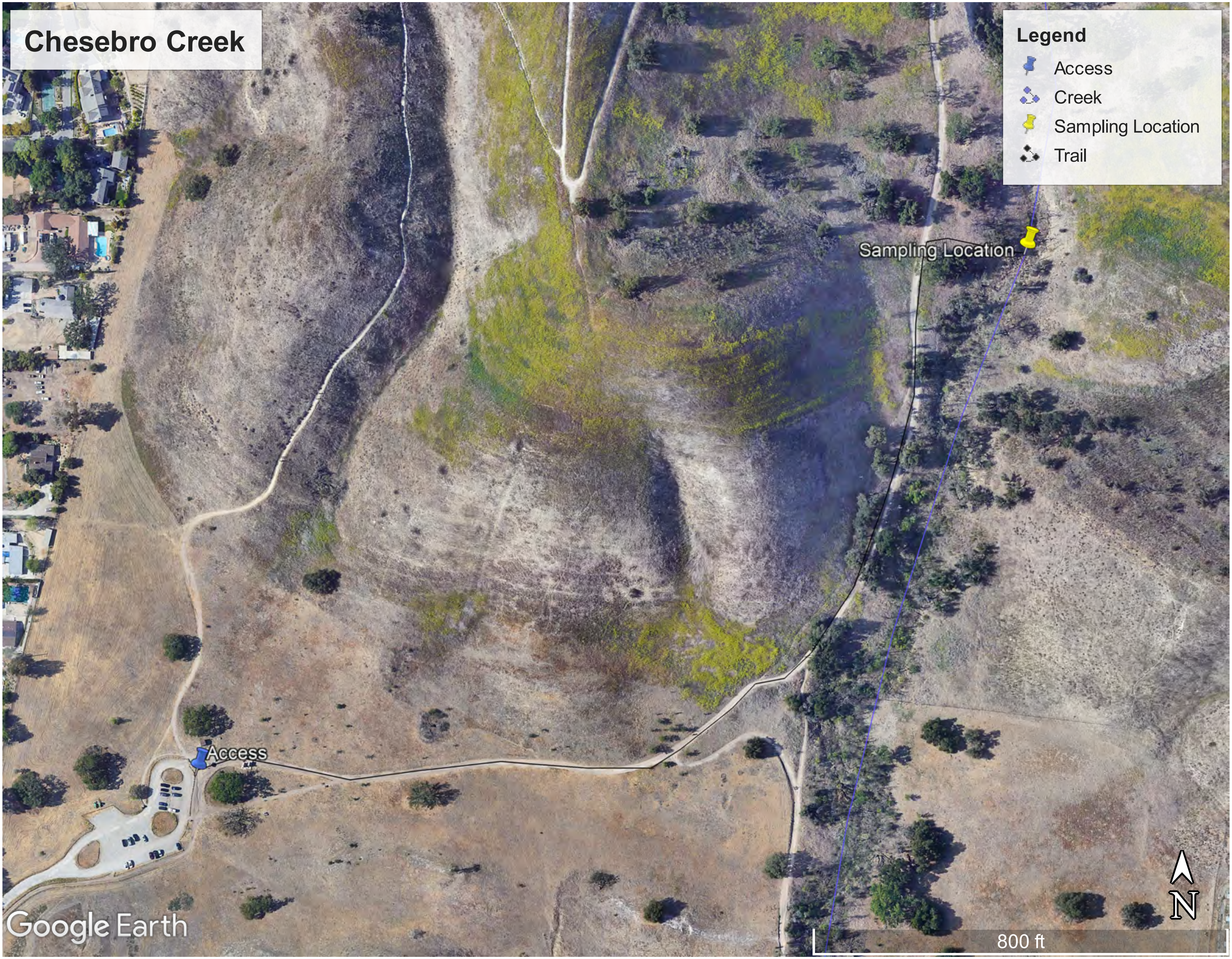
- Park on Valley Circle Blvd just east of Woolsey Canyon Road
- Walk <0.1 miles to the sampling location where culvert crosses under Valley Circle Blvd (may need sampling pole or other collection device for this location)

Figure 8. Parking on Valley Circle Blvd

Figure 9. Culvert under Valley Circle Blvd

Figure 10. Alternate View of Culvert

Figure 11. Sampling Location


Chesebro Creek
Legend
Access
Creek
Sampling Location
Trail
Sampling Location
Access
Google Earth
800 ft
N

Chesebro Creek – Alternate Natural Background Sampling Location:

- Park in parking lot at Chesebro Canyon Trailhead (closed sunset to 8am)
- Walk 0.5 miles to the sampling location, just off the main trail

Figure 12. Chesebro Canyon Trailhead

Figure 13. Chesebro Canyon Trail

Figure 14. Sampling Location from Main Trail

Figure 15. Sampling Location


East Las Virgenes
Legend
Access
Creek
Sampling Location
Trail
N1
Sampling Location
N1
Access
Google Earth
700 ft
N

East Las Virgenes Creek – Alternate Natural Background Sampling Location:

- Park at the end of Las Virgenes Road at the Upper Las Virgenes Canyon Open Space Trailhead
- Walk 0.4 miles to the sampling location, small trail just off the main trail

Figure 16. Las Virgenes Trailhead

Figure 17. Las Virgenes Trail

Figure 18. Trail to Sampling Location

Figure 19. Sampling Location

ATTACHMENT B: MONITORING PARAMETERS AND ANALYTICAL METHODS

Group	Analyte	Method	MDL (target)	RL	Bottle	Hold Time
Metals, Total & Dissolved	Antimony	200.8	0.5 ug/L	2.0 ug/L	1 x 250mL poly, HNO3	180 Days
	Arsenic	200.8	0.5 ug/L	1.0 ug/L		
	Barium	200.8	5 ug/L	10 ug/L		
	Beryllium	200.8	0.5 ug/L			
	Cadmium	200.8	0.25 ug/L	1.0 ug/L		
	Chromium	200.8	2.5 ug/L	5.0 ug/L		
	Copper	200.8	0.5 ug/L	2.0 ug/L		
	Iron	200.8	8.0 ug/L	20 ug/L		
	Lead	200.8	0.5 ug/L	1.0 ug/L		
	Manganese	200.8	0.5 ug/L	1.0 ug/L		
	Nickel	200.8	5.0 ug/L	10 ug/L		
	Selenium	200.8	0.5 ug/L	1.0 ug/L		
	Silver	200.8	0.5 ug/L	1.0 ug/L		
	Thallium	200.8	0.2 ug/L	1 ug/L		
	Zinc	E200.7	2.0 ug/L	20 ug/L		
	Boron	E200.7	0.025 mg/L	0.05 mg/L		
	Mercury	245.1	0.017 ug/L	0.05 ug/L		28 days
	Chromium VI	218.6	0.25 ug/L	1	2 x 250mL poly, unpreserved	10 days
	bis (2-ethylhexyl) phthalate	E625.1	2.2 ug/L	5.0 ug/L	# x 40 mL VOA	3 days
	Cyanide	SM4500-CN-E	2.5 ug/L	5.0 ug/L	500-mL Poly-CN/ NaOH	14 days
	Fluoride	E300	0.25 mg/L	0.5 mg/L	60-mL Poly-300.0/314	28 days
	Perchlorate	E314.0	0.95 ug/L	4.0 ug/L	60-mL Poly-300.0/314	28 days
	Trichloroethene	E624.1	0.25 ug/L	0.5 ug/L	40-mL VOA-624.1	3 days
Nutrients	Nitrate as N	300	0.055 mg/L	0.11 mg/L	1 x 500mL poly, unpreserved	2 days
	Nitrite as N		0.024 mg/L	0.15 mg/L		
	Sulfate		0.25 mg/L	0.5 mg/L		
Dioxins and Furans	17 congeners to calculate TCDD TEQ	1613B	1.4 – 45.9 pg/L[1]	10 – 100 pg/L[1]	2 x 1L amber, unpreserved	1 Year
Radioactivity	Gross Alpha	900	N/A	3.0 pCi/L	1 x 1L poly, unpreserved	180 days
	Gross Beta		N/A	4.0 pCi/L		
	Radium-226	903	N/A	1.0 pCi/L	2 x 1L poly, HNO3	180 days
	Radium-228	904	N/A	1.0 pCi/L		180 days
	Strontium-90	905	N/A	3.0 pCi/L	2 x 1L poly, NHO3	180 days
	Tritium	E906.0	N/A	500 pCi/L	Unknown	180 days
Solids	TSS	2540D	0.5 mg/L	1.0 mg/L	1 x 1L poly, unpreserved	7 days
	% sand	ASTM D4462	N/A	0.01%	1 x 1L poly, unpreserved	
	% silt		N/A	0.01%		
	% clay		N/A	0.01%		

MDL = Method Detection Limit, RL = Reporting Limit, N/A = Not Applicable

1. MDL and RL vary by congener

Appendix B: 2022/23 BMP and Subarea Monitoring Program Laboratory Reports

(see separate document)

Appendix C: 2022/23 Exceeding Constituent Source Investigation

Prepared for

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Los Angeles, CA 90013

Appendix C: 2022/23 Exceeding Constituent Source Investigation

Prepared by

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CWR0801
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Acronyms

BEF	Bioaccumulation Equivalency Factor
BMP	Best Management Practice
BOD_5	Biological Oxygen Demand over a 5-day period
DNQ	Detected not Quantified
DTSC	Department of Toxic Substances Control
IQR	Interquartile Range
ISRA	Interim Source Removal Action
LOE	Lines of Evidence
MDL	Method Detection Limit
µg/L	micrograms per liter
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
NPDES	National Pollutant Discharge Elimination System
ND	Not Detected
pCi/L	picocuries per liter
PS	Particulate Strength
RFI	RCRA Facility Investigations
RCRA	Resource Conservation and Recovery Act
Rv	Volumetric Runoff Coefficient
SSFL	Santa Susana Field Laboratory
SWTS	Stormwater Treatment System
TCDD	Tetrachlorodibenzo-p-dioxin
TEF	Toxic Equivalency Factor
TEQ	Toxic Equivalence
TSS	Total Suspended Solids
WHO	World Health Organization

Executive Summary

Sources of permit limit and benchmark exceedances in 2022/2023 were investigated through multiple data analyses to provide independent lines of evidence (LOE) that when considered together provide a weight of evidence identifying one or more sources of the constituent concentration that was measured in each exceeding outfall sample, or at a minimum confirm whether impacted soils can be conclusively ruled out as a source, leaving only non-industrial sources as the only plausible explanation for the concentration measured in stormwater. If impacted soils could not be ruled out as a source for an exceedance, then new recommendations are made to further identify and/or control such sources to stormwater. The various LOEs considered were:

- **material inventory or physical presence** (e.g., whether surface soils impacted for the exceeding constituent are present in the upstream watershed, whether chemical masses added by the stormwater treatment systems add significantly to masses present in influent stormwater [applicable to manganese], and whether groundwater seeps/springs are present above the exceeding outfall, are known to have elevated concentrations for the constituent, and are believed to contribute a meaningful percent of flow during the exceeding sampling event, like may be the case during low flow / post-storm sampling [applicable to sulfate at Outfall 002])
- **spatial patterns** (since stormwater concentrations and particulate strengths should be similar across the property and offsite if ubiquitous non-industrial sources like natural background soils and atmospheric deposition are the sources);
- **stormwater particulate strengths vs (solid) source material samples** (since these should roughly match if the solid materials, like impacted soils or natural background soils, are the source to stormwater particulates); and
- **metal ratio fingerprinting** (since the ratios of particulate-bound constituents to known soil-derived constituents [like iron] should be the same in stormwater as in natural background soils if natural background soils are the source).

Constituents that exceeded current permit limits and benchmarks in the historically-wet 2022/2023 rainy season were iron, manganese, TCDD TEQ (no DNQ), and sulfate. Iron and manganese limits/benchmarks are based on secondary MCLs for drinking water (i.e., taste/odor, not health based), sulfate limits/benchmarks are based on historic surface water quality in the region according to the Basin Plan, and TCDD TEQ (no DNQ) limits/benchmarks are based on human health for fish consumption (however neither fish nor fishing are known to occur at or near SSFL outfalls or drainages). Aluminum exceeded new proposed permit limits in the 2022/2023 season. Potential sources evaluated were:

- **Onsite Soils:** Soils from areas potentially impacted by former operations were characterized for the Resource Conservation and Recovery Act (RCRA) program and other regulatory programs, including the RCRA Feasibility Investigations (RFI) conducted across the site.

- **Background Soils:** Natural background soils were evaluated using monitoring results from offsite soils evaluated in the California Department of Toxic Substances Control (DTSC) SSFL Background Soils Study (DTSC 2012).

- **Pavement Solids:** Particulates on pavements were collected quarterly from six sites throughout the Outfall 009 watershed in 2016-2017 and Outfall 009 and 011 watersheds in 2018.

- **Treated wood utility poles and adjacent soils:** Treated wood utility poles and adjacent soils were evaluated by collecting samples of the treated wood utility pole material and the soil adjacent to treated woods at dozens of locations in 2016, 2020, and 2021.
- **Atmospheric Deposition Solids:** Dry atmospheric deposition solid samples were collected monthly at the SSFL Fire Station and Helipad over the course of a year in 2016-2017.
- **Natural Seeps (sulfate only):** Outfall flow rates were reviewed to determine if the sample exceeding for sulfate was representative of stormwater or later baseflow or seep contributions. Also, past seep characterization studies were reviewed to compare concentrations observed in seeps.

The combined LOEs indicated that the exceeding iron and manganese concentrations were likely attributable to natural background soils present throughout SSFL. One manganese exceedance at Outfall 011 had a higher particulate strength that was not able to be explained by any sources evaluated, however, there is some uncertainty concerning the particulate strength calculation for that sample due to a low suspended solids concentration in the sample. TCDD TEQ (no DNQ) exceedances at Outfalls 010 and 011 were likely primarily from natural background soils with smaller but more concentrated contributions from impacted soils (RFI Soils), treated wood poles and adjacent soils, and pavement solids. The sulfate exceedance at Outfall 002 (sampled during a late season, small storm when low steady flowrates were fed by bank exfiltration or "interflow" and more representative of baseflow than stormwater) is most likely attributable to the shale geology of the area and localized natural seeps. The local natural seeps have naturally elevated levels of sulfate and several are mapped along this buffer zone drainage, especially during wet years and late winter periods when the surrounding water table is most elevated (however they are not significant enough to generate flow at the outfall during the dry season).

1. Introduction

The purpose of this investigation was to evaluate potential sources that may have contributed to effluent limit and benchmark exceedances at the Santa Susana Field Laboratory (SSFL) National Pollutant Discharge Elimination System (NPDES) Outfalls during the 2022/23 rainy season. The twelve active SSFL NPDES Outfall locations are shown in Figure 1.

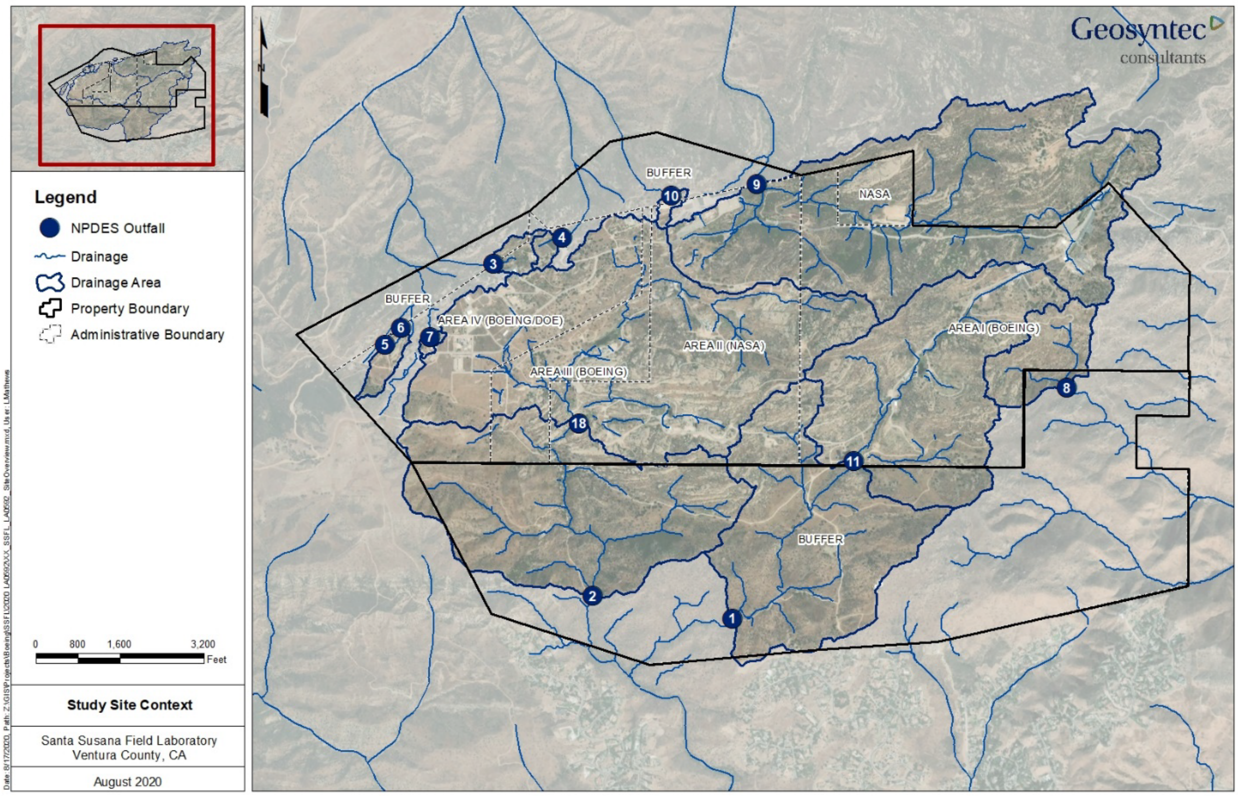


Figure 1. Santa Susana Field Laboratory (SSFL) National Pollutant Discharge Elimination System (NPDES) Outfalls

The long-term average annual rainfall at SSFL from 1959 to 2023 is 17.3 inches[1], occurring primarily in winter storms from September through May. Highly variable periods of above or below average rainfall are common. A total of 45.8 inches of rainfall was measured in the 2022/23 reporting year (July 1, 2022 – June 30, 2023). A total of 16 qualifying rain events occurred in 2022/23, where a "rain event" is defined by the permit as greater than 0.1 inches of rainfall in 24 hours, preceded by at least 72 hours of dry weather. Of the sixteen rain events, eleven produced discharges at one or more NPDES outfalls, and four events had permit limit or benchmark exceedances.

Constituents that exceeded an effluent limit or benchmark at least once in the 2022/23 rainy season were: iron (10 exceedances); manganese (2 exceedances); sulfate (1 exceedance); and Tetrachlorodibenzo-p-dioxin Toxic Equivalence (TCDD TEQ) (no DNQ) (2 exceedances). Iron and manganese limits/benchmarks are based on secondary MCLs for drinking water (i.e., taste/odor, not health based), sulfate

[1] Data from the Simi Hills – Rocketdyne Lab gauge (Ventura County Watershed Protection District site 249) was used to determine annual rainfall from 1958/59 through 1977/78 and from 1984/85 through 2000/01. Rainfall data from 2001/02 through 2022/23 was recorded at the Area 4 gauge, which was relocated to Area 1 on January 1, 2013), resulting in a combined period of record of 57 years.

limits/benchmarks are based on historic surface water quality in the region according to the Basin Plan, and TCDD TEQ (no DNQ) limits/benchmarks are based on human health for fish consumption (however neither fish nor fishing are known to occur at or near SSFL outfalls or drainages). A summary of each exceedance is shown in Table 1 below, along with the associated total suspended solids (TSS) concentration for each sample.

Table 1. 2022/2023 Effluent Limit and Benchmark Exceedances

Rain Event and Depth (inches)	Sample Date	Outfall	Parameter	Units	Results	Limit	Limit Type	TSS (mg/L)
12/27/2022-1/5/2023 (7.46)	01/06/2023	001	Iron	mg/L	0.83	0.3	Benchmark	20
12/27/2022-1/5/2023 (7.46)	01/02/2023	002	Iron	mg/L	0.86	0.3	Benchmark	20
12/27/2022-1/5/2023 (7.46)	01/06/2023	002	Iron	mg/L	0.93	0.3	Benchmark	23
1/8-10/2023 (6.32)	01/11/2023	010	TCDD TEQ (No DNQ)	µg/L	4.60E-08	2.80E-08	Benchmark	8.3
1/8-10/2023 (6.32)	01/10/2023	011	Manganese	µg/L	61	50	Effluent Limit	4.2
1/14-16/2023 (3.19)	01/15/2023	001	Iron	mg/L	3.6	0.3	Benchmark	43
1/14-16/2023 (3.19)	01/15/2023	002	Iron	mg/L	1.3	0.3	Benchmark	31
1/14-16/2023 (3.19)	01/17/2023	011	Iron	mg/L	0.78	0.3	Effluent Limit	7.6
2/23-3/1/2023 (10.1)	02/26/2023	001	Iron	mg/L	3.7	0.3	Benchmark	45
2/23-3/1/2023 (10.1)	02/25/2023	011	Iron	mg/L	4	0.3	Effluent Limit	92
2/23-3/1/2023 (10.1)	02/25/2023	011	Manganese	µg/L	79	50	Effluent Limit	92
2/23-3/1/2023 (10.1)	02/25/2023	011	TCDD TEQ (No DNQ)	µg/L	5.80E-08	2.80E-08	Effluent Limit	92
3/10-15/2023 (6.48)	03/11/2023	001	Iron	mg/L	1.9	0.3	Benchmark	27
3/10-15/2023 (6.48)	03/16/2023	011	Iron	mg/L	3.2	0.3	Effluent Limit	42
5/1-4/2023 (0.73)	05/05/2023	002	Sulfate	mg/L	380	300	Benchmark	3.1

At the time of writing there was a tentative draft NPDES permit for SSFL pending a board decision. In it there were a number of proposed changes to permit limits, both establishing new limits for analytes that previously had none and updating values for analytes with existing limits. A preliminary review and evaluation of 2022/2023 samples greater than these tentative draft permit limits (one exceedance), listed in Table 2, is included in this report. Per the NPDES permit, concentrations detected below the reporting limit (J-flagged or estimated results) are not counted as an exceedance, however, the following analytes had detected concentrations between the method detection limit and reporting limit: mercury, heptachlor and indeno (1,2,3-cd) pyrene. These three analytes will not be further discussed in this report, however, they are included in the offsite background stormwater monitoring suite along with aluminum.

Table 2. 2022/2023 Concentrations Detected Above Tentative Draft Permit Limits

Rain Event and Depth (inches)	Sample Date	Outfall	Parameter	Units	Results	Limit	TSS (mg/L)
12/27/2022-1/5/2023 (7.46)	1/6/2023	008	Aluminum	mg/L	1.2	1	10

A variety of natural and anthropogenic sources present at the SSFL were evaluated to determine their potential to contribute to surface water exceedances, the majority of which reflect pollutants that are predominantly in particulate form, hence an investigative focus on *solid* sources rather than aqueous ones (except for sulfates). This source evaluation was accomplished by performing various data analyses to establish a "weight of evidence" means of source hypothesis testing. Various lines of evidence (LOEs), as described in the sections below, were evaluated to determine the likelihood that a source was a major contributor to constituents exceeding the effluent limits or benchmarks at the outfalls. The potential solid sources evaluated, and the associated sampling performed for each, include:

- **Background Soils:** Natural background soils were evaluated based on offsite soils evaluated in the California Department of Toxic Substances Control (DTSC) SSFL Background Soils Study (DTSC 2012). Only surface soils in the top 6 inches of background soil were used to evaluate the solids concentration since these are the soils most likely to be mobilized by stormwater runoff. These were bulk soil samples and included all particle sizes, not just the smallest particles that are mobilized in stormwater.
- **Onsite Soils:** Soils from areas potentially impacted by former operations were characterized for the Resource Conservation and Recovery Act (RCRA) program and other regulatory programs, including the RCRA Feasibility Investigations (RFI) conducted across the site. Only surface soils still in place in the top 6 inches within each watershed were used to represent the solids concentration of areas potentially impacted by former operations since these are the soils most likely to be mobilized by stormwater runoff. Note that this includes samples both within and outside of potential cleanup areas. For purposes of this source investigation, potentially impacted soils are assumed to be those with a concentration above background soils. These soil samples were also bulk samples and included all particle sizes, not just the smallest particles that are mobilized in stormwater.
- **Pavement Solids:** Particulates on pavements were collected quarterly from six sites throughout the Outfall 009 watershed between 2016-2017. The collected samples were sieved into three size fractions for analyses. Only the <75 micrometer (μm) fraction is considered here, since this is the most likely particle size to be mobilized by stormwater.

- **Treated Wood:** Treated wood utility poles and adjacent soils were evaluated by collecting samples of the treated wood utility pole material itself and the soil adjacent to treated woods at 28 locations in 2016, 2020, and 2021. While treated wood is the source of elevated constituents, the impacted adjacent soils are more likely to be mobilized rather than the treated wood itself so the smallest soil particles (<75 micrometers) near treated wood poles are the focus of the solid sources evaluation.
- **Atmospheric Deposition Solids:** Dry atmospheric deposition solid samples were collected monthly at the SSFL Fire Station and Helipad over the course of a year between 2016-2017. Atmospheric deposition was (and continues to be) evaluated to determine whether typical dry deposition at the site that is mobilized during wet weather may have contributed to exceedances. Atmospheric deposition solids are in the small particle size range.
- **Natural Seeps (sulfate only):** Outfall flow rates were reviewed to determine if the sample was representative of stormwater or later baseflow or seep contributions. Also, past seep characterization studies were reviewed to compare sulfate concentrations observed in seeps with the observed stormwater sulfate concentration in the exceeding sample.

Each LOE (line of evidence) is described in detail below to determine the source of the constituent concentration that was measured in each exceeding outfall sample, or at a minimum confirm whether impacted soils can be conclusively ruled out as a source, leaving only non-industrial sources as the only plausible explanation for the concentration measured in stormwater. If impacted soils can not be ruled out as a source of any particular exceedance, then new investigation and/or implementation recommendations are made to further identify and/or control such sources to stormwater.

2. Lines of Evidence

Multiple LOEs were considered when investigating potential sources of exceedances. This approach uses independent assessments and findings to see if they concur in the identification of potential source(s). Each LOE and how it was used to support a particular source conclusion is summarized in Table 3 and described below. Where more than one LOE supports that a source may be a contributor for a particular constituent, then there is a greater likelihood that the hypothesized source contributed to or caused the exceedance.

Table 3. Questions and Lines of Evidence

Questions	Line of Evidence	Criteria to Answer 'Yes' to Questions
Are there local sources unique to particular watersheds where exceedances are occurring?	Spatial Patterns	Particulate strengths differ between watersheds (i.e. extreme values or box plots do not overlap)
	Material Inventory	The potential source is physically present in the watershed
Can this year's effluent limit or benchmark exceedances be the result of one or more of the potential sources investigated?	Particulate Strengths	The upper end (99th percentile) of the solids concentration (i.e. soils, pavement solids, etc.) is greater than or equal to the exceeding stormwater particulate strength
	Fingerprinting: Ratios to Iron/Manganese[2]	Stormwater results are within the 95th percentile confidence interval of the ratio observed in background soils or in line with background stormwater

2.1. Spatial Patterns

Spatial patterns were used to evaluate whether there are sources unique to certain watersheds that were responsible for effluent limit or benchmark exceedances. Box plots of stormwater concentrations and particulate strengths were used to illustrate the basic relationships of each watershed's water quality. As shown in Figure 2, the box plots reflect the median, 25th percentile, 75th percentile, and 1st and 99th percentile values. The individual sample results are shown as points over the box plots to differentiate between detected (black border) and non-detected (gray border) results. A difference in concentration or particulate strengths between outfalls may indicate there was a unique source within a particular watershed (particulate strengths are described in more detail in Section 2.2). Background and ambient stormwater were also compared in this analysis and results from outfalls vs background and ambient areas are colored accordingly in the plots for each constituent with an effluent limit or benchmark exceedance in the past rainy season.

[2] These metals have been definitively found to be from natural background soils therefore they serve as a reliable reference for testing whether other stormwater pollutants exceedances are similarly derived from background soils.

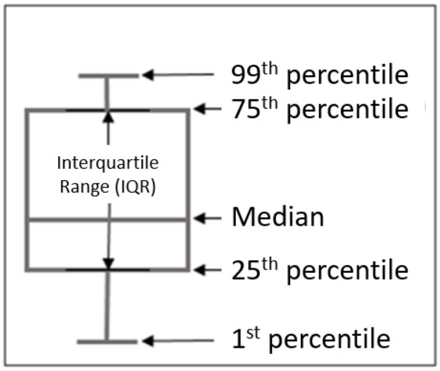


Figure 2. Box Plot Key

2.2. Particulate Strengths

Particulate strength (PS) calculations were used to determine if solids concentrations in potential sources are high enough to cause effluent limit or benchmark exceedances in stormwater. PS is the constituent concentration associated with particulate matter in stormwater and is a means to normalize stormwater constituent concentrations by TSS. Normalizing non-filtered constituent concentrations (the difference between the total and filtered concentrations) by TSS is helpful for comparing solid concentrations of hypothesized sources with the particulate material in the aqueous stormwater samples. This method is useful for the constituents that are highly associated with particulates and are not found in significant quantities in filtered (dissolved and colloidal) forms. PS values have been previously used by the Surface Water Expert Panel and Geosyntec to assess sources of metals in SSFL NPDES outfall compliance monitoring data (SSFL Surface Water Expert Panel, 2009). PS is calculated in stormwater using the following equation and applying the appropriate unit conversions.

$$PS = \frac{(\text{total concentration} - \text{filtered concentration})}{\text{total suspended solids concentration}}$$

Samples where both the total and filtered concentrations were detected were used to determine the average filtered fractions for each constituent at each sample location. This average filtered fraction was used in the PS calculations for samples with no filtered fraction reported or for filtered results below the detection limit. Non-detect results, where the total concentration was below the detection limit, are excluded from the particulate strength evaluations. TCDD TEQ is assumed to have a filtered fraction of zero because of the congeners' extremely low solubility and high partitioning coefficient to solids.

The solid source sample results represent bulk samples and include all particle sizes, with the exception of pavement solids and soils near treated wood poles, where the fine fraction (<75 µm) was considered separately. This is important to note, because the PS of the fine fraction is typically higher than the bulk fraction. Also, outfall stormwater samples typically contain a higher percent of the fine fraction compared to the original sources due to the selective mobilization of fine particles in stormwater runoff. For example, the fine fraction (<75 µm) of sediments collected from the Outfall 009 watershed had a median lead solids concentration over four times higher than other fractions (46.9 mg/kg in fine vs 10.2 and 10.7 mg/kg in medium and coarse, respectively). More importantly, as shown in Figure 3, the median fine fraction concentration was over four times higher than the median bulk concentration of the soil sample calculated using the weighted average of each size fraction. A similar trend is observed for other constituents and soil sample subgroups as shown in Figure 4 to Figure 7. This means the outfall sample PS is more influenced by the smaller particle sizes, which have a higher constituent PS. This needs to be considered when comparing the PS of outfall samples to the source samples that are based on bulk solids.

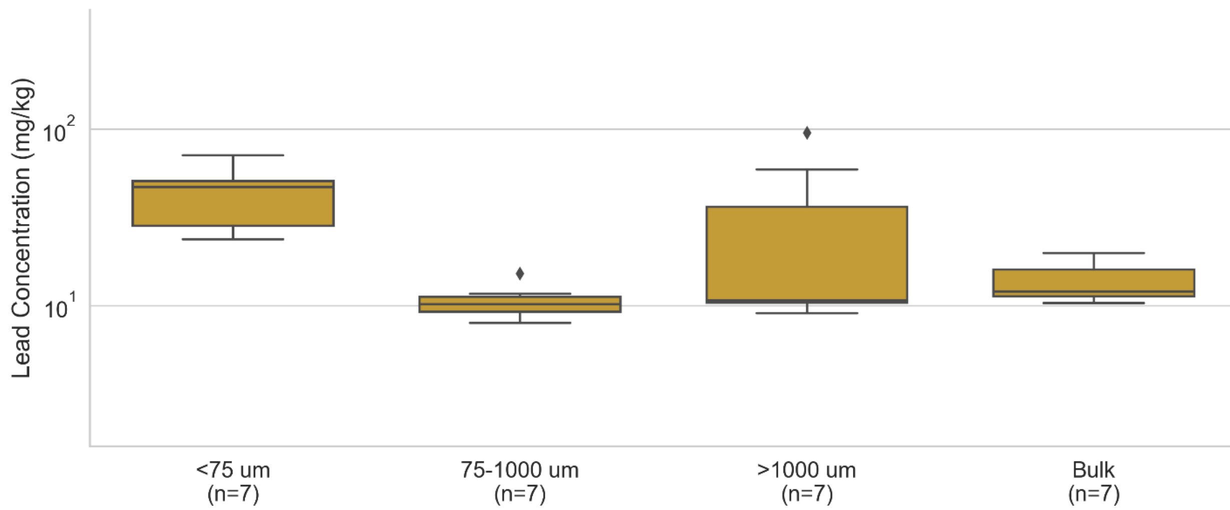


Figure 3. Lead Concentration in Northern Drainage Sediment by Sediment Size Fraction and Calculated Bulk Concentration

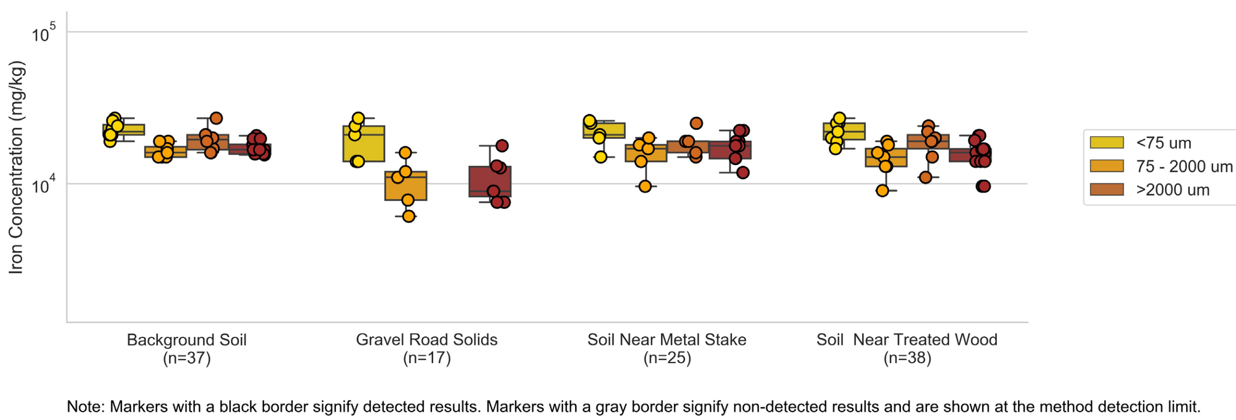
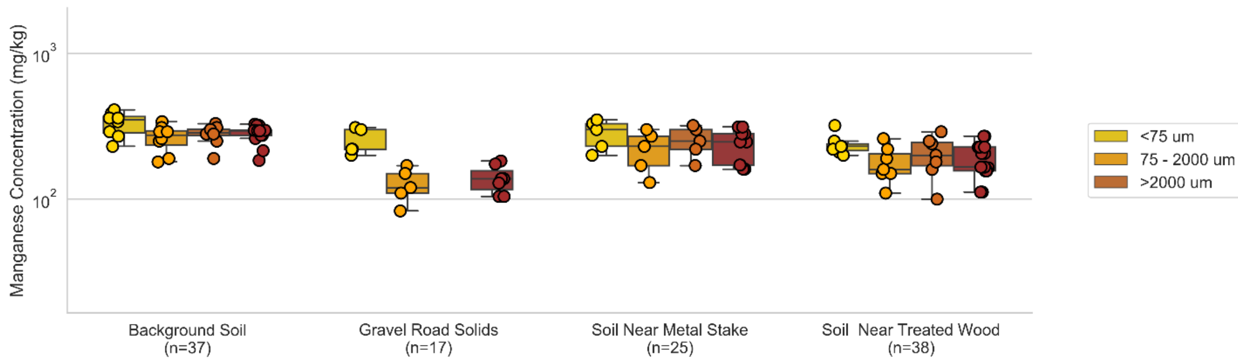
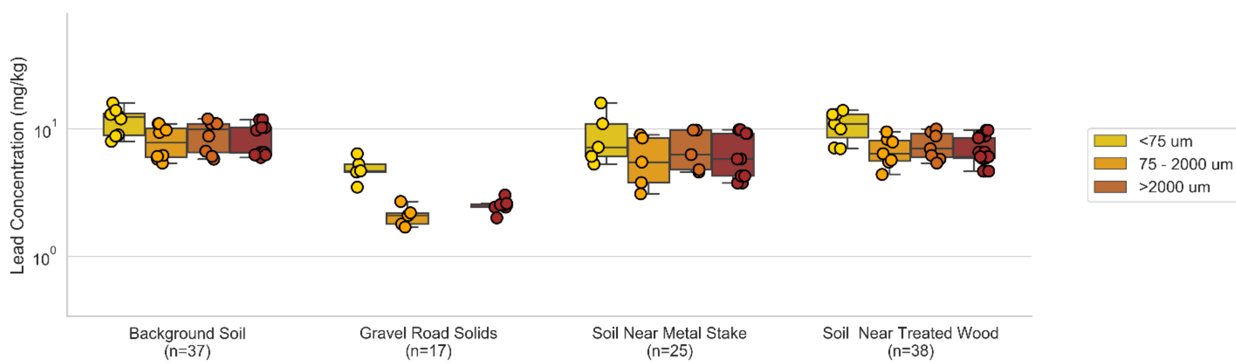


Figure 4. Iron Concentration In Soil Samples by Particle Size Fraction and Calculated Bulk Concentration



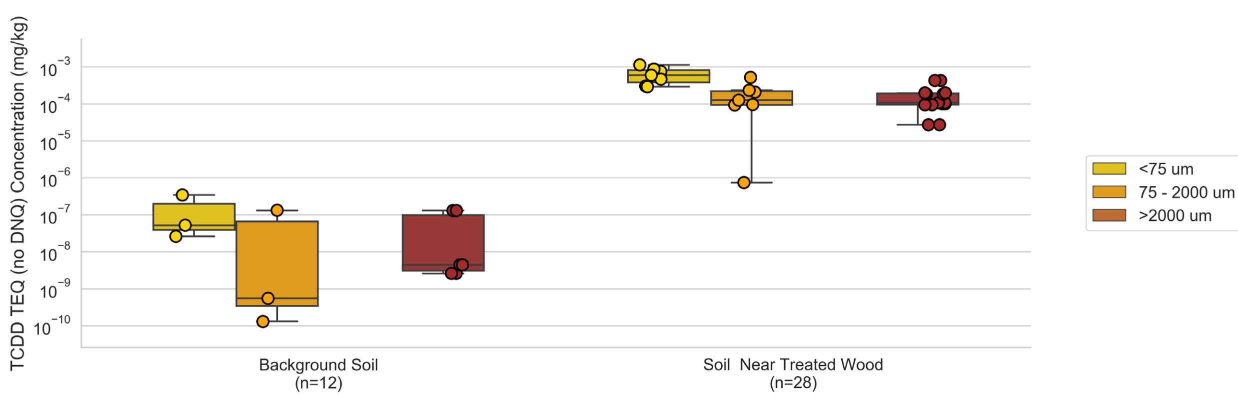
Note: Markers with a black border signify detected results. Markers with a gray border signify non-detected results and are shown at the method detection limit.

Figure 5. Manganese Concentration In Soil Samples by Particle Size Fraction and Calculated Bulk Concentration



Note: Markers with a black border signify detected results. Markers with a gray border signify non-detected results and are shown at the method detection limit.

Figure 6. Lead Concentration In Soil Samples by Particle Size Fraction and Calculated Bulk Concentration



Note: Markers with a black border signify detected results. Markers with a gray border signify non-detected results and are shown at the method detection limit.

Figure 7. Dioxin Concentration In Soil Samples by Particle Size Fraction and Calculated Bulk Concentration

This effect of size fractions is also reflected in stormwater from different watersheds having different suspended sediment size distributions. This can result in a watershed with more coarse grain mobilization having a lower particulate strength in stormwater than a watershed with more fine grain mobilization even if the soils and concentrations within both watersheds are equal (grain size mobilization may vary based on slope, flow velocity, drainage length, surface roughness that flow is passing over, rainfall patterns, etc.).

Table 4. Average Percent Mass by Particle Size in Stormwater Samples

Watershed			Average Percent Mass by Particle Size		
Category	Sample Count	Median TSS (mg/L)	Clay <3.91 um	Silt 62.5-3.91 um	Sand 1000-62.5 um
Onsite Paved Subareas	17	41	12%	61%	27%
Onsite Unpaved Subareas	19	16	15%	52%	33%
Offsite Background/ Ambient Subareas	24	245	21%	67%	12%
NPDES Outfalls (001, 002, 008, 009)	10	4.35* (n=46)	38%	57%	5%

*Not analyzed concurrently with PSD

When comparing stormwater PS to solid source concentrations, if the upper bar in the box plots indicating the 99th percentile was greater than or equal to the stormwater PS, this was assumed to support the hypothesis that the source material could be contributing to the exceeding concentration. An example plot with annotations is shown in Figure 8 based on the following logic:

- **Likely Source**: 99th percentile concentration of the potential source is higher than the particulate strength of the exceeding sample;
- **Possible Source**: extreme values of the potential source concentrations are above the exceeding sample particulate strength, but the 99th percentile of the potential source is slightly less than the exceeding sample; and
- **Not A Likely Source**: all measured concentrations of the potential source are less than the exceeding sample.

The following conventions are used in all of the plots comparing stormwater PS to solid source concentrations.

- Red markers indicate PS values of outfall samples whose stormwater concentration exceeded an effluent limit or benchmark in the past year.
- Orange markers indicate an exceedance in a prior year.
- Royal blue markers signify stormwater samples that did not exceed an effluent limit or benchmark in the past year.
- Light gray markers indicate non-exceedance samples from prior years.

- Black markers represent individual solid sample concentrations (only shown if too few samples to draw box plot).
- Soils samples include top 6 inches only to reflect what is most likely to be mobilized in stormwater.
- Purple dashed line represents the Soil Background Threshold Value (BTV). If a UTL 95-95 was not developed in DTSC's Chemical Background Study Report (DTSC 2012a) or Combined-Data Background Thresholds Values and Methodology Narrative (DTSC 2012b), the BTV is equal to the maximum reporting limit (RL) for non-detect and J qualified data. This value is based on offsite background soil samples.

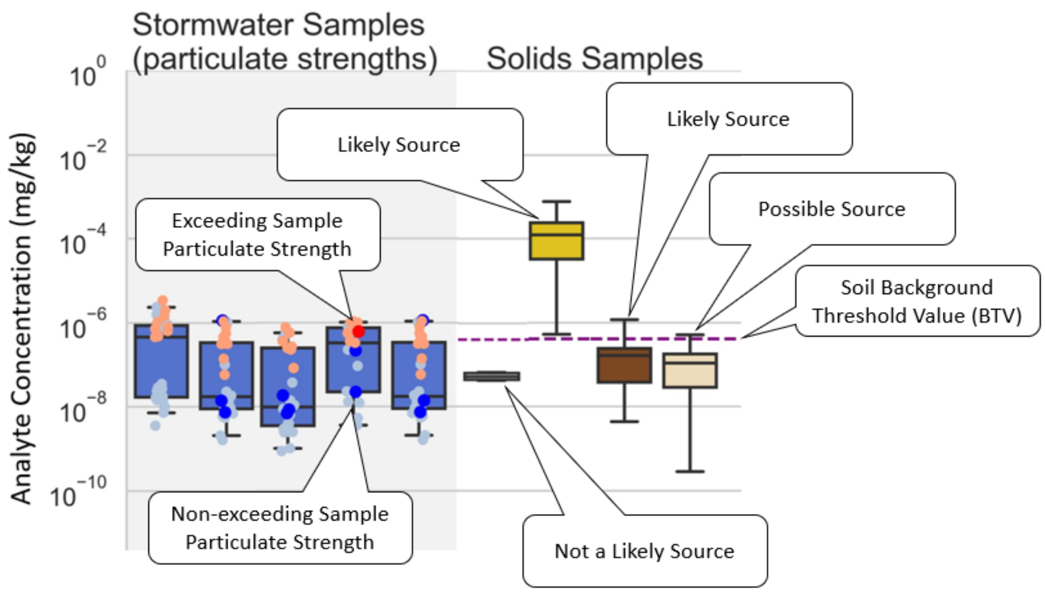
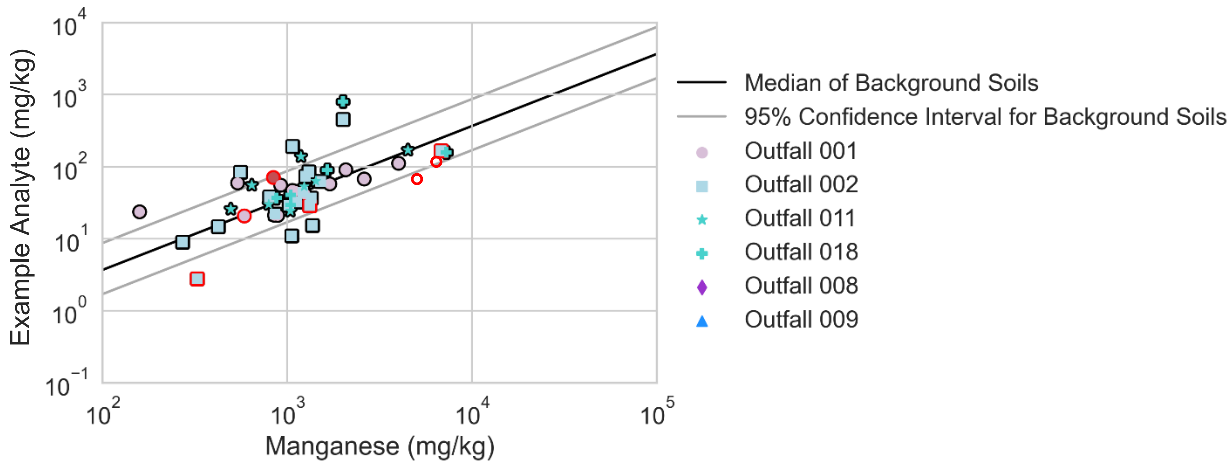


Figure 8. Example PS Plot

2.3. Fingerprinting: Metal Ratios

Metal ratio fingerprinting were used as a second LOE, in addition to PS, to determine if background soils could have caused effluent limit or benchmark exceedances. Metal ratios were used to identify potential constituent sources by the ratio of concentrations of multiple constituents in source material samples to the particulate strengths of stormwater samples. Iron and manganese were chosen to be the reference analytes because they are primarily soil derived, are not known soil cleanup drivers at SSFL, and are present at relatively consistent concentrations in most soils, and their stormwater PS results confirm this general understanding by matching levels in background soils. The ratios of each constituent to iron (or manganese in the case of iron exceedances) are presented in plots showing the median ratio and 95th percentile confidence interval for background soils compared to individual stormwater results. Figure 9 shows an example plot for an example exceeding analyte compared against manganese, with black and gray lines showing the median and 95th percentile confidence interval, respectively. Where stormwater results were within ranges found for background soils, as is the case for the exceeding samples outlined in red below, a supporting LOE was assumed supporting the hypothesis that the source of exceedances was likely background soils. NPDES sampling frequency requirements differ between parameters and as a result, not all samples have concurrent iron and manganese results[3].



Note: Samples whose stormwater concentration exceeded a water quality objective are marked with a red border.

Figure 9. Example Analyte: Manganese Metal Ratio Plot

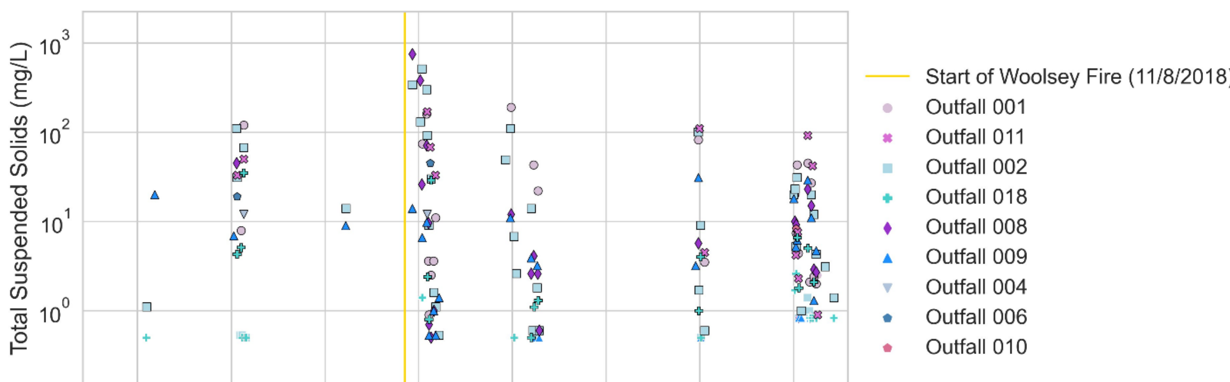
[3] For iron and manganese, the NPDES Permit for SSFL (NPDES NO. CA0001309) states that, "If the detected concentration exceeds the criteria, the frequency of analysis must be increased [from once per year] to once per discharge (once per month at Outfall 019/020). After four consecutive samplings demonstrate compliance, then the frequency reverts back to annual sampling."

3. Results

This section presents the Outfall stormwater results for each constituent that exceeded effluent limits or benchmarks in 2022/23 according to the LOEs approaches described above.

3.1. Total Suspended Solids (TSS)

TSS does not have a benchmark or permit limit, however, it is useful to the interpretation of other constituents to understand the general trends of TSS in SSLF stormwater samples. Stormwater concentrations of TSS in the 2022/23 season have decreased overall compared to the 2018/19 season, as shown in Figure 10, which shows TSS results from the current permit term. The concentrations are most similar to the 2016/17 and 2021/22 seasons, which also received above average rainfall. The long-term site-wide concentrations indicate that 2022/23 concentrations are generally in line with the range of concentrations in non-fire years. **The temporal patterns of TSS concentrations indicate that concentrations in 2022/23 are similar to other non-wildfire years.**



Notes:
1. Markers with a black border signify detected results.
2. Markers without a border signify non-detected result and are shown at the method detection limit.

Figure 10. Timeseries of TSS Concentrations 2015/16-2022/23

As shown in Figure 11, the highest concentrations of TSS this year were at Outfalls 001 and 011, followed by Outfall 002. Outfalls 001 and 002 are largely undeveloped watersheds, but both occasionally receive stormwater from an upstream developed watershed with an advanced stormwater treatment system (Outfall 011 and 018, respectively). The highest TSS concentration (92 mg/L) at Outfall 011 occurred during the 25-year, 24-hour rainfall event on 2/25/2023 when the Perimeter Pond overflowed and stormwater was only partially treated by the media filter at Outfall 011. Similarly, the highest TSS concentration (45 mg/L) at Outfall 001 was collected during the same 25-year, 24-hour rainfall event. **This pattern suggests that areas with higher TSS concentrations may be associated with erosion of soils in undeveloped watersheds without the stormwater treatment measures or significant structural BMPs that are prevalent in the more developed watersheds**. However, this alone does not indicate BMPs are necessary as these outfall concentrations are generally in line with or lower than natural watershed concentrations, and even the highest TSS concentrations measured at outfalls this year are at the low end of the typical range of TSS concentrations for stormwater in undeveloped watersheds (offsite background).

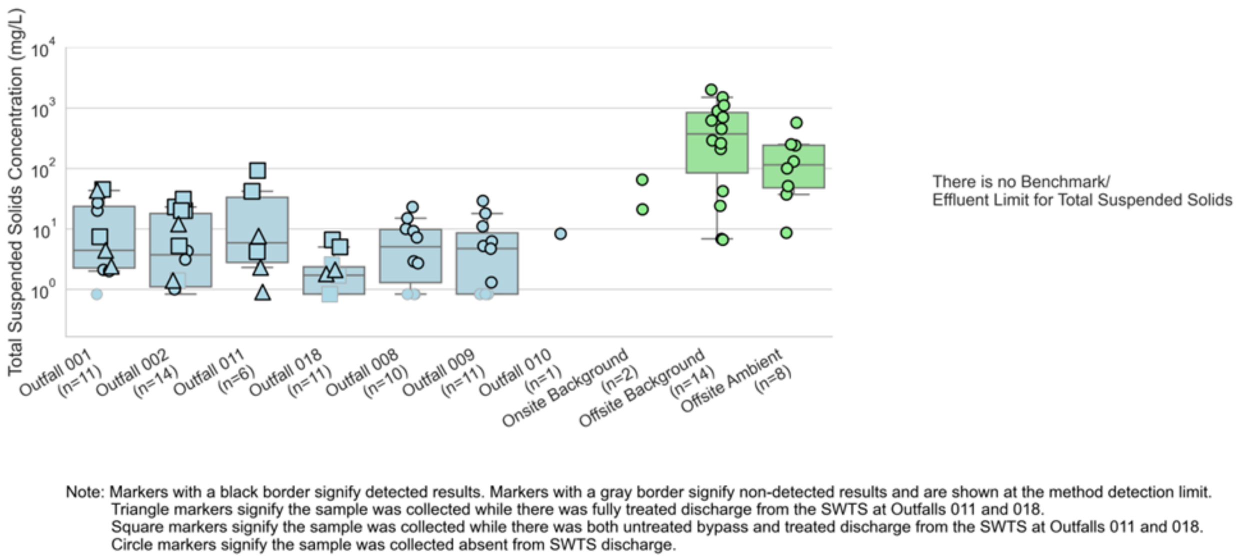


Figure 11. 2022/23 TSS Concentrations by Outfall

TSS is also used to compute COC particulate strengths, but particulate strength is only a useful metric for evaluating source of exceedances for COCs that are highly particulate-associated. Therefore, COC-TSS relationships are checked to confirm which pollutants are primarily particulate-associated. Figure 12 through Figure 16 show the concentration of exceeding constituents compared to the TSS concentration in each sample. The positive correlation in the plots for iron, manganese, and aluminum indicate that stormwater concentrations for those analytes are heavily influenced by TSS concentrations and the mobilization of soils. The less obvious, but still statistically significant, TSS relationship in the TCDD TEQ (no DNQ) plot are caused by the laboratory reporting individual congener results, often at very low concentrations near the detection limit, and the toxic equivalency factor applied to these congeners turning a near-continuous distribution of values into narrow discrete ranges. Results are highly variable by outfall and storm. However, this does not alter the understanding that TCDD TEQ is highly particulate associated (and therefore that particulate strengths can be used to identify its likely sources of exceedance) because its soil organic carbon partitioning coefficient is so high. The poor correlation between TSS and sulfate supports the understanding that sulfate is present in dissolved form and its transport pathway is independent of soil/sediment mobilization.

For the TSS correlation plots below, a best fit line and 95% confidence intervals for detected results are shown using dashed lines. The slope of the best fit line was further investigated to determine if it was a statistically significant non-zero (a slope of zero would indicate no relationship between a given analyte and TSS). The Wald Test with t-distribution of the test statistic was used to find the two-sided p-value for a hypothesis test whose null hypothesis is that the slope is zero. A p-value of less than 0.05 indicates a statistically significant relationship between the exceeding constituent and TSS concentrations. TCDD TEQ (no DNQ), iron, manganese, aluminum, and sulfate had a significant slope term indicating a statistically significant relationship with TSS, with all but sulfate having a positive correlation.

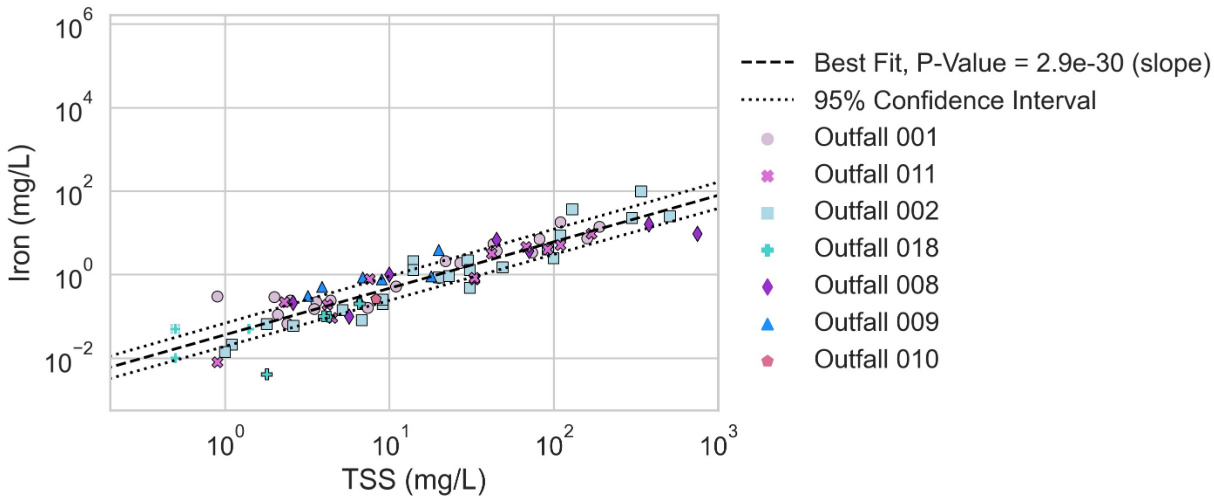


Figure 12. Iron vs TSS Concentrations at SSFL NPDES Outfalls from 2004-2023

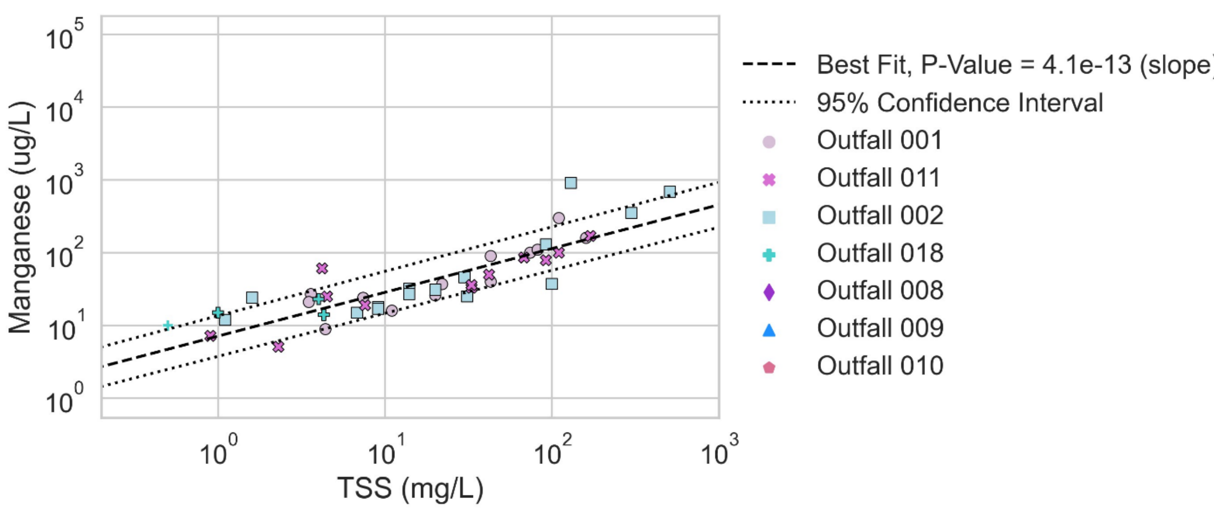


Figure 13. Manganese vs TSS Concentrations at SSFL NPDES Outfalls from 2004-2023

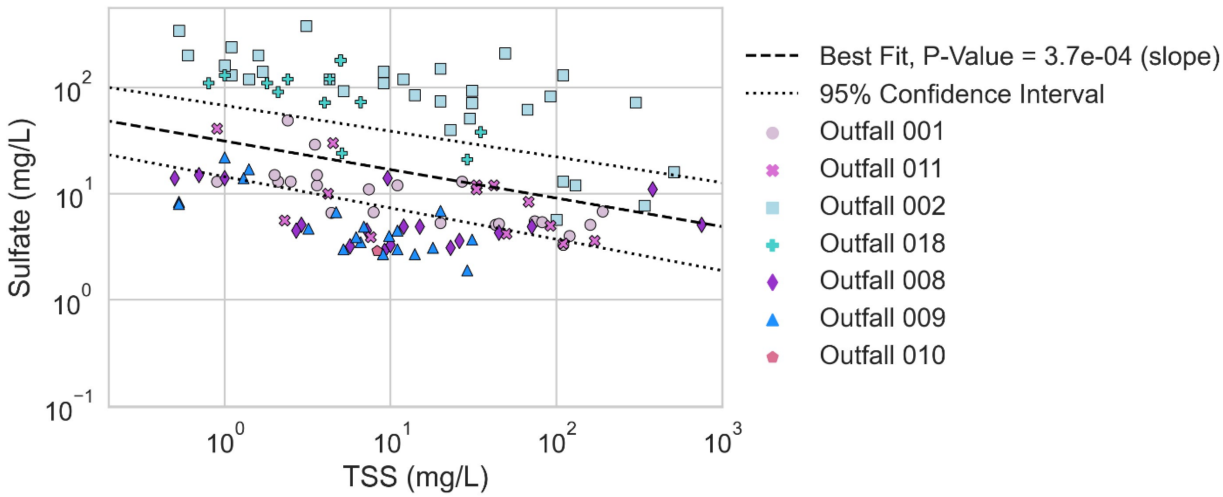


Figure 14. Sulfate vs TSS Concentrations at SSFL NPDES Outfalls from 2015-2023

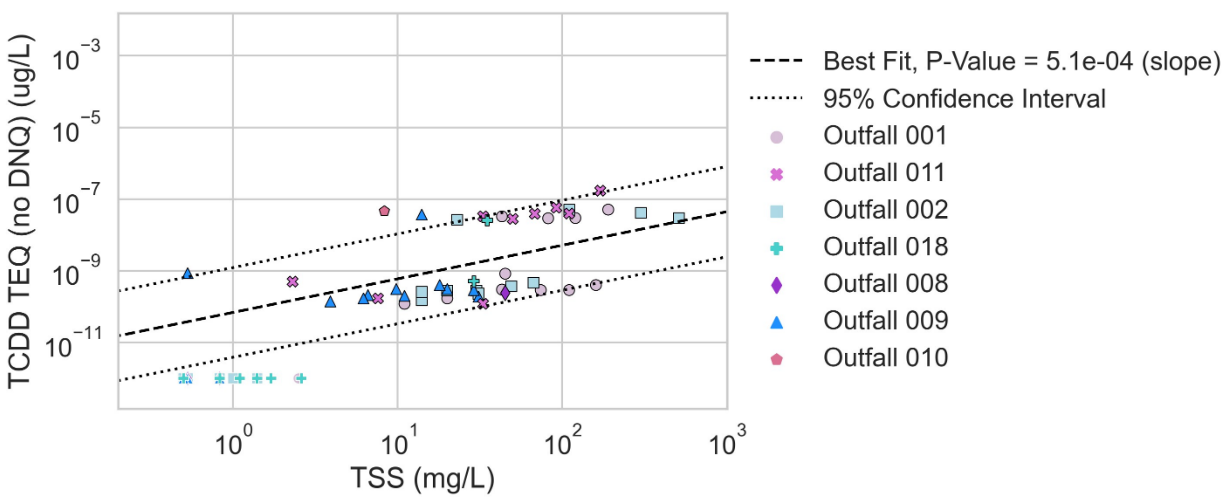


Figure 15. TCDD TEQ (no DNQ) vs TSS Concentrations at SSFL NPDES Outfalls from 2015-2023

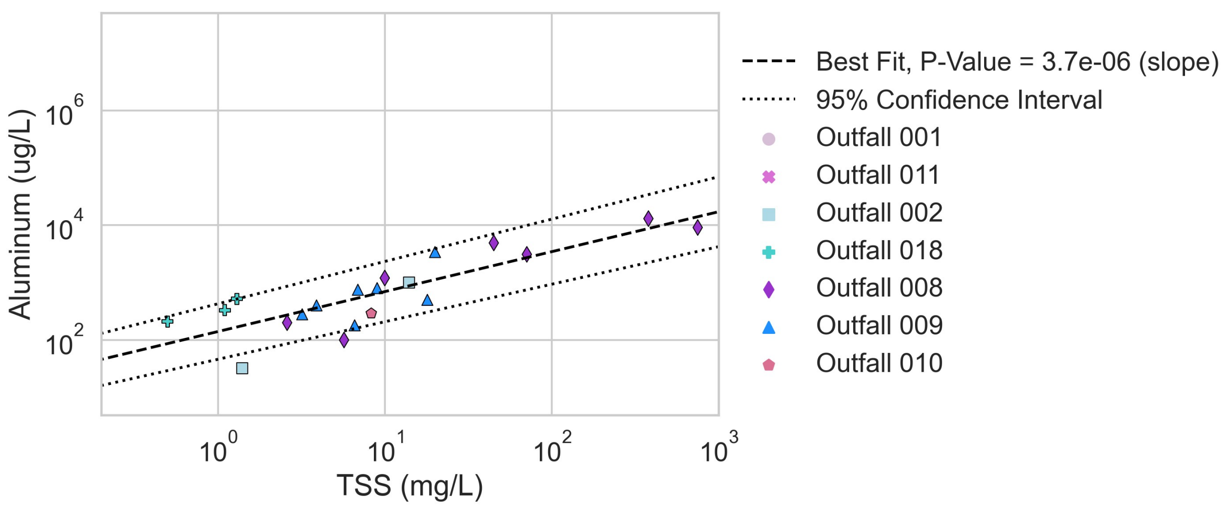


Figure 16. Aluminum vs TSS Concentrations at SSFL NPDES Outfalls from 2015-2023

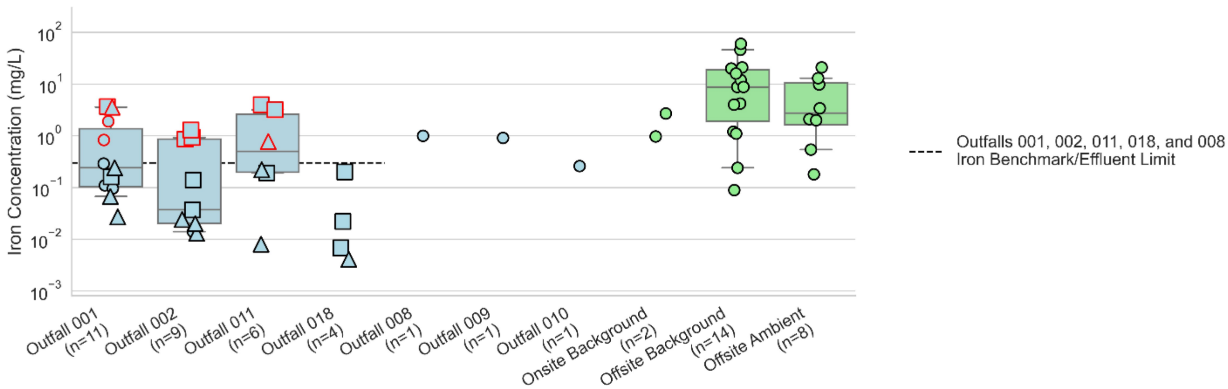
3.2. Iron

Iron concentrations were above the 0.3 mg/L effluent limit or benchmark at Outfalls 001, 002, and 011 a total of nine times in the 2022/23 season (there is no limit for iron at Outfalls 008, 009, and 010). While the current permit has a limit of 0.3 mg/L it is important to note that this is not a human or aquatic life based limit, but rather an aesthetic one (color or taste). Additionally, the draft tentative permit proposes removing limits for iron on the basis that it is from background and not a human health risk, and is also noted as "naturally occurring, low-toxicity chemical" in the DTSC Standardized Risk Assessment Methodology (SRAM) for SSFL[4] and does not have a human health risk based a soil screening level for the final comprehensive cleanup.

Although Figure 17a shows the highest iron concentrations were measured at Outfalls 001, 002, and 011 and lower in SWTS effluent samples at 018 and 002 and during 7-day, post-storm baseflow samples, Figure 17b shows the PS values were more consistent across outfalls and at offsite background locations, indicating the differences in concentrations were driven by TSS rather than a concentrated, local source. **The spatial pattern indicates that the outfalls likely share the same diffuse, site-wide source of iron in stormwater.**

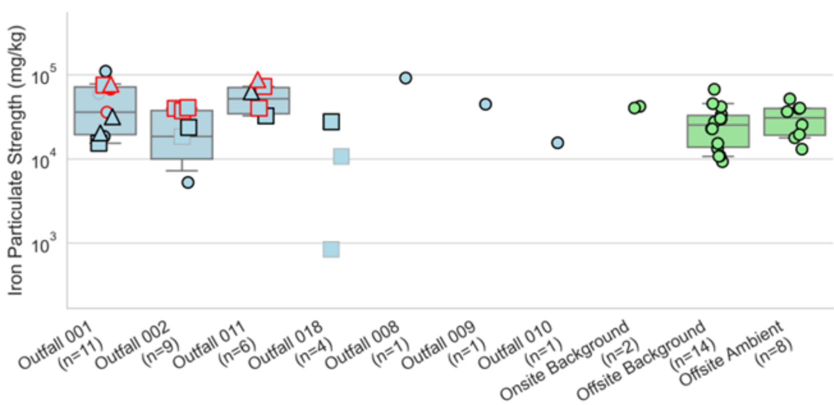
[4] Table 12-2 of Appendix F of the Final Standardized Risk Assessment Methodology, Revision 2 Addendum (SRAM Rev 2 Addendum [2022]), Santa Susana Field Laboratory (SSFL), Ventura County, California.

a)



Note: Markers with a black border signify detected results. Markers with a gray border signify non-detected results and are shown at the method detection limit.
Markers with a red border signify stormwater concentration exceeded an effluent limit or benchmark.
Triangle markers signify the sample was collected while there was fully treated discharge from the SWTS at Outfalls 011 and 018.
Square markers signify the sample was collected while there was both untreated bypass and treated discharge from the SWTS at Outfalls 011 and 018.
Circle markers signify the sample was collected absent from SWTS discharge.

b)



Note: Markers with a black border signify detected results. Markers with a gray border signify an estimated result.
Markers with a red border signify stormwater concentration exceeded an effluent limit or benchmark.
Triangle markers signify the sample was collected while there was fully treated discharge from the SWTS at Outfalls 011 and 018.
Square markers signify the sample was collected while there was both untreated bypass and treated discharge from the SWTS at Outfalls 011 and 018.
Circle markers signify the sample was collected absent from SWTS discharge.

Figure 17. 2022/23 Iron Concentrations (a) and Particulate Strengths (b) by Outfall

The PS of iron in stormwater, plotted in Figure 18, was compared to the concentration of iron in various solid source samples. This year's exceeding samples at Outfall 002 and one each at Outfalls 001 and 011 were in-line with the concentrations in background soils, but a few of the PS values of the exceeding samples this year were higher than the majority of concentrations in the sources evaluated. However, PS of iron at Outfalls 001, 011, and 002 were in line with the upper range of background stormwater. **Bottom line, the PS values of the exceeding samples at Outfalls 001, 011, and 002 were in-line with background stormwater.**

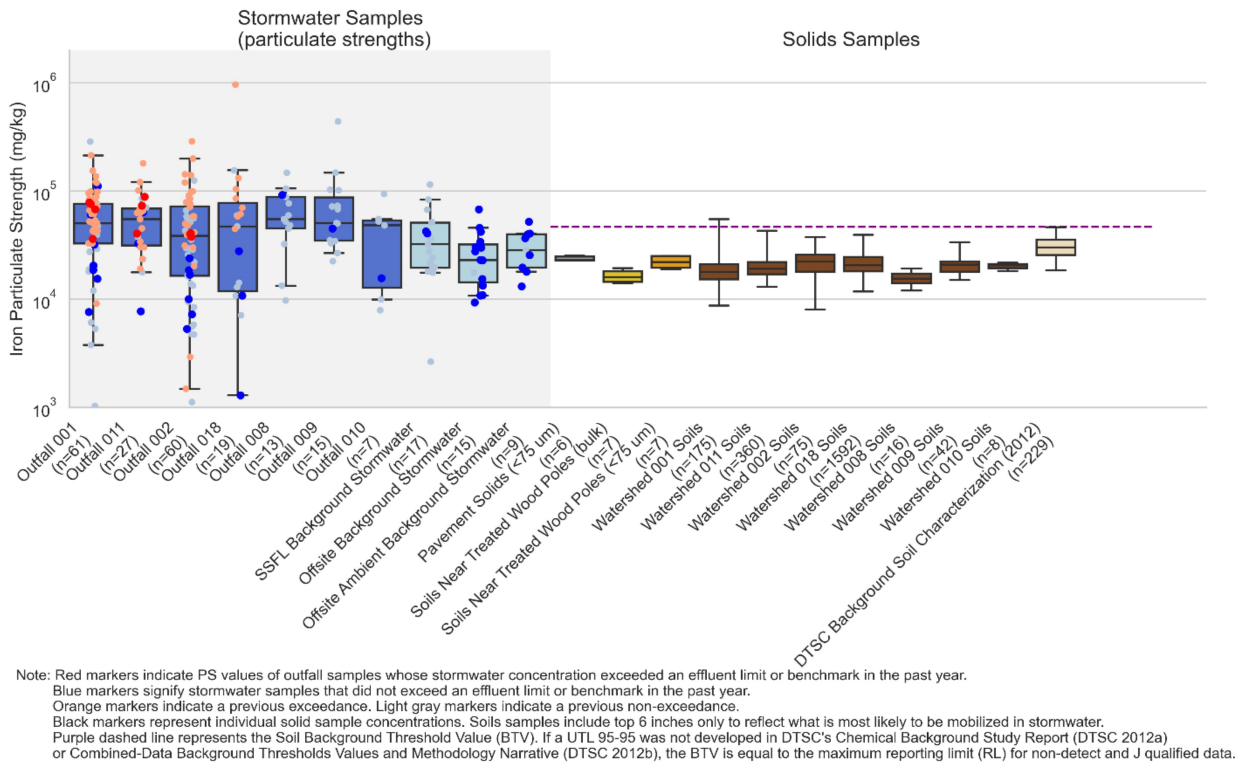


Figure 18. Iron Particulate Strength in Outfall Stormwater Samples vs. Solid Source Materials

The PS of iron was compared against manganese (both are found in relatively consistent concentrations in soils) to evaluate if the stormwater ratios were consistent with natural background ratios. Figure 19 shows that the ratios found in the exceeding stormwater samples at Outfalls 001, 011, and 002 fall within the background soil 95% confidence interval, which supports **that background soils were likely the source of the iron exceedances** in the 2022/23 season.

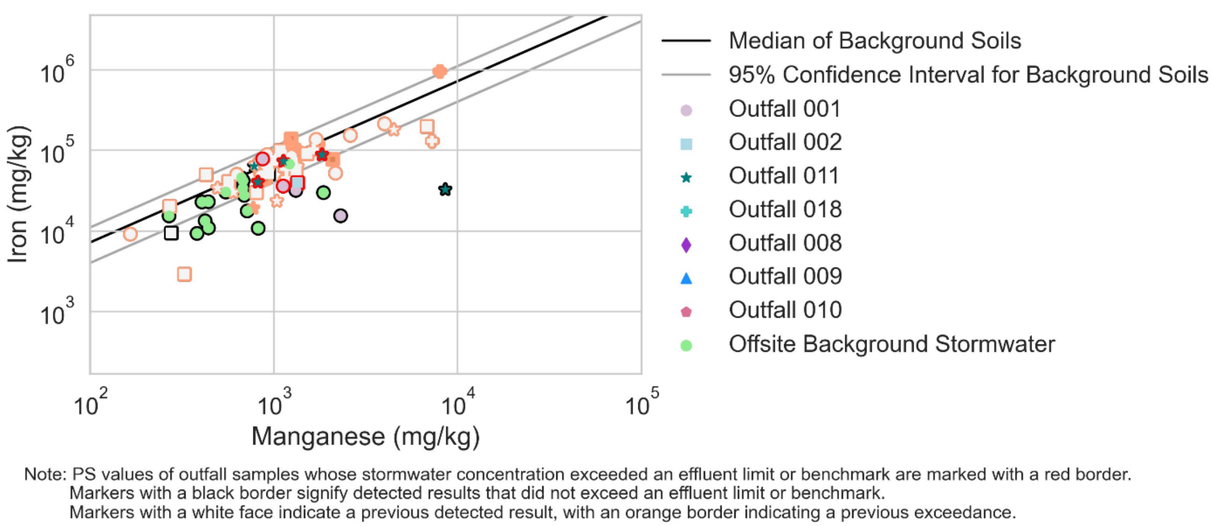


Figure 19. Iron:Manganese Metal Ratio Plot

3.3. Manganese

Manganese concentrations were above the 50 µg/L effluent limit at Outfall 011 two times in 2022/23. While the permit has a limit of 50 µg /L it is important to note that this is not a human or aquatic life-based limit, but rather an aesthetic one (color or taste). Additionally, manganese is not a cleanup driver in the final comprehensive cleanup at SSFL.

As illustrated in Figure 20a, manganese concentrations were fairly consistent across the site, and generally lower than concentrations at the offsite background and ambient locations. Both manganese exceedances at Outfall 011 occurred when the SWTS was operational during large storms (10-year and 25-year, 24-hour evens) when there was also bypass from Perimeter Pond flowing to the Outfall. Figure 20b shows particulate strengths were consistent across the outfalls with the exception of one exceeding sample at Outfall 011. **The spatial pattern indicates that all outfalls likely shared the same diffuse, site-wide source of manganese in stormwater, with the exception of the single elevated sample at OF011.**

a)

b)

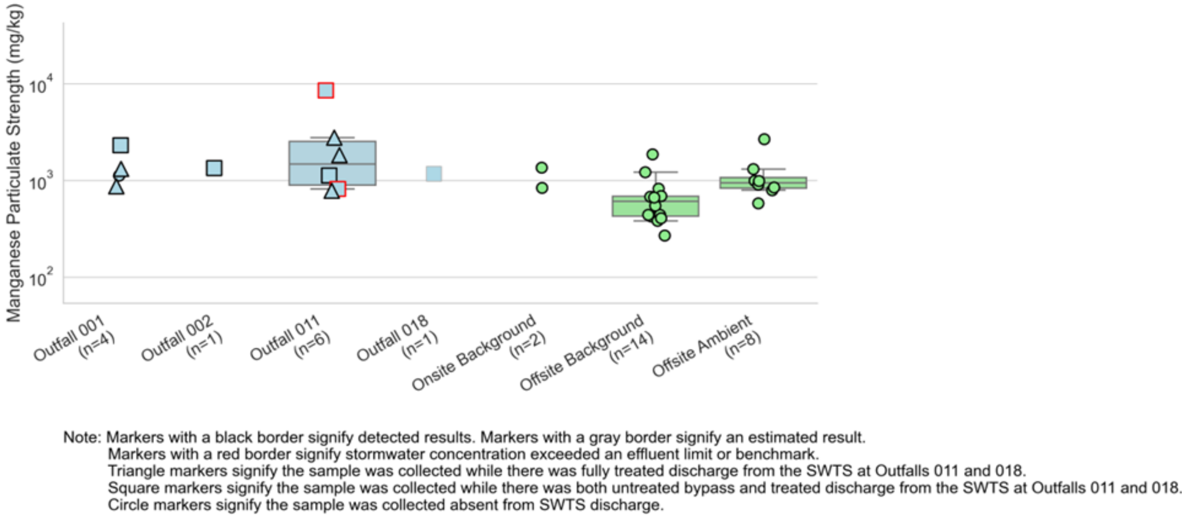
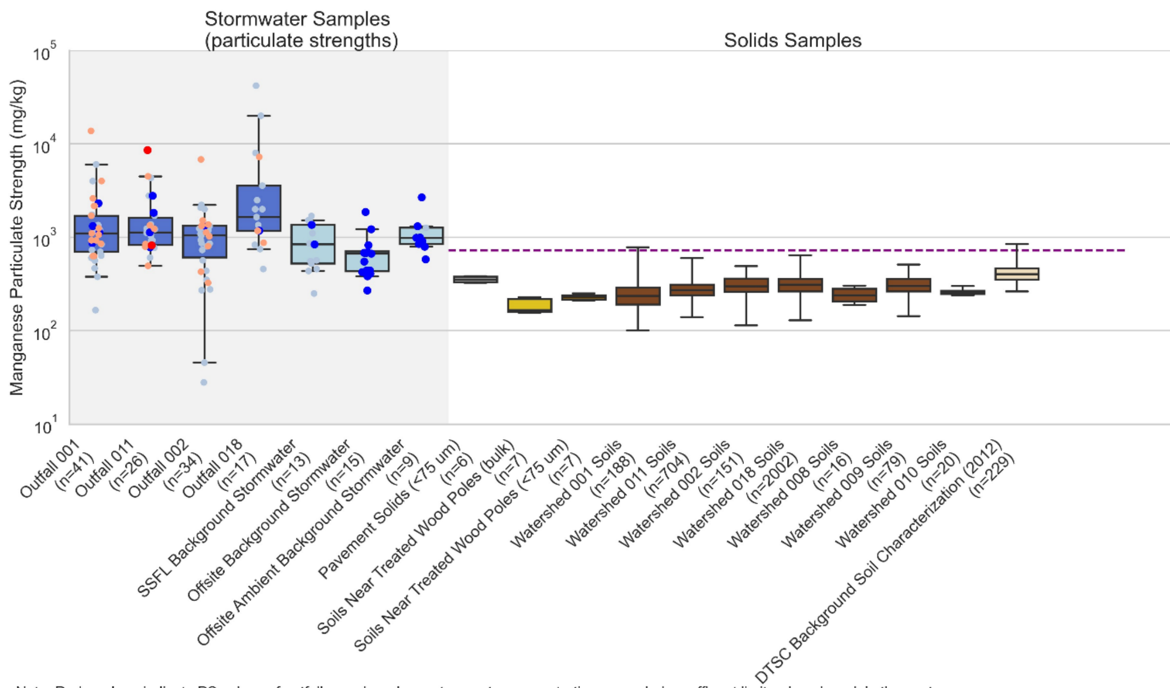


Figure 20. 2022/23 Manganese Concentrations and Particulate Strengths by Outfall

The PS of the outfall stormwater samples compared to the various potential sources are shown in Figure 21. The exceeding sample's PS in the first discharge of the year was not below the 99% threshold of any of the sources evaluated. However, the PS of the other exceeding sample at Outfall 011 was in line with concentrations found in background stormwater, and at the 99% of background soils. This difference between soils concentration and stormwater particulate strength again highlights the multiplier effect that is observed in stormwater versus the original soil source due to the preferential mobilization of finer particles that typically have a higher concentration than the bulk soil (as shown in Figure 5). Additionally, manganese appears to have a higher multiplier effect than iron when comparing offsite background soils to offsite background stormwater. **The PS values of one exceeding 2022/23 sample could not be explained by the solid source samples evaluated, but the other was in-line with background stormwater. Most importantly, the elevated PS of this one exceeding sample cannot be explained by impacted soils since Figure 21 shows manganese concentrations in soils found in Watershed 011 are the same or lower than DTSC offsite background soil samples.**



Note: Red markers indicate PS values of outfall samples whose stormwater concentration exceeded an effluent limit or benchmark in the past year.
Blue markers signify stormwater samples that did not exceed an effluent limit or benchmark in the past year.
Orange markers indicate a previous exceedance. Light gray markers indicate a previous non-exceedance.
Black markers represent individual solid sample concentrations. Soils samples include top 6 inches only to reflect what is most likely to be mobilized in stormwater.
Purple dashed line represents the Soil Background Threshold Value (BTV). If a UTL 95-95 was not developed in DTSC's Chemical Background Study Report (DTSC 2012a) or Combined-Data Background Thresholds Values and Methodology Narrative (DTSC 2012b), the BTV is equal to the maximum reporting limit (RL) for non-detect and J qualified data.

Figure 21. Manganese PS in Outfall Stormwater Samples vs. Solid Source Materials

The PS of manganese was compared against iron to evaluate if the stormwater ratios were consistent with natural background ratios. Figure 22 shows that one exceeding stormwater sample fell within the background soil 95% confidence interval, which suggests that **background soils are likely the source of one of the manganese exceedances** in the 2022/23 rainy season. For the Outfall 011 manganese exceedance that fell outside of the background soil 95% confidence interval and above background stormwater samples, other sources in addition to background soils may be responsible. The Outfall 001 sample that was also slightly elevated in its manganese ratio to iron this year was collected during the same storm event that the Outfall 011 sample ratio was elevated, so their sources may be the same.

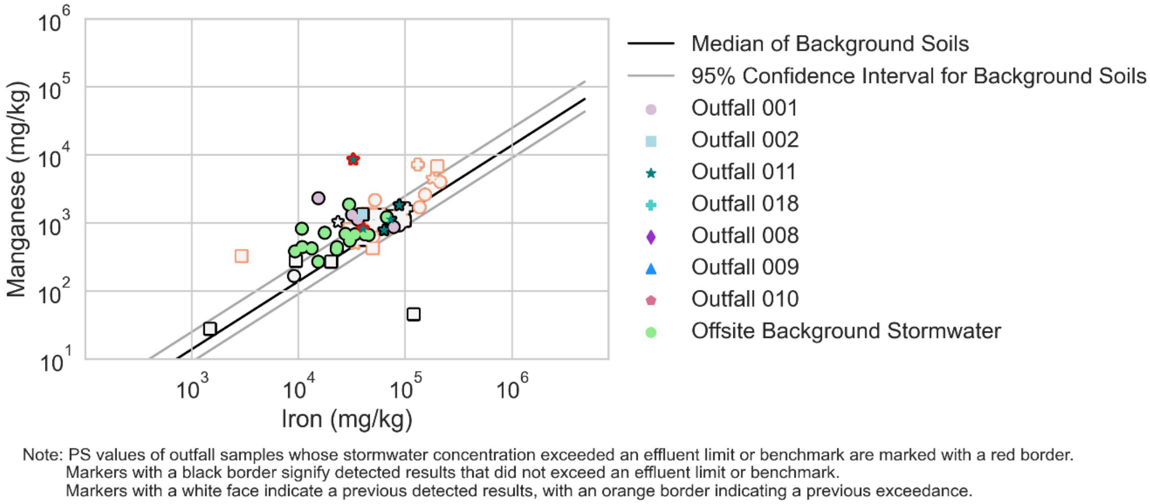


Figure 22. Manganese:Iron Metal Ratio Plot

In order to evaluate the potential effects of treatment chemicals used in the SWTS that discharges at Outfall 011, a mass balance evaluation of manganese was conducted on the sample that could not be explained by background soils alone. A small amount of 2.3% potassium permanganate solution is added during a step in the stormwater treatment process. The mass of manganese added as potassium permanganate was about 35% of the mass of manganese measured in the Outfall 011 exceeding sample, so while it could have contributed to the higher particulate strength, it is unlikely that the potassium permanganate dosing caused the manganese exceedances at Outfall 011. In addition, most of the added manganese at the treatment plant is recovered with the captured sediment that is removed from the stormwater, with very little actually discharged in the treated stormwater. Based on all of the lines of evidence, **the exceeding sample with the elevated PS is likely due to background soils in addition to an unknown source other than impacted soils**. The influent and effluent concentrations and permanganate dosing will be more closely monitored during the startup of SWTS operations to reduce the possibility of impacts from the treatment system.

3.4. Sulfate

Sulfate concentrations were above the 300 mg/L benchmark at Outfall 002 one time in 2022/23, in a sample that was collected during post-storm baseflow (non-stormflow) conditions. While the permit has a limit of 300 mg /L it is important to note that this is not a human health-based limit, but rather based on the LA Basin Plan. Additionally, sulfate is also noted as “naturally occurring, low-toxicity chemical” in the DTSC Standardized Risk Assessment Methodology (SRAM) for SSFL[5] and is not a soil cleanup driver in the final comprehensive cleanup list.

As illustrated in Figure 23, sulfate concentrations were highest at Outfalls 002 and 018. Outfall 002 is in an undeveloped watershed that has numerous natural seeps and receives runoff from an upstream developed watershed with an advanced SWTS (at Outfall 018). **Spatial patterns indicate there may be a local source elevating sulfate concentrations in the 002/018 watersheds.** Similar concentrations are observed at the offsite background location indicating the elevated concentrations could have a natural

[5] Table 12-2 of Appendix F of the Final Standardized Risk Assessment Methodology, Revision 2 Addendum (SRAM Rev 2 Addendum [2022]), Santa Susana Field Laboratory (SSFL), Ventura County, California.

source. A background location in a tributary to Outfall 002 and not influenced by the SWTS was sampled in order to discover other potential sources of sulfate. Sulfate was detected at 490 mg/L in a March 2023 stormwater sample at this location. Previous samples at this location have ranged from 2.5 to 620 mg/L.

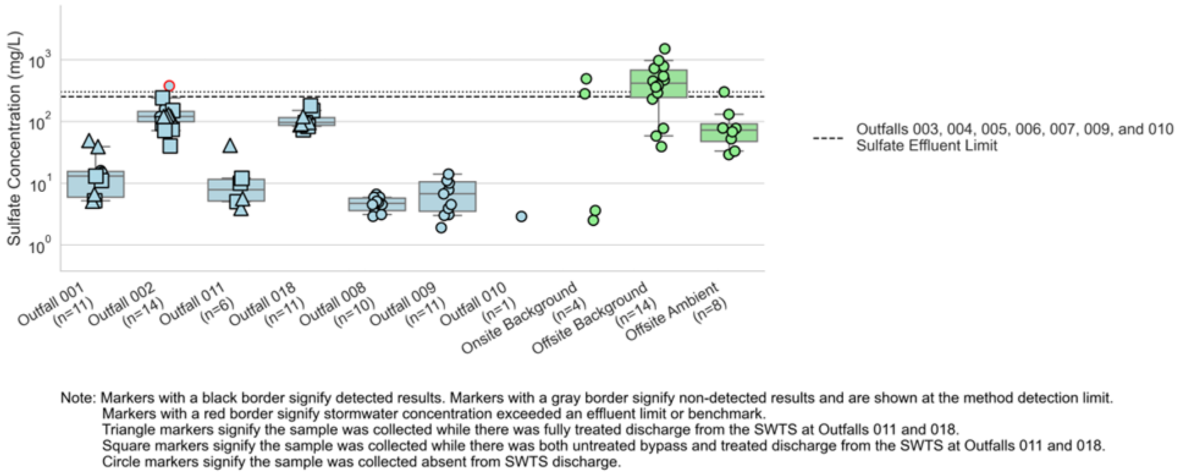


Figure 23. 2022/23 Sulfate Concentrations by Outfall

The Santa Susana Formation, which is found in just the southwest corner of SSFL, contains shale and shaly sandstone. In contrast, the Chatsworth formation, which covers the rest of the site, is entirely sandstone. Shale is known to contain sulfur which further helps to explain the high sulfate reported by the Groundwater Expert Panel in seeps above and below Outfall 002 (and nearby offsite). Additionally, sulfate concentrations in stormwater samples at the site are typically highest during baseflow periods and late in the wet season when the water table is highest, as shown in Figure 24. **Together, these lines of evidence demonstrate that the sulfate exceedance at Outfall 002 is most likely from natural sources.** Additionally, the 2022 SRAM[6] excludes sulfate from its constituent list because it is a "naturally occurring, low-toxicity chemical" and doesn't present a human or ecological health risk.

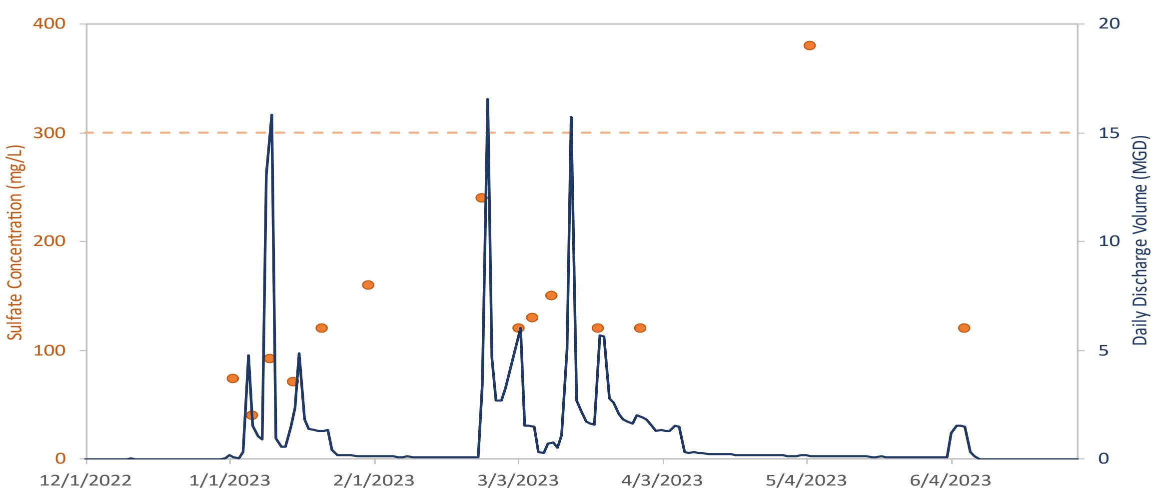


Figure 24. Outfall 002 Sulfate Concentration (and 300 mg/L Benchmark) vs Daily Discharge Volume at Outfall 002

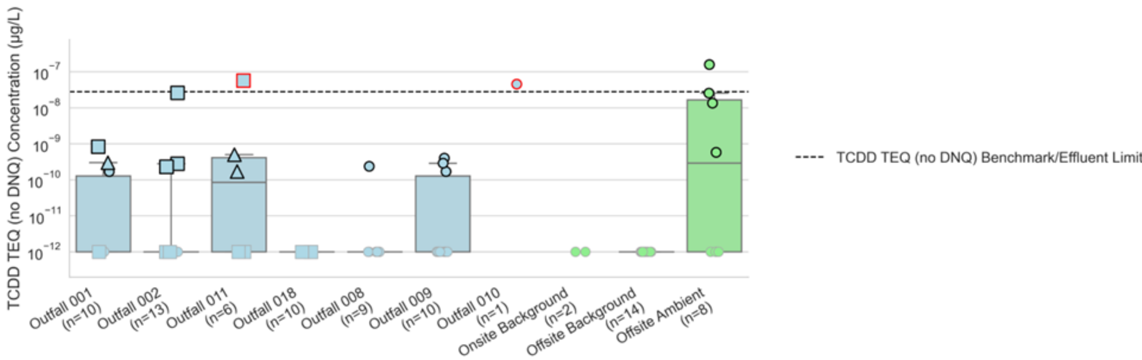
[6] Table 12-2 of Appendix F of the Final Standardized Risk Assessment Methodology, Revision 2 Addendum (SRAM Rev 2 Addendum [2022]), Santa Susana Field Laboratory (SSFL), Ventura County, California.

3.5. TCDD TEQ (no DNQ)

The TCDD TEQ (no DNQ) concentrations at Outfalls 011 and 010 were above the effluent limit once each in 2022/23. TCDD TEQ (no DNQ) limits are based on human health for fish consumption, however, neither fish nor fishing are known to occur at or near SSFL outfalls or drainages. Unlike the other exceeding parameters this year, dioxins and furans are a cleanup parameter at the site. The exceedance at Outfall 011 occurred during a 25-year storm event which exceeds the design storm of the stormwater treatment BMPs. The sample was collected during a period of overflow at Perimeter Pond and represents a mix of stormwater treated by the SWTS and the media filter at the outfall and untreated overflow from Perimeter Pond. The exceedance at Outfall 010 occurred during a 10-year storm event which also exceeded the design capacity of the capture and diversion system that usually routes stormwater from this drainage area to Silvernale Pond for treatment. The sample there included stormwater partially treated by the media filter at Outfall 010.

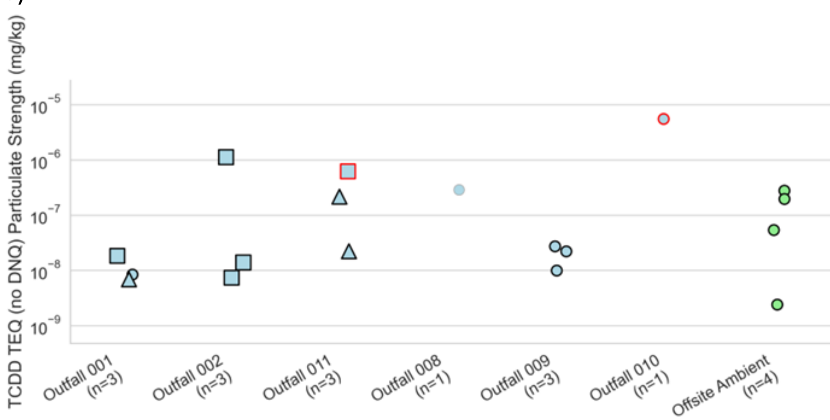
Figure 25a shows the 2022/23 outfall concentrations of TCDD TEQ (no DNQ), including the exceeding samples at Outfall 011 and Outfall 010. Figure 25b shows the outfall PS values of TCDD TEQ (no DNQ), with the highest PS value located at Outfall 010. **The spatial patterns indicates that while all outfalls likely shared the same diffuse, site-wide source of TCDD TEQ (no DNQ) in stormwater, there may be localized sources with higher TCDD TEQ (no DNQ) concentrations that drives exceedances.** Looking at the offsite background and ambient (open space with roads and rural residential) stormwater indicates that there are ambient sources of TCDD TEQ (no DNQ) present at the site that could be contributing to the exceedances.

a)



Note: Markers with a black border signify detected results. Markers with a gray border signify non-detected results and are shown at the method detection limit.
Markers with a red border signify stormwater concentration exceeded an effluent limit or benchmark.
Triangle markers signify the sample was collected while there was fully treated discharge from the SWTS at Outfalls 011 and 018.
Square markers signify the sample was collected while there was both untreated bypass and treated discharge from the SWTS at Outfalls 011 and 018.
Circle markers signify the sample was collected absent from SWTS discharge.

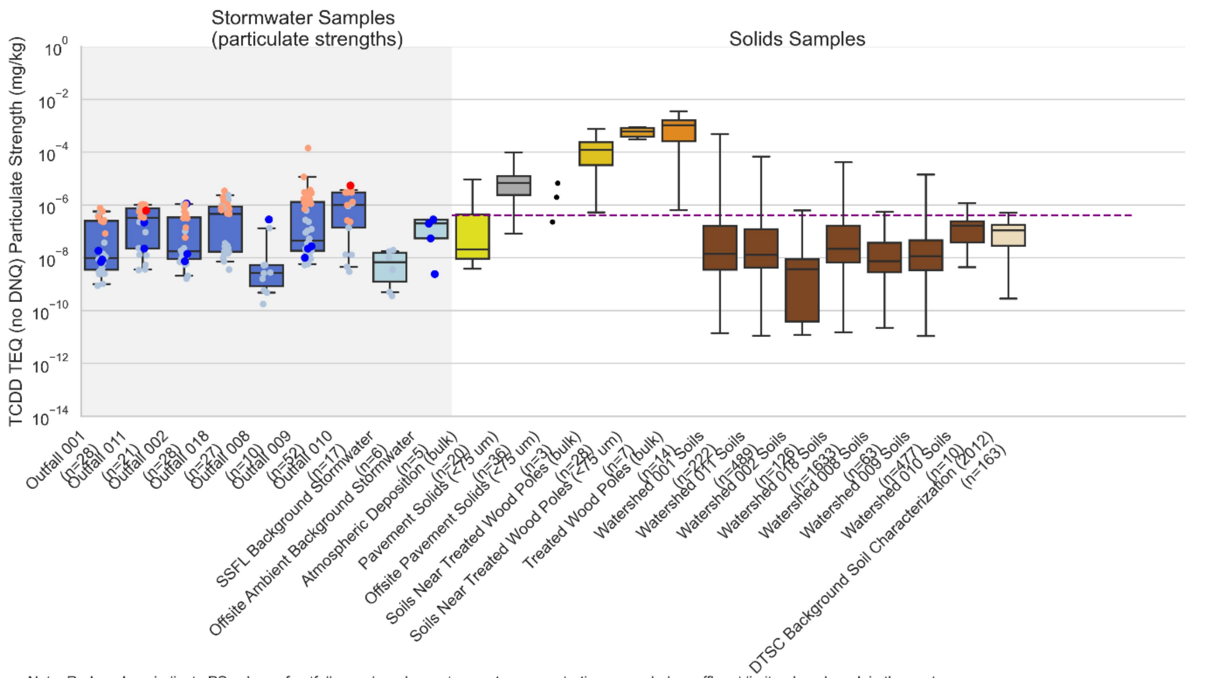
b)



Note: Markers with a black border signify detected results. Markers with a gray border signify an estimated result.
Markers with a red border signify stormwater concentration exceeded an effluent limit or benchmark.
Triangle markers signify the sample was collected while there was fully treated discharge from the SWTS at Outfalls 011 and 018.
Square markers signify the sample was collected while there was both untreated bypass and treated discharge from the SWTS at Outfalls 011 and 018.
Circle markers signify the sample was collected absent from SWTS discharge.

Figure 25. 2022/23 Dioxins Concentrations and Particulate Strengths by Outfall

As shown in Figure 26, the exceeding samples had PS values that could have come from pavement solids, soils near treated wood utility poles, treated wood utility poles, and impacted soils (more likely at Outfall 011, whereas soils in the 010 watershed have lower dioxin concentrations). Of these sources, pavement solids and soils near treated wood have sufficiently high particulate strengths (about 10x to 100x the exceeding samples), quantity, and mobility onsite to be significant contributors of TCDD TEQ (no DNQ) in stormwater. Additionally, the highest soil concentrations found in potential cleanup areas in the Outfall 011 watershed are 1x to 10x the exceeding sample, indicating these soils could also have contributed to the exceedance. On the other hand, soil samples in the Outfall 010 potential cleanup areas have TCDD TEQ (no DNQ) concentrations more similar to background soils, so pavement and treated wood utility poles are a more likely source of the elevated PS in the exceeding sample. Together, this indicates the **TCDD TEQ (no DNQ) exceedances in stormwater were likely from pavement solids (<75 µm), soils near treated wood, impacted soils, and/or, background soils.**



Note: Red markers indicate PS values of outfall samples whose stormwater concentration exceeded an effluent limit or benchmark in the past year.
Blue markers signify stormwater samples that did not exceed an effluent limit or benchmark in the past year.
Orange markers indicate a previous exceedance. Light gray markers indicate a previous non-exceedance.
Black markers represent individual solid sample concentrations. Soils samples include top 6 inches only to reflect what is most likely to be mobilized in stormwater.
Purple dashed line represents the Soil Background Threshold Value (BTV). If a UTL 95-95 was not developed in DTSC's Chemical Background Study Report (DTSC 2012a) or Combined-Data Background Thresholds Values and Methodology Narrative (DTSC 2012b), the BTV is equal to the maximum reporting limit (RL) for non-detect and J qualified data.

Figure 26. Dioxins PS (2022/23 Outfall Stormwater Samples) vs. Solid Source Materials

The extent treated wood poles have an effect on the surrounding soils was further investigated in 2021 by collecting soil samples at various distances from poles. Figure 27 summarizes the results of this sampling along with previous soils sampled near treated wood poles that were analyzed for different size fractions. The highest concentrations were found in the fine fraction and 1 ft away from the treated wood pole. Looking at the bulk soil samples, concentrations decreased with increasing distance from the pole and the lowest were found 20 ft away from poles, but still slightly above background. These results indicate a strong correlation between dioxin concentrations and distance from poles, which supports the hypothesis that treated wood poles were the source of dioxin in the surrounding soils, particularly in Outfall 011 which has dozens of poles along the road and main drainage.

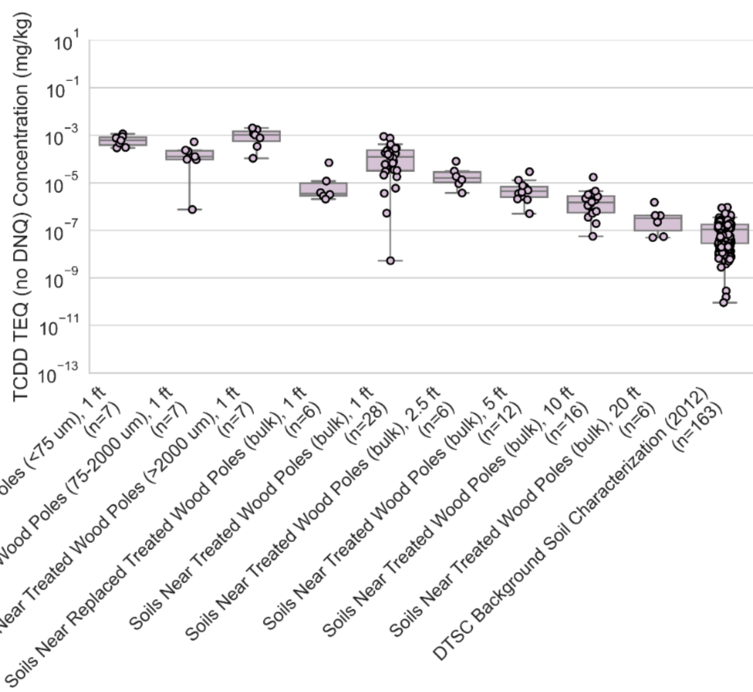


Figure 27. TCDD TEQ (no DNQ) Concentrations in Soils at Varying Distances from PCP-Treated Wood Utility Poles Compared to Background Soil Concentrations

The PS of TCDD TEQ (no DNQ) was compared against iron to evaluate if the stormwater ratios were consistent with natural background ratios. Figure 28 show that while most stormwater samples fall within the background soil 95% confidence interval, the exceeding samples are generally slightly elevated. The exceeding sample at Outfall 011 sample this year falls within the 95% confidence interval, which **supports background soils as a potential source of the 011 TCDD TEQ (no DNQ) exceedances** during the 2022/23 rainy season**.** However, the Outfall 010 exceeding stormwater sample falls outside of the background soil 95% confidence interval, which **indicates that other sources like pavement solids and treated wood are likely also contributing to the exceeding sample.**

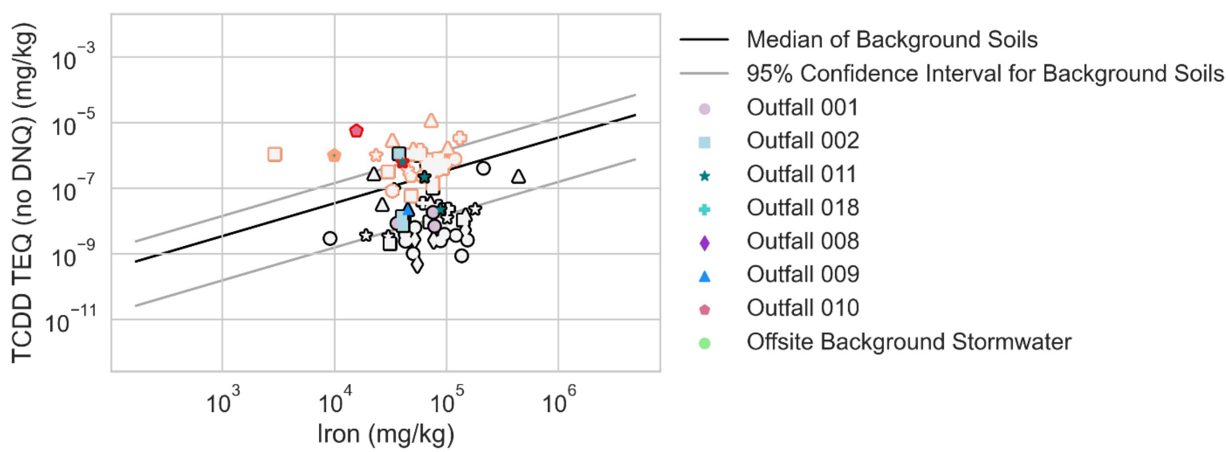


Figure 28. Dioxin vs Iron Metal Ratio Plot

4. Preliminary Source Investigation for Tentative COPCs

This section presents results for constituents of potential concern (COPC) that exceeded an effluent limit included in the 2023 draft tentative permit but not in the permit that was in effect for the 2022/23 season. There is less data available for a source evaluation since aluminum has not been included in recent stormwater investigations. Source sampling recommendations are being updated to include this analyte moving forward.

4.1. Aluminum

Aluminum concentrations were detected above the 1 mg/L tentative effluent limit at Outfall 008 one time in 2022/23. The limit for aluminum is based on the primary drinking water MCL which assumes a lifetime consumption at that level.

The concentrations of aluminum in onsite soil samples collected from the top 6 inches were mapped over the potential soil cleanup areas identified in DTSC Potential Environmental Impact Report and colored to show ones below the background threshold yellow and those above purple (4 samples) in Figure 29. This figure demonstrates that aluminum concentrations in unimpacted soils across site are no different than aluminum concentrations in soil cleanup areas (orange shaded areas). As reflected in Figure 29, more than **99.9% of soil samples have aluminum concentrations below the background threshold value (BTV)**, which is further evidence that there are no industrial or impacted soil sources of aluminum at the site, and therefore aluminum exceedances in stormwater are likely from natural background soils.

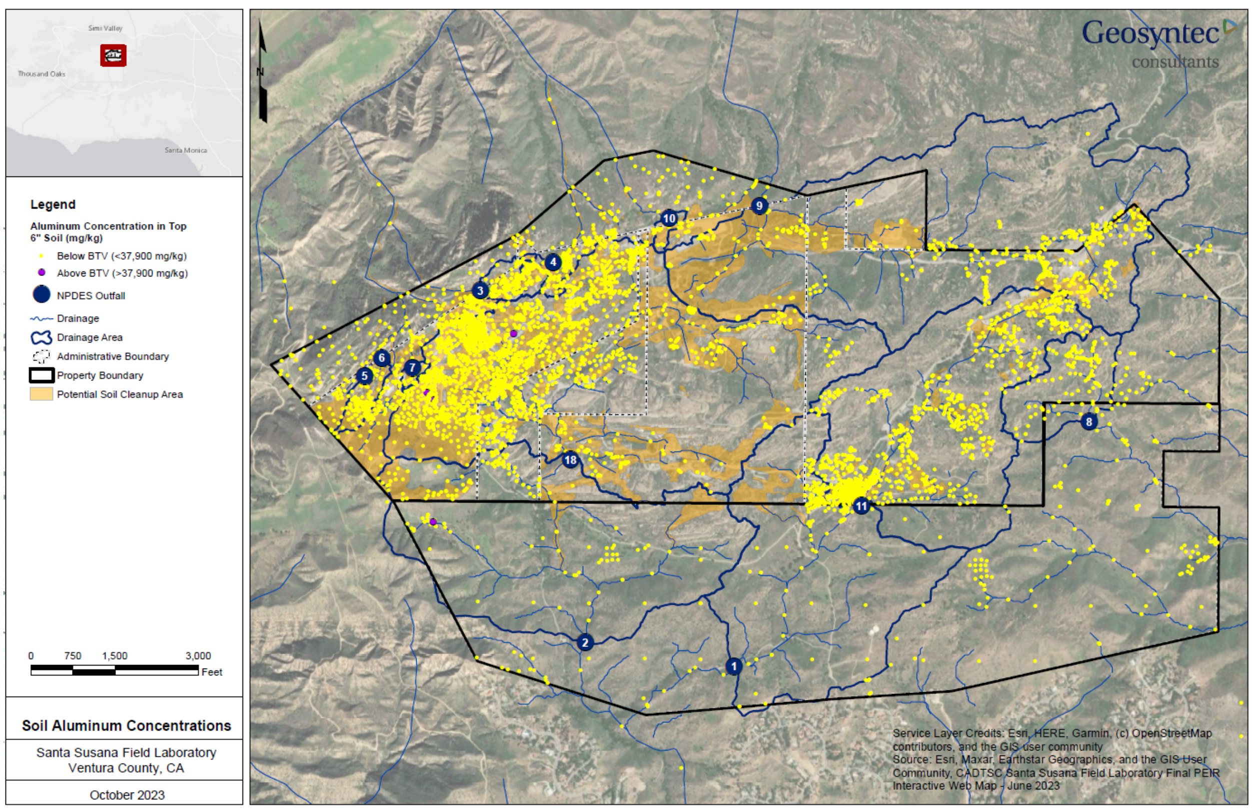
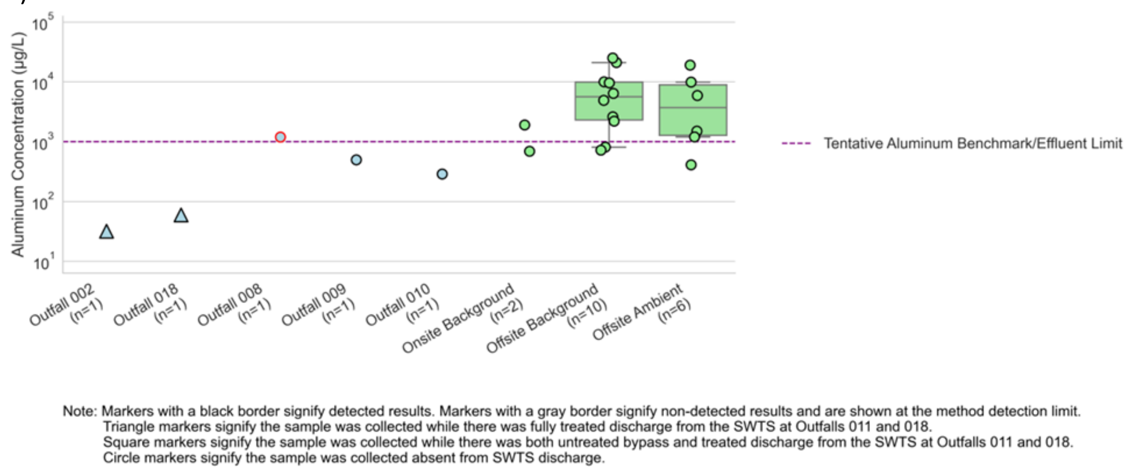


Figure 29. Aluminum Concentrations in SSFL Surface Soils (Top 6 inches)

Figure 30 shows the concentration of aluminum measured at the outfalls and background locations this year. **With only one sample per outfall location this year, there is not sufficient data to inform spatial trends.**

a)



b)

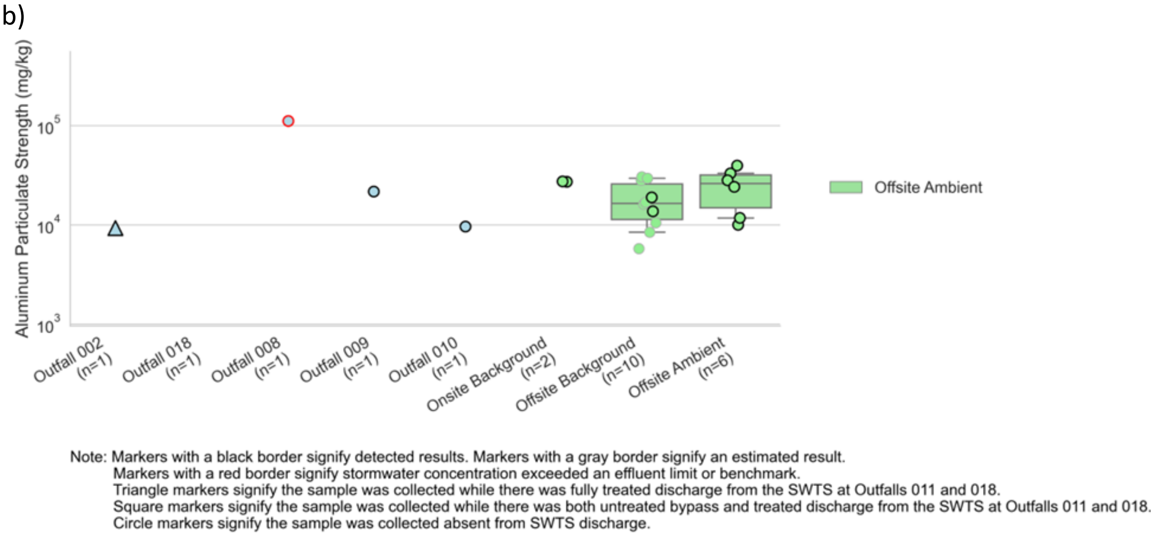
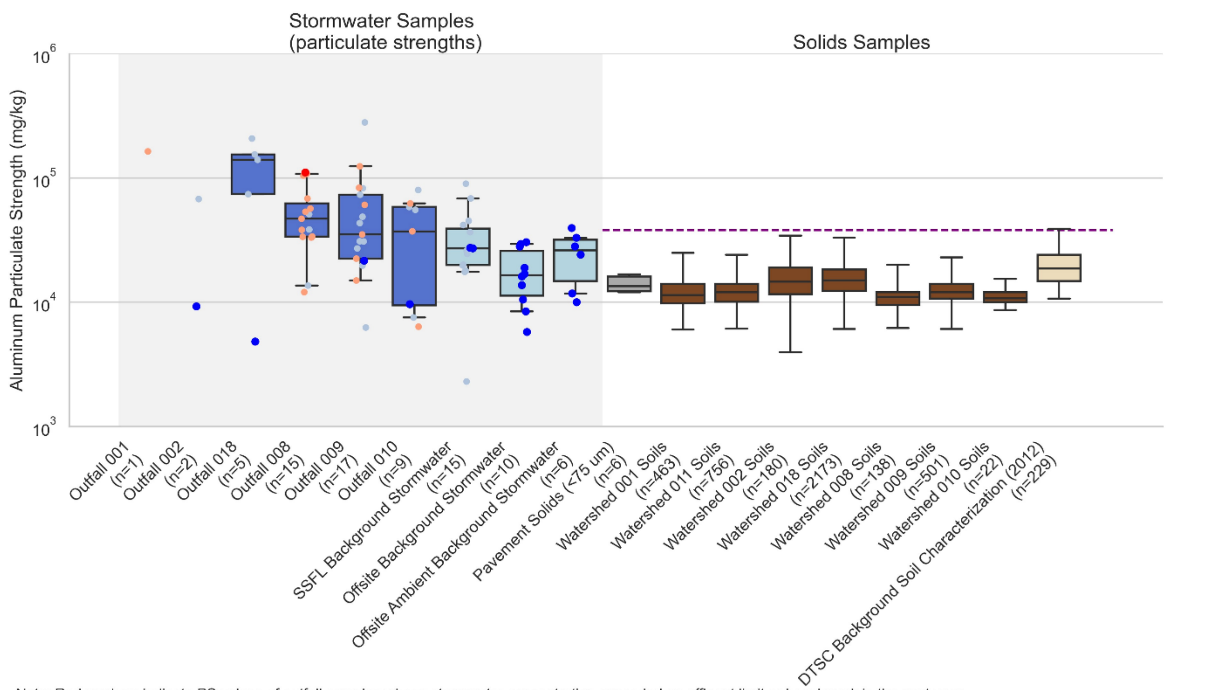


Figure 30. 2022/23 Aluminum Concentrations and Particulate Strengths by Outfall

The PS of the outfall stormwater samples compared to the various potential sources are shown in Figure 31. The exceeding Outfall 008 sample's PS was not below the 99th percentile of any of the sources evaluated. However, concentrations of aluminum at Outfalls 008, 009 and 010 were generally in line with concentrations found in background stormwater at SSFL Outfalls 001 and 002 have only one and two results, respectively, which is insufficient to draw any conclusions and Outfall 018 particulate strength is likely affected by the SWTS and reduced TSS. **The PS values of one exceeding sample could not be explained by the solid source samples evaluated, but is most similar to background stormwater. Most importantly, the elevated PS of this one exceeding sample cannot be explained by impacted soils since**

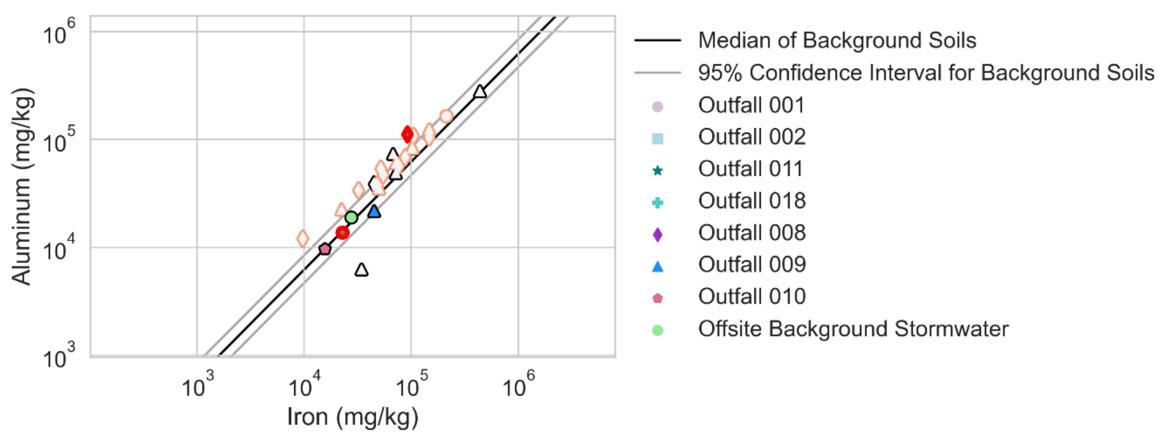
the 99th percentile of aluminum concentrations in soils in the NPDES watersheds are below the background threshold value and the same or lower than DTSC offsite background soil samples.



Note: Red markers indicate PS values of outfall samples whose stormwater concentration exceeded an effluent limit or benchmark in the past year.
Blue markers signify stormwater samples that did not exceed an effluent limit or benchmark in the past year.
Orange markers indicate a previous exceedance. Light gray markers indicate a previous non-exceedance.
Black markers represent individual solid sample concentrations. Soils samples include top 6 inches only to reflect what is most likely to be mobilized in stormwater.
Purple dashed line represents the Soil Background Threshold Value (BTV). If a UTL 95-95 was not developed in DTSC's Chemical Background Study Report (DTSC 2012a) or Combined-Data Background Thresholds Values and Methodology Narrative (DTSC 2012b), the BTV is equal to the maximum reporting limit (RL) for non-detect and J qualified data.

Figure 31. Aluminum PS in Outfall Stormwater Samples vs. Solid Source Materials

The PS of aluminum was compared against iron to evaluate if the stormwater ratios were consistent with natural background ratios. Figure 32 shows that this year's stormwater sample fell on the background soil 95% confidence interval, and nearly all the other stormwater samples also plot very tightly along the median line, which further supports that **background soils are a likely source of aluminum in the one 2022/23 exceeding sample and at all the outfalls in general**.



Note: PS values of outfall samples whose stormwater concentration exceeded an effluent limit or benchmark are marked with a red border.
Markers with a black border signify detected results that did not exceed an effluent limit or benchmark.
Markers with a white face indicate a previous detected results, with an orange border indicating a previous exceedance.

Figure 32. Aluminum:Iron Metal Ratio Plot

5. Conclusions

The evaluation of 2022/2023 exceedances was accomplished through the several analyses described above. The various LOEs provide a collective weight of evidence to identify which sources most likely contributed to each benchmark or permit limit exceedance in the 2022/23 reporting year. These permit limit/benchmark exceedances: (a) don't represent elevated human health risks, (b) aren't attributed to impacted soils except for potentially dioxins, and (c) for dioxin exceedances occurred during extreme storm events that exceeded existing treatment system capacity design. For every exceeding constituent SSFL exceeding concentrations were comparable to or lower than concentrations measured at offsite reference watersheds which are undeveloped and non-industrial.

The combined LOEs revealed that the elevated iron and manganese concentrations were likely attributable to natural soils present throughout SSFL, the sulfate exceedance at Outfall 002 was most likely attributable to the shale geology of the area and localized natural seeps, while elevated TCDD TEQ (no DNQ) results were likely affected by contributions from localized sources. TCDD TEQ (no DNQ) exceedances at Outfalls 010 and 011 were most likely from natural background soils with smaller (based on relative amounts of material in the watershed) but more potent (based on solids concentration) contributions from impacted soils (at Outfall 011), treated wood poles, and pavement solids. In some cases, one or more of the potential source materials evaluated was determined to be a potential source of the exceeding constituent found in stormwater. A summary of these analyses is presented in Table 5.

This year's annual report recommendations include measures to address these exceedance sources and collect more data for the source analysis for potential new COPCs. For every exceedance that may have been caused by something other than natural background sources (i.e., TCDD TEQ (no DNQ) at Outfalls 010 and 011), a new BMP recommendation was made and is documented in this year's annual report. These recommendations include hardening the Perimeter Pond berm to reduce erosion and sediment mobilization (in response to high TSS results (high for one of the more developed watersheds) during overflow at Perimeter Pond) and adding additional soil stabilization and erosion control and pole wattles in Outfall 010 watershed.

Table 5. Summary of LOEs by Outfall and Constituent

Parameter	Outfall	Sample Date	Could Impacted Soils Be Contributing?	Particulate Strengths	Fingerprinting Soil Metal Ratios	Exceedance Sources with Most Weight of Evidence
Iron	001	1/6/2023	Not likely, about 99% of soils in 001 watershed are below background threshold	background stormwater	background soils	background soils
Iron	001	1/15/2023		background stormwater	background soils	background soils
Iron	001	2/26/2023		background stormwater	background soils	background soils
Iron	001	3/11/2023		background stormwater	background soils	background soils
Iron	002	1/2/2023	Not likely, more than 99% of soils in 002 watershed are below background threshold	background stormwater	background soils	background soils
Iron	002	1/6/2023		background stormwater	background soils	background soils
Iron	002	1/15/2023		background stormwater	background soils	background soils
Iron	011	1/17/2023	Not likely, more than 99% of soils in 011 watershed are below background threshold	background stormwater	background soils	background soils
Iron	011	2/25/2023		background stormwater	background soils	background soils
Iron	011	3/16/2023		background stormwater	background soils	background soils
Manganese	011	1/10/2023	Not likely, more than 99% of soils in 011 watershed are below background threshold	inconclusive, exceeding particulate strength was greater than sources	not background soils	inconclusive, possible SWTS effects
Manganese	011	2/25/2023		background stormwater	background soils	background soils
Sulfate	002	5/5/2023	*N/A, not a cleanup driver, soil sulfate data not available*	*N/A*	*N/A*	natural shale geology, natural seeps
TCDD TEQ (No DNQ)	010	1/11/2023	Yes, it is a cleanup driver, some watershed 010 soil samples have elevated concentrations relative to background	pavement solids, soils near treated wood, impacted soils	not background soils	pavement solids, soils near treated wood, impacted soils
TCDD TEQ (No DNQ)	011	2/25/2023	Yes, it is a cleanup driver, some watershed 011 soil samples have elevated concentrations relative to background	pavement solids, soils near treated wood, impacted soils, and/or, background soils	background soils	pavement solids, soils near treated wood, impacted soils, and/or, background soils
Aluminum*	008	1/6/2023	Not likely, more than 99% of soils in 008 watershed are below background threshold	background stormwater	background soils	background soils

* Aluminum does not have a current permit limit, but the tentative permit limit in the draft 2023 NPDES permit was exceeded in one sample in the 2022/23 season.

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Appendix D: 2022/23 BMP Performance Analysis

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Appendix D: Treatment Best Management Practice (BMP) Performance Analysis

2022/23 Reporting Year

Prepared by

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and

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CWR0801
October 2023

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Acronyms

ANOVA	Analysis of Variance
BMP	Best Management Practice
CA	California
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
mg/kg	micrograms per kilogram
mg/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

Ongoing performance monitoring and evaluations are conducted at existing stormwater treatment Best Management Practices (BMPs) installed at the Boeing Santa Susana Field Laboratory (Site) at the direction of the Surface Water Expert Panel ("Expert Panel"). These include passive stormwater treatment BMPs installed within the Outfall 009 watershed and active stormwater treatment systems (SWTSs) to treat stormwater just prior to discharge from Outfalls 011 and 018. The treatment BMPs are intended to reduce pollutants and stormwater volume via filtration, adsorption, ion exchange, and evapotranspiration processes before stormwater reaches its discharge point from the Site, in order to comply with the National Pollutant Discharge Elimination System (NPDES) permit standards as issued to Boeing by the Los Angeles Regional Water Quality Control Board (NPDES Permit No. CA0001309 for the Boeing Company, SSFL, Canoga Park, CA, Order No. R4-2015-0033 ["2015 Permit"]) (LARWQCB, 2015).

As an update to the treatment BMP performance analysis conducted annually in accordance with the *Site-Wide Stormwater Work Plan and 2014/15 Annual Report* ("2015 Work Plan") (Santa Susana Surface Water Expert Panel and Geosyntec Consultants, 2015), data collected during the 2022/23 reporting year were incorporated into an existing dataset that began in December 2009. Analyzed NPDES constituents of concern (COCs) monitored at the inlet and outlet locations of these controls included total suspended solids (TSS), total lead, total copper[1], and dioxins (TCDD TEQ, DNQ excluded, BAFs included). Performance monitoring data were analyzed to assess the effectiveness, and anticipate major maintenance needs, of the culvert modification (CM) media filters, upper lot media filter, lower parking lot sedimentation basin and biofilter (lower lot biofilter), ELV treatment BMP, and B1436 detention bioswales (detention bioswales). Performance monitoring data were also collected at the active SWTSs at Outfalls 011 and 018 during the 2022/23 reporting year.

Table 1 summarizes the 2015 Permit Limits for TSS, total lead, total copper, and dioxins at NPDES outfalls. The Permit Limits do not apply to effluent discharges from the treatment BMPs themselves, however they are used here as a reference for evaluating performance of existing treatment BMPs in the SSFL watersheds. And while there is not a TSS limit at Outfall 009, there is a TSS limit at both Outfall 011 and 018, and TSS sample results are also often used as a proxy for evaluating and estimating particulate strengths of other constituents.

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

Table 1. COC NPDES Permit Limits by Outfall

Outfall	NPDES Permit Limit			
	TSS (mg/l)[1]	Total Lead (µg/l)	Total Copper (µg/l)	Dioxins (µg/l)
001[2]	45	5.2	14	2.80×10^{-8}
002[2]	45	5.2	14	2.80×10^{-8}
003	-	5.2	13	2.80×10^{-8}
004	-	5.2	13	2.80×10^{-8}
005	-	5.2	13	2.80×10^{-8}
006	-	5.2	13	2.80×10^{-8}
007	-	5.2	13	2.80×10^{-8}
008	-	5.2	14	2.80×10^{-8}
009	-	5.2	13	2.80×10^{-8}
010	-	5.2	13	2.80×10^{-8}
011	45	5.2	14	2.80×10^{-8}
018	45	5.2	14	2.80×10^{-8}
019	45	5.2	14	2.80×10^{-8}
020	45	5.2	14	2.80×10^{-8}

[1] TSS limit applies to dry weather samples only. There is no NPDES Permit Limit for TSS in wet weather.
[2] Numerical values for the parameters shown at this outfall are benchmarks, not effluent limitations.

Long-term average annual rainfall at SSFL from 1958/59 through 2022/23 is 17.3 inches[2], compared to a total of 45.8 inches recorded in 2022/23. The 2022/23 reporting year had the highest total precipitation recorded in the available 56-year period of record (POR), and only 5% of annual rainfall totals were greater than 40.1 inches. Most of the 2022/23 annual rainfall occurred in late December 2022 to March 2023. The 2022/23 reporting year[3] included 16 rain events, with monitored treatment BMPs in the Outfall 009 Watershed sampled during nine of the events. A rain event is defined by the 2015 Permit as at least 0.1 inches of rainfall in 24 hours preceded by at least 72 hours of dry weather. Between 4 and 16 rain events have occurred per year from 2009/10 to 2022/23, with an average of 10.8 events per year. Table 2 summarizes rain events from 2009/10 through 2022/23. Non-qualifying rain events describe rainfall that did not meet the "rain event" definition. Rows shaded gray indicate rain events without a complete pair of influent and effluent samples, often dictated by a lack of sampleable flow into or out of the treatment BMP or due to the reduction in sampling following the 2016/2017 reporting year. There were several rain events with 24-hr rainfall totals that exceeded the Expert Panel design storm[4] (1-year, 24-hour design

[2] Historical rainfall records covering 1958/59 – 2000/01 from the Simi Hills-Rocketdyne Laboratory gauge (Ventura County Watershed Protection District, site 249) (rainfall data were not available from 1977/1978 through 1984/1985) and 2001/02 – 2022/23 from the Area 4 gage were combined and referenced to assess average annual rainfall over the 56-year period of record (POR).
[3] Annual reporting years are defined as June 1 through May 31 (as opposed to water years, typically defined as October 1 through September 30).
[4] The design storm is not applicable to the CMs, as they were constructed to take advantage of specific site conditions and were generally under-sized compared to the design storm.

storm of 2.5 inches), including rain events from 12/27/2022 to 1/5/2023, 1/8/2023 to 1/10/2023, 2/23/2023 to 3/1/2023, and 3/10/2023 to 3/15/2023. These rain events had maximum 24-hour rainfall totals of 3.48, 5.43, 6.51, and 3.60 inches, which correspond to the 2-year, 24-hour storm (3.33 inches), 10-year, 24-hour storm (5.14 inches), 25-year, 24-hour storm (6.2 inches) events, and 2-year, 24-hour storm (3.33 inches), respectively.

Table 2. Sample Collection Event Rainfall Data Summary
(gray rows indicate dates without complete paired samples)

Date(s)	Average Intensity (in/hr)	Max Intensity (in/hr)	Event Total (in)	Event Duration (hrs)	Cumulative Rainfall - Qualifying Events (in)	Number of Treatment BMP Samples[1]
10/13/2009 – 10/14/2009	0.05	0.24	2.48	35	2.48	-[1]
12/7/2009 – 12/13/2009	0.02	0.25	3.43	57	5.91	-[1]
1/17/2010 – 1/22/2010	0.05	0.52	6.88	123	12.79	-[1]
2/5/2010 – 2/6/2010	0.04	0.20	1.84	43	14.63	-[1]
2/9/2010	0.01	0.17	0.20	3	14.83	-[1]
2/19/2010	0.01	0.05	0.14	8	14.97	-[1]
2/24/2010	0.01	0.03	0.12	12	15.09	-[1]
2/27/2010	0.06	0.34	1.52	17	16.61	-[1]
3/6/2010	0.02	0.13	0.38	11	16.99	-[1]
4/4/2010 – 4/5/2010	0.03	0.23	0.86	13	17.85	-[1]
4/11/2010 – 4/12/2010	0.03	0.22	0.65	11	18.50	-[1]
Non-qualifying rain event total[2]			*0.89*			
2009/10 Total			**19.39**			-[1]
10/5/2010 – 10/6/2010	0.049	0.18	0.93	20	0.93	-[1]
10/16/2010 – 10/25/2010	0.003	0.22	0.69	216	1.62	-[1]
11/17/2010 – 11/21/2010	0.011	0.23	0.97	89	2.59	-[1]
12/5/2010	0.018	0.09	0.41	10	3.0	-[1]
12/17/2010 – 12/22/2010	0.054	0.37	7.22	131	10.22	-[1]
12/25/2010 – 12/26/2010	0.030	0.22	0.57	9	10.79	-[1]
12/29/2010	0.043	0.10	0.43	7	11.22	-[1]
1/2/2011 – 1/3/2011	0.014	0.12	0.38	17	11.60	-[1]
2/15/2011 – 2/20/2011	0.019	0.45	2.33	121	13.93	-[1]
2/25/2011 – 2/26/2011	0.030	0.22	1.50	20	15.43	-[1]
3/2/2011 – 3/3/2011	0.007	0.03	0.13	8	15.56	-[1]
3/6/2011 – 3/7/2011	0.006	0.02	0.12	10	15.68	-[1]
3/18/2011 – 3/27/2011	0.030	--	6.00	197	21.68	-[1]
5/15/2011 – 5/18/2011	0.009	0.08	0.67	76	22.35	-[1]
Non-qualifying rain event total[2]			*1.04*			
2010/11 Total			**23.39**			**67**
10/5/2011	0.090	0.18	0.90	9	0.90	-[1]
11/4/2011 – 11/6/2011	0.041	0.23	0.58	59	1.48	-[1]
11/11/2011 – 11/12/2011	0.035	0.26	0.76	22	2.24	-[1]

Date(s)	Average Intensity (in/hr)	Max Intensity (in/hr)	Event Total (in)	Event Duration (hrs)	Cumulative Rainfall - Qualifying Events (in)	Number of Treatment BMP Samples[1]
11/19/2011 – 11/21/2011	0.031	0.29	0.78	35	3.02	-[1]
12/12/2011 – 12/17/2011	0.006	0.21	0.80	137	3.82	-[1]
1/21/2012 – 1/23/2012	0.017	0.15	1.06	62	4.88	-[1]
2/27/2012	--	--	0.00	--	4.88	-[1]
3/16/2012 – 3/18/2012	0.052	0.31	1.51	29	6.39	-[1]
3/25/2012 – 3/26/2012	0.079	0.51	2.12	21	8.51	-[1]
4/10/2012 – 4/13/2012	0.034	0.36	2.37	64	10.88	-[1]
4/23/2012 – 4/26/2012	0.003	0.09	0.26	80	11.14	-[1]
Non-qualifying rain event total[2]			*0.19*			
2011/12 Total			**11.33**			**88**
11/14/2012 – 11/18/2012	0.010	0.36	0.99	99	0.99	-[1]
11/28/2012 – 12/4/2012	0.011	0.12	1.49	139	2.48	-[1]
12/12/2012 – 12/18/2012	0.005	0.07	0.68	129	3.16	-[1]
12/22/2012 – 12/26/2012	0.013	0.18	1.13	87	4.29	-[1]
1/23/2013 – 1/27/2013	0.020	0.18	1.78	89	6.07	-[1]
2/8/2013 – 2/9/2013	0.008	0.07	0.12	15	6.19	-[1]
2/19/2013	0.025	0.09	0.25	10	6.44	-[1]
3/7/2013 – 3/8/2013	0.041	0.23	0.87	7	7.31	-[1]
5/5/2013 – 5/6/2013	0.040	0.16	0.48	7	7.79	-[1]
Non-qualifying rain event total[2]			*0.31*			
2012/13 Total			**8.10**			**29**
11/20/2013 – 11/21/2013	0.013	0.12	0.47	17	0.47	-[1]
12/7/2013	0.070	0.09	0.28	4	0.75	-[1]
2/6/2014 – 2/7/2014	0.015	0.15	0.28	16	1.03	-[1]
2/26/2014 – 3/2/2014	0.052	0.47	4.62	89	5.65	-[1]
4/1/2014 – 4/2/2014	0.008	0.14	0.22	28	5.87	-[1]
Non-qualifying rain event total[2]			*0.20*			
2013/14 Total			**6.07**			**27**
10/31/2014 – 11/1/2014	0.045	0.33	0.36	8	0.36	-[1]
11/30/2014 – 12/4/2014	0.033	0.40	3.20	97	3.56	-[1]
12/11/2014 – 12/12/2014	N/A[3]	N/A[3]	2.62	N/A[3]	6.18	-[1]
12/15/2014 – 12/17/2014	0.025	0.33	0.91	36	7.09	-[1]
1/10/2015 – 1/11/2015	0.071	0.23	1.56	22	8.65	-[1]
1/26/2015 – 1/27/2015	0.015	0.06	0.25	17	8.90	-[1]
2/22/2015 – 2/23/2015	0.008	0.06	0.21	26	9.11	-[1]
3/1/2015 – 3/3/2015	0.024	0.22	1.44	60	10.55	-[1]
5/14/2015 – 5/15/2015	0.017	0.30	0.41	24	10.96	-[1]
Non-qualifying rain event total[2]			*0.26*			
2014/15 Total			**11.22**			**17**

Date(s)	Average Intensity (in/hr)	Max Intensity (in/hr)	Event Total (in)	Event Duration (hrs)	Cumulative Rainfall - Qualifying Events (in)	Number of Treatment BMP Samples[1]
7/18/2015 – 7/19/2015	0.027	0.32	0.83	31	0.83	0
9/14/2015 – 9/15/2015	0.050	0.39	1.10	22	1.93	8
10/5/2015 – 10/6/2015	0.025	0.32	0.45	18	2.38	0
12/13/2015	0.055	0.06	0.11	2	2.49	0
12/19/2015 – 12/22/2015	0.008	0.08	0.52	65	3.01	6
1/5/2016 – 1/10/2016	0.030	0.60	3.87	129	6.88	29
1/18/2016 – 1/20/2016	0.005	0.02	0.20	40	7.08	0
1/31/2016	0.108	0.27	0.86	8	7.94	0
2/17/2016 – 2/18/2016	0.027	0.10	0.57	21	8.51	17
3/5/2016 – 3/7/2016	0.029	0.29	1.57	54	10.08	4
3/11/2016	0.088	0.34	0.44	5	10.52	15
4/7/2016 – 4/9/2016	0.010	0.10	0.52	52	11.04	16
5/6/2016	0.128	0.22	0.77	6	11.81	0
Non-qualifying rain event total[2]			*0.16*			
2015/16 Total			**11.97**			**113**
10/16/2016 – 10/17/2016[4]	0.008	0.05	0.22	28	0.22	0
10/28/2016 – 10/31/2016	0.006	0.16	0.41	68	0.63	5
11/20/2016 – 11/21/2016	0.024	0.18	0.53	22	1.16	3
11/26/2016	0.055	0.15	0.22	4	1.38	8
12/15/2016 – 12/16/2016	0.093	0.20	1.58	17	2.96	12
12/21/2016 – 12/24/2016	0.030	0.31	1.99	66	4.95	6
12/30/2016 – 12/31/2016	0.011	0.11	0.45	41	5.40	14
1/4/2017 – 1/13/2017	0.013	0.26	2.74	211	8.14	33
1/18/2017 – 1/23/2017	0.050	0.69	5.70	114	13.84	25
2/2/2017 – 2/11/2017	0.013	0.17	2.84	218	16.68	23
2/16/2017 – 2/21/2017	0.049	0.71	5.81	119	22.49	21
2/26/2017	0.022	0.05	0.20	9	22.69	0
3/21/2017 – 3/22/2017	0.028	0.07	0.36	13	23.05	0
4/7/2017 – 4/8/2017	0.024	0.08	0.17	7	23.22	0
Non-qualifying rain event total[2]			0.13			
2016/17 Total			**23.35**			**150**
1/8/2018 – 1/9/2018	0.068	0.37	2.78	41	2.78	11
2/26/2018 – 3/3/2018	0.015	0.15	1.66	109	4.44	10
3/10/2018 – 3/16/2018	0.012	0.30	1.92	155	6.36	0
3/21/2018 – 3/23/2018	0.059	0.45	2.94	50	9.30	15
Non-qualifying rain event total[2]			0.45			
2017/18 Total			**9.75**			**36**
10/12/2018 – 10/13/2018	0.037	0.13	0.48	13	0.48	0

Date(s)	Average Intensity (in/hr)	Max Intensity (in/hr)	Event Total (in)	Event Duration (hrs)	Cumulative Rainfall - Qualifying Events (in)	Number of Treatment BMP Samples[1]
11/21/2018 – 11/22/2018	0.092	0.26	0.55	6	1.03	0
11/28/2018 – 11/29/2018	0.045	0.30	1.17	26	2.20	14
12/5/2018 – 12/6/2018	0.068	0.44	2.51	37	4.71	16
1/5/2019 – 1/8/2019	0.030	0.31	1.69	57	6.40	12
1/12/2019 – 1/17/2019	0.043	0.34	5.68	133	12.08	8
1/31/2019 – 2/5/2019	0.053	0.56	6.27	119	18.35	8
2/9/2019 – 2/16/2019	0.018	0.39	3.12	172	21.47	8
2/27/2019 – 3/8/2019	0.016	0.25	3.21	195	24.68	11
3/20/2019 – 3/21/2019	0.005	0.03	0.11	23	24.79	0
5/10/2019 – 5/11/2019	0.005	0.04	0.13	29	24.92	0
5/16/2019 – 5/19/2019	0.014	0.21	1.17	82	25.96	9
Non-qualifying rain event total[2]			0.20			
2018/19 Total			**26.29**			**86**
11/20/2019	0.185	0.33	0.37	2	0.37	5
11/27/2019 – 11/30/2019	0.023	0.28	2.10	90	2.47	14
12/4/2019 – 12/8/2019	0.018	0.31	2.01	109	4.48	5
12/22/2019 – 12/26/2019	0.044	0.49	3.88	89	8.36	10
1/16/2020 – 1/17/2020	0.064	0.31	0.70	11	9.06	0
2/22/2020	0.037	0.10	0.11	3	9.17	0
3/10/2020 – 3/23/2020	0.022	0.40	7.08	319	16.25	9
4/5/2020 – 4/13/2020	0.021	0.29	3.81	187	20.06	4
5/18/2020	0.031	0.07	0.22	7	20.28	0
Non-qualifying rain event total[2]			0.26			
2019/20 Total			**20.54**			**47**
12/28/2020 – 12/29/2020	0.060	0.28	1.62	27	1.62	0
1/23/2021 – 1/25/2021	0.006	0.11	0.32	50	1.94	0
1/28/2021 – 1/30/2021	0.040	0.27	1.32	33	3.26	3
3/10/2021 – 3/12/2021	0.018	0.16	0.94	51	4.20	11
3/15/2021	0.042	0.08	0.21	5	4.41	0
Non-qualifying rain event total[2]			0.13			0
2020/21 Total			**4.54**			**14**
10/4/2021	0.12	0.35	0.48	4	0.48	0
10/22/2021 – 10/25/2021	0.016	0.37	1.04	64	1.52	8
12/7/2021 – 12/9/2021	0.0033	0.040	0.18	55	1.70	0
12/13/2021 – 12/16/2021	0.041	0.78	2.96	72	4.66	19
12/22/2021 – 12/31/2021	0.060	0.42	11.8	196	16.46	22
1/15/2022 – 1/19/2022	0.0025	0.060	0.22	87	16.68	0
3/28/2022 – 3/29/2022	0.044	0.32	0.93	21	17.61	4
4/21/2022 – 4/22/2022	0.088	0.17	0.35	4	17.96	0

Date(s)	Average Intensity (in/hr)	Max Intensity (in/hr)	Event Total (in)	Event Duration (hrs)	Cumulative Rainfall - Qualifying Events (in)	Number of Treatment BMP Samples[1]
Non-qualifying rain event total[2]			0.22			0
2021/22 Total			**18.18**			**53**
9/9/2022 – 9/11/2022	0.00017	0.04	0.14	32	0.14	0
11/1/2022 – 11/2/2022	0.0014	0.06	0.17	5	0.31	0
11/7/2022 – 11/9/2022	0.0034	0.35	1.96	53	2.27	7
12/1/2022 – 12/5/2022	0.0057	0.10	1.29	95	3.56	0
12/10/2022 – 12/12/2022	0.0054	0.48	2.17	38	5.73	5
12/27/2022 – 1/5/2022	0.025	0.47	7.46	217	13.22	19
1/8/2023 – 1/10/2023	0.050	0.59	6.32	36	19.54	10
1/14/2023- 1/16/2023	0.025	0.32	3.19	49	22.73	7
1/19/2023 – 1/19/2023	0.00049	0.06	0.12	2	22.85	0
1/29/2023 – 1/30/2023	0.0021	0.10	0.31	10	23.16	0
2/23/2023 – 3/1/2023	0.042	0.6	10.1	144	33.26	3
3/5/2023 – 3/6/2023	0.0019	0.07	0.22	16	33.48	0
3/10/2023 – 3/15/2023	0.029	0.48	6.48	130	39.96	3
3/19/2023 – 3/22/2023	0.013	0.23	3.02	76	42.98	3
3/29/2023 – 3/30/2023	0.0053	0.34	1.88	38	44.86	3
5/1/2023 – 5/4/2023	0.0014		0.73	71	45.63	0
Non-qualifying rain event total[2]			0.27			0
2022/23 Total			**45.83**			**60**

[1] Totals of Number of Treatment BMP Samples include influent and effluent, background and non-background. Annual totals are shown for early reporting years without breakdowns by rain event, as presented in past Annual Reports.

[2] Rainfall was observed but did not meet the NPDES definition for a rain event.

[3] Area I weather station malfunctioned during rain event; Station 436 rainfall totals used in the absence of hourly rainfall data.

[4] Station 436 rainfall data used from 3:00 a.m. to 4:00 a.m. on 10/16/2016 while the Area I station was off-line.

2. Overview

2.1 Treatment BMPs

Performance assessments of treatment BMPs at the SSFL site were conducted through collection and analysis of water quality sample data and are presented in the following sections. Table 3 summarizes evaluated treatment BMPs as well as their characteristics and components.

Culvert Modifications (CMs) and Other Media Filters. Culverts that convey stormwater under roadways were modified by installing headboards and removable weir boards in front of the upstream culvert inlet. Stormwater entering the treatment BMP is blocked from flowing directly through the culvers by the weir boards, forcing the stormwater through filter media for treatment before exiting through perforated pipe laterals and flowing into the existing culvert. Excess water overtops the weir boards, bypassing the media treatment, during periods of large flow rates. The CMs were installed as provisional sedimentation and filtration stormwater control measures to be continually evaluated for pollutant reduction capabilities and capture performance. The six CMs analyzed are comprised of media filters and HDPE linings laid above existing, galvanized[5] corrugated metal pipes. The B-1 media filter consists of a media bed without a slip-liner. In addition to evaluating treatment BMP performance, monitoring data have been used to evaluate potential treatment BMP enhancements that could improve stormwater treatment performance and to assess their effectiveness once implemented. Monitoring data analyzed in performance evaluations are described in Section 2.2.

- **CM-1** was installed and initially sampled in 2009/10. Improvements at the CM include 2011/12 addition of filter fabric over the weir board for enhanced flow control and 2017/18 construction of an inlet for runoff from the adjacent roadway area. CM-1 was reconstructed and outfitted with new treatment media in August 2018. Sampling of the newly reconstructed CM and road runoff inlet began in 2018/19.
- **CM-3** was installed and initially sampled in 2009/10. As described in Section 2.2, performance monitoring data used in these analyses were first collected 2016/17. An inlet allowing the CM to receive runoff from an adjacent roadway was constructed in May 2017, and sampling of the influent road runoff began in 2016/17. In 2019/20, CM-3 was rebuilt with a modified configuration, upstream check dams were installed, and the first paired influent and effluent samples were collected at the newly reconstructed CM.
- **CM-9** was installed and initially sampled in 2009/10. Improvements were made in 2011/12, including the September 2011 removal of Area I Landfill (A1LF) asphalt upstream and the January 2012 addition of filter fabric over the weir board.
- The **B-1 Media Filter** was installed and first sampled in 2011/12. Curb cut improvements were implemented at the media filter in November 2012.

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[5] Galvanization of the metal does not present a water quality concern as zinc is not a COC at the Site.

- The **Upper Lot Media Filter** was installed and initially sampled in 2016/17.
- **CM-8** and **CM-11** receive runoff from areas without history of industrial activities or known soil contamination, which are therefore considered representative of background conditions at the SSFL site. Both CMs were installed and first sampled in 2009/10.

Lower Lot Biofilter. The stormwater detention and biofiltration BMP was installed and first sampled in 2013/14. It includes a sedimentation basin for pretreatment upstream of a biofiltration media bed. The lower lot biofilter receives flow from the lower parking lot, making up roughly 40% of the total tributary area to the biofilter, and the drainage area to the 24" storm drain that enters a cistern in the lower lot upstream of the biofilter. The storm drain collects runoff from areas near the administrative building, natural hillsides, and effluent flows from the southern detention bioswales and Boeing administrative area inlet filter.

Detention Bioswales. The northern and southern B1436[6] detention bioswales were installed upstream of the lower lot biofilter in December 2014 to capture and slowly release flows downstream to the lower lot biofilter. Treatment occurs in the bioswales, although the primary purpose was to slow the influent runoff to the lower lot biofilter and reduce flows that bypass the lower lot biofilter during large storm events. Initial performance monitoring was conducted at the northern detention bioswale in 2014/15 and at the southern detention bioswale in 2015/16. The change in total volume of runoff captured after implementation of the detention bioswales was estimated by simulating the period from implementation on November 1, 2014, through April 1, 2019, in the site-wide Stormwater Management Model (SWMM), both with and without the bioswales. Model results indicated installation of the bioswales provided a 24% increase in biofilter capture efficiency, from 59% to 73%. Considering runoff from only the lower parking lot priority treatment area, results indicated an 8% increase in runoff capture efficiency, from 80% to 88%, over the same period.

ELV Treatment BMP. The stormwater detention and filtration ELV treatment BMP was installed and initially monitored in 2013/14. The drainage layers and filtration media of the BMP were rebuilt in Summer 2021 to reduce apparent media washout during stormwater treatment. New, clean gravel was installed at the bottom of the tank, a layer of pea gravel was added above the larger gravel, and the existing media was placed back on top of the pea gravel (i.e., the treatment media itself was not replaced). Following the reconstruction, the system was flushed with potable water to reduce sediment within the system. Initial performance monitoring of the rebuilt treatment BMP was conducted in 2021/22.

Active stormwater treatment systems (SWTSs). Outfalls 011 and 018 have had active SWTSs since 2012 to augment the storage and sedimentation provided by existing ponds. The SWTSs provide advanced stormwater treatment using a treatment train of a screen filter, flocculation, oxidation, ActiFlo coagulation, buffering, sand and bag filters, and granulated activated carbon (GAC), with stormwater ponds upstream for flow equalization and pretreatment by sedimentation.

[6] B1456 refers to a former building at this location that was demolished by Boeing in its effort to remove man-made structures at SSFL.

Stormwater in Perimeter Pond near Outfall 011 is pumped to the R-1 Pond for flow equalization, settling and evaporation. When the storage of the pond nears capacity, stormwater in the pond is treated using the advanced SWTS. The SWTS at Outfall 011 has experienced lapses in operation in its lifetime, most recently due to damage from the Woolsey Fire, however, it was repaired in late 2019 and operational again prior to the first 2019/20 storm event.

Stormwater is pumped from Outfalls 003, 004, 005, 006, 007, 009 helipad, and 010 to Silvernale Pond before being treated by the Outfall 018 SWTS alongside stormwater from the Outfall 018 Watershed. Local storage volumes and pumping rates vary for each outfall capture and diversion system but for the most part they are all believed to exceed the Expert Panel's site-specific design storm based on past performance, as there have only been 12 overflow discharges at outfalls since 2010/11 (from Outfalls 004, 006, and 010; there have been zero discharges at Outfalls 003, 005, and 007).

Table 3 summarizes characteristics of each treatment BMP.

Table 3. Treatment BMP Features

Treatment BMP Characteristic	BMP						
	CM Sites	B1 Media Filter	Upper Lot Media Filter	Lower Lot Biofilter	ELV Treatment BMP	Detention Bioswales	SWTSs
Media filtration-based[1]	x	x	x	x	x		
Subsurface storage-based						x	
Pretreatment incorporated		x		x	x		x
Outlet flow controls				x	x	x	
Vegetation				x		x	
Vertical flow regime		x	x	x	x	x	
Horizontal flow regime	x	x					
Active treatment							x

[1] Using a custom treatment medium for SSFL treatment BMPs consisting of sand, zeolite, and granulated activated carbon (GAC).

The aforementioned treatment BMPs are discussed herein; however, it should be noted that other activities have been performed at the Site that are not discussed herein but also affect the quality of stormwater runoff from the Site. These include but are not limited to channel stabilization measures in the Northern Drainage channel, soil removal actions, building/parking lot removal, and site revegetation.

2.2 Sampling

Concentrations of influent and effluent grab samples collected at evaluated stormwater treatment BMPs were compared against each other to assess pollutant concentration reductions achieved by the treatment measures. Although split samples were periodically collected and used for quality assurance/quality control (QA/QC) purposes, only primary samples were included in performance analyses. Treatment BMP performance sampling was reduced following the 2016/17 reporting year given the completion of building demolition and revegetation in the Outfall 009 watershed, as well as the observations from previous sampling that statistically supports the effective performance of treatment BMPs already in operation for a number of years. Starting in 2017/18, sampling was reduced to two storm events per year at the upper lot media filter, southern detention bioswale, lower lot biofilter, CM-1 (influent-west and effluent sample points), and the ELV Treatment BMP, as a check of continued performance with time and to track maintenance needs.

CMs and Other Media Filters. Influent grab samples taken at CMs are collected from flowing surface water upstream of the maximum ponding extent observed at the CM prior to a given sample date. The number of paired samples collected per CM ranges from 2 to 38 pairs for TSS (10 to 11 pairs for background BMPs, 2 to 38 pairs for non-background BMPs), 0 to 39 pairs for dioxins (0 to 11 pairs for background BMPs, 6 to 39 pairs for non-background BMPs), 0 to 38 pairs for lead (0 to 10 pairs for background BMPs, 5 to 38 pairs for non-background BMPs), and 0 to 34 pairs for copper (no sample pairs for background BMPs, 5 to 34 pairs for non-background BMPs) for 2011/12 through 2022/23. Since October 2011, effluent grab samples at CM-1, CM-9, CM-3, and the B-1 media filter have been collected from the underdrain outlet rather than from the culvert outlet. Effluent grab samples at CMs, including CM-8 and CM-11, were previously collected at downstream culvert outlets where culvert pipes discharge to the Northern Drainage. Flows from the culvert outlets may have represented both treated and partially treated runoff, where partially treated runoff would have included both treated discharge and bypass flow through or over effluent weir boards.

Initial samples collected at the B-1 media filter in 2012/13 indicated the potential of media washout as the BMP was becoming operational and were not used for the performance analyses. Subsequent quantitative assessments of data collected at the B-1 media filter from 2013/14 through 2015/16 indicated effective treatment performance with sufficient samples, such that sampling at the BMP could be subsequently discontinued. Continuing visual checks of B-1 media filter and other passive stormwater treatment BMPs in the Outfall 009 Watershed are performed routinely to identify potential concerns or maintenance needs.

TSS, dioxins, and lead performance data collected across CM-8 and CM-11 were analyzed separately from data collected at other CMs and other media filters to assess background conditions and associated COC concentrations in runoff. Comprehensive evaluations of background conditions were conducted on sample data collected at CM-8 and CM-11 through 2010/11, such that sampling at the CMs could then be discontinued. Prior to 2019/20, the eastern tributary area to CM-1 was considered reflective of background conditions. However, further assessment indicated that the eastern drainage area was not as descriptive of background conditions as drainage areas to CM-8 and CM-11, and influent data collected from the CM-1 eastern tributary area were evaluated in non-background analyses starting in 2020/21.

As slip-lined HDPE pipes at CM-3 were inserted from both influent and effluent sides, they could not be sealed at the meeting point. Intermittent discharge from the HDPE pipe outlet was observed between February 2010 and March 2011 without influent runoff flowing to the CM, indicating the potential of subsurface interflow contributing to the effluent discharge. Sampling at the CM was therefore temporarily discontinued after 2010/11 and was resumed in 2016/17, and samples collected prior to 2016/17 were not retained for performance analyses. Sampling to characterize influent runoff from an adjacent roadway area began in 2016/17 following the addition of a road runoff inlet to the CM in the second quarter of 2017.

Lower Lot Biofilter. Sampling beginning in 2012/13 at the lower lot biofilter includes influent, mid-point, and effluent samples, collected from the cistern discharge pipeline, the sediment basin outlet, and the biofilter effluent pipe, respectively. Samples have been collected during 36 rain events to date. Sampling results analyzed in performance evaluations include post-biofilter effluent samples collected in early 2014 which represented a blend of treated, filtered underdrain water and biofilter overflow and unusually turbid results observed during a 2014/15 event. The observed turbidity may have resulted from the Building 1436 area contributing sediments to stormwater runoff as the building was removed and before the site was fully stabilized. Samples were not collected at the biofilter midpoint during 2013/14, as the sample location was submerged and inaccessible. In summer of 2023, the Lower Lot began being used for soil stockpiling for the Shooting Range ISE interim cleanup project. However, the cleanup operation started after the last samples reported in this annual report had been collected.

Detention Bioswales. The bioswales provide storage and pre-treatment for stormwater runoff as they allow for larger volumes of stormwater to be treated by the lower lot biofilter by providing peak flow attenuation and equalization, along with partial capture of stormwater particulates. There are three sampling points along the southern detention bioswale, including two influent and one effluent. Influent samples are collected from the outlet of the upstream rock crib swale and the inlet for runoff from the adjacent contractor laydown area, and effluent samples are collected from the underdrain. COC concentrations observed at the two influent sample points are flow-weighted based on size and imperviousness of the corresponding drainage area to estimate single representative influent concentrations to the bioswale. Paired influent and effluent performance data were collected at the southern detention bioswale during a total of 28 events, including two events in 2022/23.

Paired influent and effluent samples were collected at the northern detention bioswale from a curb cut along the eastern side of the bioswale and from the underdrain, respectively, during eight events in 2015/16 and 2016/17. Sampling at the northern detention bioswale was subsequently discontinued upon having collected enough data to assess performance of both detention bioswales through southern detention bioswale data alone.

ELV Treatment BMP. Sampling at the ELV treatment BMP includes influent, midpoint, and effluent samples, which are collected from the influent pipe, combined flow from the eastern and western sample ports between the settling tanks and media filter, and the effluent pipe, respectively. Samples were collected at the ELV treatment BMP during 23 events from 2013/14 through 2022/23, including 20 paired influent and effluent samples, seven of which was collected in 2022/23.

Some of the sampling issues included: Sample data collected during the initial storm events treated by the treatment BMP in 2013/14 could have been reflective of media flushing as the BMP became operational. Two separate power outages have occurred during the operation of the ELV treatment BMP. During a large storm event from the end of February through early March 2014, a storm drain plug under Helipad Road diverted excess roadway runoff to the ELV sump and treatment system. Erosion controls in the upstream earthen channel were overwhelmed by the storm event, and strong inflows to the BMP caused a failure of the sump pump resulting in a power outage.

Performance monitoring could not be conducted at the ELV treatment BMP for the remainder of 2018/19 after the November 2018 Woolsey Fire caused a power outage. A generator was installed to prevent future outages, and the BMP was operational again in 2019/20. Drainage layers and filter media of the ELV treatment BMP were rebuilt in Summer 2021, as described in Section 2.1, after previously collected data indicated the potential of media fines export through the underdrain, based on a decrease in dioxins particulate strength in the treated stormwater before and after the media layer.

SWTSs. Two influent sample results from each SWTS are available, one from 2021/22 and one from 2022/23. These samples were collected from the stormwater ponds as the water was pumped to the treatment facilities and therefore represent influent to the SWTSs. Additionally, corresponding sample results from the respective outfalls are available and are considered representative of the SWTS effluent.

The Expert Panel evaluated the need for additional performance monitoring in light of the reduced demolition activity at the SSFL site in recent years, particularly within the Outfall 009 watershed, and the relatively large number of samples already available to evaluate performance. After 2016/17, sampling was reduced to twice per year at the upper lot media filter, southern detention bioswale, lower lot biofilter, CM-1 (influent-west and effluent), and the ELV Treatment BMP.

Sampling will continue at these treatment BMPs during two rain events per year as a check on continued performance with time and as one of the indicators of needed maintenance. Sampling at the ELV treatment BMP will be decreased to two rain events per year, similar to the other treatment BMPs. Influent sampling frequency of the active SWTSs will be in accordance with the NPDES permit. Monitoring was discontinued at the Boeing administrative area inlet filter following the 2021/22 reporting year due to its continued poor performance of COC removals.

2.3 Treatment BMPs with Multiple Influent Sample Points

Tributary areas, also known as drainage areas, contributing surface runoff to treatment BMPs are characterized by sampling at an influent monitoring location. A single, flow-weighted influent concentration for treatment BMPs with multiple influent drainage areas is calculated from each measured influent concentration by rain event, flow-weighted according to drainage area size and imperviousness. treatment BMPs with multiple influent drainage areas and monitoring locations, which include CM-1, CM-9, CM-3, the B-1 media filter, upper lot media filter, and the southern detention bioswale, are described below.

- **CM-1** receives runoff from an eastern tributary comprised of largely undeveloped hillsides and part of the now-demolished Building 212, a western tributary comprised of paved roadway and a hillside previously utilized for ELV activity, and another area mainly comprised of road runoff.
- **CM-3** receives runoff from undeveloped hillsides and a clean soil borrow area at the top of the watershed, south of the adjacent roadway. After the addition of a road runoff inlet in May 2017, CM-3 also receives runoff from a portion of roadway.
- **CM-9** receives runoff from a paved roadway to the east known as Area II Road, as well as from A1LF and the parking lot of former Building 1324, which was demolished late Summer 2011.
- The **B-1 Media Filter** receives runoff from a northern drainage area of paved roadway and a southern drainage area that contributes upper B-1 Interim Source Removal Action (ISRA) areas, road runoff, and effluent from the sedimentation basin.
- The **Upper Lot Media Filter** receives runoff predominantly from undeveloped hillsides to the southeast and a parking lot to the south.

- The **Southern Detention Bioswale** receives runoff discharged from an upstream rock crib swale and from a paved contractor laydown area adjacent to the detention bioswales.

CM-8 and CM-11 receive runoff from undeveloped areas with no history of industrial activities or soil contamination. Stormwater quality influent to the CMs is therefore considered to be reflective of natural background conditions at the SSFL site.

Table 4 lists treatment BMPs included in the performance analysis as well as descriptions of their respective drainage areas, and approximate percentages of impervious cover (characterized by exposed rock, roadways, and buildings). The overall Site includes numerous other areas managed by BMPs that vary in type from asphalt removal and erosion control BMPs to CMs and additional types of treatment control BMPs.

Table 4. Treatment BMP Sites and Drainage Areas

Treatment BMP	Drainage Area (acres)	Approximate Imperviousness
CM-1	52.8 (pre-ELV improvements)	6.5%
	43.5 (post-ELV improvements)	6.8%
CM-3	17.2	6.5%
CM-8	2.6	12%
CM-9	10.2	48%
CM-11	5.7	26%
B-1 Media Filter	8.6	23%
ELV Treatment BMP	15.6 (Helipad plug in place)	26%
	6.6 (Helipad plug removed)	37%
Lower Lot Biofilter	29.9[1]	53%
Northern Detention Bioswale	2.6	50%
Southern Detention Bioswale	15.6	50%
Upper Lot Media Filter	5.1	35%
Outfall 011 SWTS	303	10%
Outfall 018 SWTS	586	20%

[1] Comprised of an 11.7-acre drainage area to the lower parking lot and an 18.2-acre drainage area to a diversion weir in the 24-inch storm drain upstream of the lower lot biofilter.

3. Results: Box Plots

Multiple-BMP box plots for TSS, dioxins, and lead are shown in Figure 2, Figure 3, and Figure 4, respectively, illustrating the ranges and basic statistics of observed influent and effluent COC concentrations at the CMs and other media filters (CM-1, CM-3 post-2016/17, CM-9, B-1 media filter, and the upper lot media filter), as well as the lower lot biofilter, ELV treatment BMP, the detention bioswales, and the SWTSs. As shown in Figure 1, box plots identify the medians, interquartile ranges (IQRs) from the 25^{th}-percentile to 75^{th}-percentile values, and the 1.5x quartile values; higher and lower levels beyond the 1.5x quartile values are plotted as diamonds. Box plots as well as statistical analyses, influent vs. effluent correlation charts, and probability plots presented in following sections, were developed using only paired sample datasets consisting of an equal number of influent and effluent samples per treatment BMP.

Extents of the overlap of the influent and effluent boxes of a given treatment BMP visually indicate the difference in observed influent and effluent concentrations, while statistical tests calculate the significance of the differences. Boxes representing paired influent and effluent data without any, or with very little, overlap, as seen with dioxins at the lower lot biofilter, indicate effective treatment BMP performance. Influent and effluent datasets producing boxes with a substantive overlap, as seen with TSS at the lower lot biofilter, indicate less difference in observed influent and effluent concentrations (i.e., less robust BMP performance). Small to moderate size paired datasets are generally assumed statistically different when a median value of a set lies outside the IQR of the other. Larger paired datasets may exhibit statistical differences even with some overlap between resulting influent and effluent boxes.

If influent concentrations are low, the differences between the influent and effluent concentrations may not be as significant (i.e., smaller percentage reductions) as when the influent concentrations are high. Effluent concentrations that are low and consistently below the effluent numeric effluent limits or benchmarks (although not applicable at internal stormwater control locations) are the best indicator of desired treatment performance, especially when influent concentrations may be higher than the limits. The box plots allow this behavior to be observed and is also further discussed during additional statistical evaluations herein.

The detention bioswales and the SWTSs were the only treatment BMPs without overlap between interquartile ranges (IQR) of influent and effluent TSS concentrations, generally indicating robust treatment control BMP performance. Overall decreases in TSS concentrations were observed at CM/media filter sites and the lower lot biofilter, although overlap is apparent between respective influent and effluent boxes. Overlap is also present between influent and effluent concentration boxes for the ELV treatment BMP, where an increase in TSS concentrations was observed.

Substantial decreases in dioxin concentrations were observed at the lower lot biofilter, detention bioswales, and the SWTSs, and overlaps of influent and effluent IQRs are not present. Overall, decreases in dioxin concentrations were observed at CM/media filter sites and the ELV treatment BMP, though data for both BMPs show an overlap between influent and effluent boxes. Almost all of the effluent dioxin concentrations from the lower lot biofilter, ELV treatment BMP, and detention bioswales are lower than the Outfall 009 Permit Limit (all of the available SWTS effluent sample concentrations were below the relevant outfall Permit Limits), while most of the influent dioxin concentrations at the lower lot biofilter, CMs/media filters, detention bioswales, and the SWTSs are greater than the relevant outfall Permit Limits.

The ELV treatment BMP generally has lower influent dioxin concentrations, with some above the Outfall 009 Permit Limit.

Overall decreases in lead concentrations were observed at the CM/media filter sites, ELV treatment BMP, detention bioswales, and SWTSs, with some overlap of influent and effluent concentrations at CM/media filter sites and the ELV treatment BMP (and very minor overlap at the detention bioswales). Overlap of influent and effluent IQRs is not present in data collected at the SWTSs. Minimal differences in influent and effluent lead concentrations were observed in the boxes for the lower lot biofilter. All of the effluent concentrations for lead at the ELV treatment BMP and detention bioswales are lower than the Outfall 009 Permit Limit. Some influent lead concentrations are greater than the Outfall 009 Permit Limit, especially at the CM/media filter sites, and detention bioswales. The lower lot biofilter also has most of the effluent concentrations below the Outfall 009 Permit Limit, but the effluent concentrations are similar to the influent concentrations. The effluent concentrations for lead at the CM/Media Filter locations have apparent concentration reductions, but with some effluent concentrations still above the Outfall 009 Permit Limit. Both the influent and effluent SWTS concentrations for lead were below the relevant outfall Permit Limits.

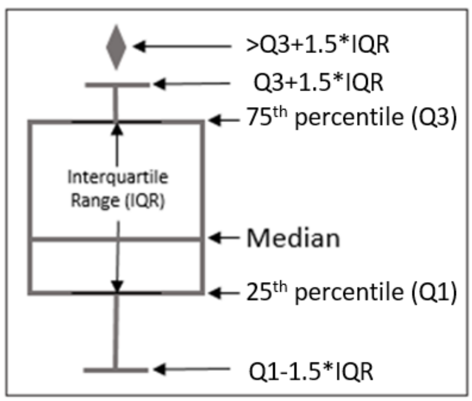

Figure 1. Box Plot Legend (*example, not to scale*)

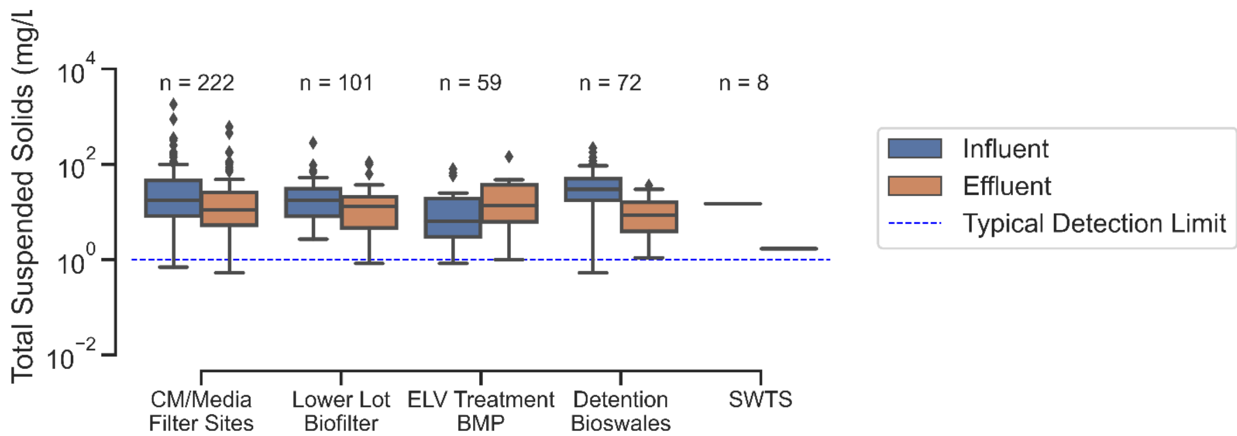

Figure 2. Multiple Treatment BMP Box Plot for TSS

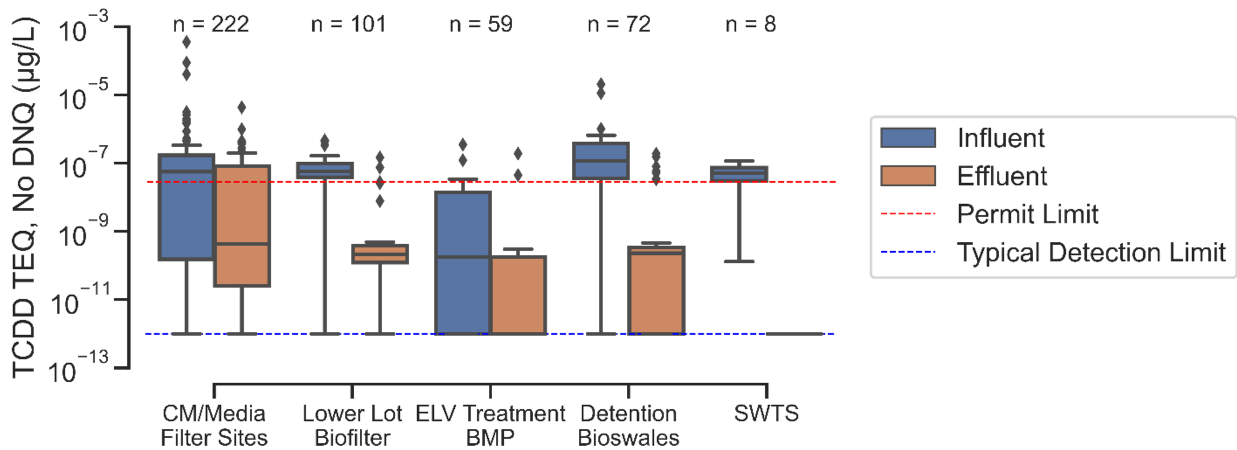

Figure 3. Multiple Treatment BMP Box Plot for Dioxins

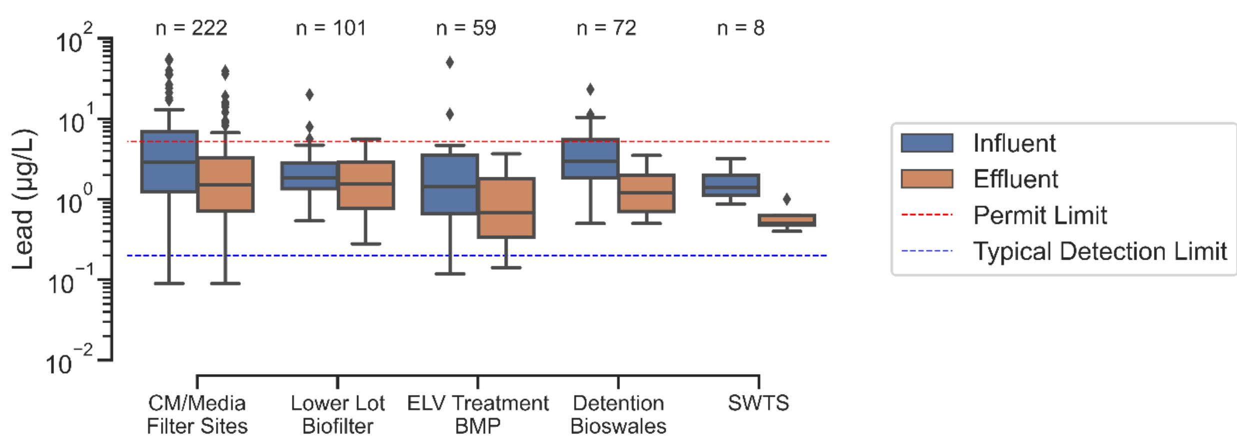

Figure 4. Multiple Treatment BMP Box Plot for Lead

4. Results: Statistical Analysis

Statistical summaries of the cumulative paired data over the 2009-2023[7] sampling period for the SSFL treatment BMPs using the non-parametric, one-tailed, binomial sign test are shown for the paired datasets in Table 5 through Table 15. The sign test assesses whether the difference in the number of sample pairs showing a decrease in concentration from the influent to the effluent, compared to sample pairs with an increase in concentration, is statistically significant. The null hypothesis suggests that the median of the difference between paired influent and effluent samples is zero (for the number of paired data available), or in other words, the number of data pairs showing an increase in concentration from the influent to effluent equals the number of data pairs showing a decrease in concentration from the influent to effluent. The test was executed based on a selected alpha value, α, in this case 0.05, the traditional critical value. The null hypothesis is rejected, with a 95% or greater confidence level, by a p-value of 0.05 or less, indicating a statistically significant difference in the number of data pairs that show a decrease, compared to an increase, in concentration from the influent to the effluent. The p-values of two-tailed binomial sign tests were divided by 2 to determine the corresponding one-tailed p-values.

A p-value greater than 0.05 indicates that the null hypothesis cannot be rejected, and the difference in the numbers of pairs showing an increase, compared to a decrease in concentration, is not statistically significant, based on the number of sample pairs available. This conclusion could be due to a lack of sample pairs with reduced concentrations. Additionally, because the total number of sample pairs used to calculate p-values excludes pairs with equal influent and effluent concentrations, which occurs most often in the case of non-detect (ND) results at both the influent and effluent, the conclusion could also be due to an insufficient number of non-equal sample pairs to be able to reject the null hypothesis.

4.1 Culvert Modification (CMs) and Media Filters

Results of statistical analyses performed on data collected at non-background CMs and other media filters are summarized in Table 5. Results of the paired sign test show that the number of data pairs with decreases in concentration from the influent to the effluent, compared to pairs showing increases in concentration, is statistically significant (p-value ≤ 0.05) for TSS, lead, and dioxins, suggesting water quality improvements are achieved by the treatment BMPs.

[7] Paired samples taken during bypass or overflow events were not included in statistical analyses, nor did the analyses consider copper data, as copper is not listed as a pollutant of concern in the 2015 Work Plan.

Table 5. Combined Non-Background Statistical Analyses:
CM-1, CM-3[2], CM-9, B-1 Media Filter, and Upper Lot Media Filter

Statistic	TSS (mg/l)		Dioxin (µg/l)		Lead (µg/l)	
	Influent	Effluent	Influent	Effluent	Influent	Effluent
Minimum	0.70	0.53	1.0E-12	1.0E-12	0.09	0.09
Maximum	1,800	610	3.6E-04	9.8E-07	55	39
Average	64	27	5.0E-06	5.7E-08	6.1	3.0
Median	17	11	5.6E-08	3.9E-10	2.8	1.3
Standard Deviation	198	65	3.7E-05	1.2E-07	10	4.9
Coefficient of Variation (COV)	3.1	2.4	7.4	2.1	1.6	1.6
Total pairs of observations	106		102		106	
Pairs with influent-to-effluent concentration reductions	70		66		78	
Pairs with influent-to-effluent concentration increases	32		18		23	
Pairs with equal influent and effluent concentrations	4		18		5	
Paired sign test p-value[1]	<0.001		<0.001		<0.001	
Statistically significant number of data pairs with concentration reductions[1]?	Yes		Yes		Yes	

[1] Non-parametric, one-tailed binomial sign test; p-values ≤ 0.05 indicate statistical significance.
[2] Post 2016/17.

Statistical analysis of data representing background conditions influent to CM-8 and CM-11 is summarized in Table 6. Though reductions of already-low COC concentrations in runoff to CM-8 and CM-11 are considered generally unlikely given their largely natural and undeveloped drainage areas, there was a statistically significant (p-value ≤ 0.05) number of paired samples with a decrease in concentration from the influent to the effluent (compared to paired data with an increase in concentration) for TSS and lead.

It should be noted that no data were collected from these sites in the most recent reporting year. Paired samples of ND results, especially for dioxins, at both the influent and effluent demonstrate favorable water quality influent to and effluent from CM-8 and CM-11, though they detract from the number of data pairs needed to result in statistical significance.

Table 6. Combined Background Statistical Analyses: CM-8 and CM-11

Statistic	TSS (mg/l)		Dioxin (µg/l)		Lead (µg/l)	
	Influent	Effluent	Influent	Effluent	Influent	Effluent
Minimum	1.0	1.0	1.0E-12	1.0E-12	0.20	0.20
Maximum	82	33	1.5E-10	3.5E-10	11	7.0
Average	13	7.6	2.7E-11	6.9E-11	3.2	1.6
Median	3.0	2.0	1.0E-12	1.0E-12	0.58	0.29
Standard Deviation	20.8	9.6	5.8E-11	1.3E-10	4.5	2.2
Coefficient of Variation (COV)	1.6	1.3	2.1	1.9	1.4	1.4
Total pairs of observations	21		11		10	
Pairs with influent-to-effluent concentration reductions	13		1		7	
Pairs with influent-to-effluent concentration increases	3		3		1	
Pairs with equal influent and effluent concentrations	5		7		2	
Paired sign test p-value[1]	0.011		0.31		0.035	
Statistically significant number of data pairs with concentration reductions[1]?	Yes		No (data numbers insufficient to indicate significance)		Yes	

[1] Non-parametric, one-tailed binomial sign test; p-values ≤ 0.05 indicate statistical significance.

4.2 Lower Lot Biofilter Treatment Train

Samples have been collected at the lower lot biofilter during 36 rain events since its implementation. Samples are taken from three locations within the biofilter treatment train: an influent, a midpoint at the sedimentation basin outlet, and a biofilter effluent. Table 7, Table 8, and Table 9 summarize respective statistics of influent-to-midpoint, midpoint-to-effluent, and influent-to-effluent for TSS, dioxins, and lead.

For TSS, the majority of data pairs showed a decrease in concentration for all steps of the treatment train (influent runoff to the sedimentation basin outlet, the sedimentation basin outlet to the biofilter outlet, and influent to biofilter outlet). However, there was insufficient data to show a statistically significant number of data pairs with concentration decreases for TSS, for the influent runoff to the sedimentation basin outlet and influent runoff to the biofilter outlet. The number of data pairs with decreases in TSS concentrations from the sedimentation basin outlet to the biofilter outlet was statistically significant.

The majority of data pairs also showed a decrease in dioxin concentrations, and the results were statistically significant for the sedimentation basin outlet to the biofilter outlet and influent runoff to the biofilter outlet. Across the system (influent runoff to the biofilter outlet), only one sample pair had effluent dioxin concentrations with higher concentrations than their paired influent sample.

For lead, the majority of sample pairs from all steps of the treatment train exhibited a decrease in lead concentration. However, the influent to sedimentation basin outlet was the only step of the treatment train to show a statistically significant number of data pairs with a decrease in concentration for lead.

Considering the entire system (influent runoff to the biofilter outlet), dioxins were the only COC to show a statistically significant (p-value ≤ 0.05) number of paired samples that decreased in concentration from the influent runoff to the biofilter outlet. Although the majority of sample pairs showed a decrease in concentration from the influent to effluent, for both TSS and lead, there were insufficient data to show statistically significant reductions.

Table 7. Lower Lot Biofilter Statistical Analyses: Influent to Midpoint Sample Points

Statistic	TSS (mg/l)		Dioxin (µg/l)		Lead (µg/l)	
	Influent	Effluent	Influent	Effluent	Influent	Effluent
Minimum	2.7	2.5	1.0E-12	1.0E-12	0.5	0.5
Maximum	280	110	4.7E-07	2.8E-07	20	6.6
Average	30	22	8.2E-08	6.3E-08	2.8	2.0
Median	17	12	5.7E-08	4.5E-08	1.7	1.6
Standard Deviation	50	26	9.3E-08	6.8E-08	3.4	1.5
Coefficient of Variation (COV)	1.6	1.15	1.1	1.08	1.2	0.74
Total pairs of observations	33		33		33	
Pairs with influent-to-midpoint concentration reductions	20		21		23	
Pairs with influent-to-midpoint concentration increases	13		11		7	
Pairs with equal influent and midpoint concentrations	0		1		3	
Paired sign test p-value[1]	0.15		0.055		0.0026	
Statistically significant number of data pairs with concentration reductions[1]?	No (data numbers insufficient to indicate significance)		No (data numbers insufficient to indicate significance)		Yes	

[1] Non-parametric, one-tailed binomial sign test; p-values ≤ 0.05 indicate statistical significance.

Table 8. Lower Lot Biofilter Statistical Analyses: Midpoint to Effluent Sample Points

Statistic	TSS (mg/l)		Dioxin (µg/l)		Lead (µg/l)	
	Influent	Effluent	Influent	Effluent	Influent	Effluent
Minimum	2.5	0.8	1.0E-12	1.0E-12	0.5	0.3
Maximum	110	110	2.8E-07	1.5E-07	6.6	5.6
Average	22	19	6.3E-08	9.3E-09	2.0	2.0
Median	12	12	4.5E-08	2.1E-10	1.6	1.5
Standard Deviation	25	25	6.7E-08	2.7E-08	1.4	1.4
Coefficient of Variation (COV)	1.2	1.34	1.06	2.9	0.72	0.73
Total pairs of observations	35		35		35	
Pairs with midpoint-to-effluent concentration reductions	22		31		19	
Pairs with midpoint-to-effluent concentration increases	11		2		16	
Pairs with equal midpoint and effluent concentrations	2		2		0	
Paired sign test p-value[1]	0.040		<0.001		0.37	
Statistically significant number of data pairs with concentration reductions[1]?	Yes		Yes		No (data numbers insufficient to indicate significance)	

[1] Non-parametric, one-tailed binomial sign test; p-values ≤ 0.05 indicate statistical significance.

Table 9. Overall Lower Lot Biofilter Statistical Analyses (Influent to Effluent Sample Points)

Statistic	TSS (mg/l)		Dioxin (µg/l)		Lead (µg/l)	
	Influent	Effluent	Influent	Effluent	Influent	Effluent
Minimum	2.7	0.8	1.0E-12	1.0E-12	0.5	0.3
Maximum	280	110	4.7E-07	1.5E-07	20	5.6
Average	31	20	9.3E-08	1.0E-08	2.8	2.0
Median	18	13	5.8E-08	2.1E-10	1.9	1.6
Standard Deviation	49	25	1.1E-07	2.8E-08	3.4	1.5
Coefficient of Variation (COV)	1.6	1.29	1.2	2.8	1.2	0.72
Total pairs of observations	34		34		34	
Pairs with influent-to-effluent concentration reductions	22		32		20	
Pairs with influent-to-effluent concentration increases	12		1		12	
Pairs with equal influent and effluent concentrations	0		1		2	
Paired sign test p-value[1]	0.06		<0.001		0.11	
Statistically significant number of data pairs with concentration reductions[1]?	No (data numbers insufficient to indicate significance)		Yes		No (data numbers insufficient to indicate significance)	

[1] Non-parametric, one-tailed binomial sign test; p-values ≤ 0.05 indicate statistical significance.

4.3 ELV Treatment BMP

Table 10, Table 11, and Table 12 summarize respective results of statistical analyses conducted on influent-to-midpoint, midpoint-to-effluent, and influent-to-effluent pairs of TSS, dioxins, and lead data collected at the ELV treatment BMP.

Results indicate a statistically significant number of data pairs with influent-to-effluent reductions of dioxins and lead concentrations. However, influent-to-effluent increases in TSS concentrations were also found statistically significant. Drainage layers and filter media located between the midpoint and effluent sample points of the BMP were rebuilt in Summer 2021 in an attempt to reduce media washout, the expected source of the increased TSS concentrations. Recent data collected in 2022/23 showed that TSS concentrations increased from the influent to the effluent in four of the seven data pairs. Four of the seven data pairs had increases in TSS concentrations from the influent to the sedimentation tank effluent, and six of the seven data pairs had increases in TSS concentrations from the sedimentation tank effluent to the effluent. These increases in TSS are expected to be due to washout of media from the treatment system.

The results also indicate statistically significant influent to midpoint reductions in lead and midpoint-to-effluent reductions of dioxins, associated with media treatment. However, there was also a statistically significant increase in TSS and lead from the midpoint to effluent.

Table 10. ELV Treatment BMP Statistical Analyses: Influent to Midpoint Sample Points

Statistic	TSS (mg/l)		Dioxin (µg/l)		Lead (µg/l)	
	Influent	Effluent	Influent	Effluent	Influent	Effluent
Minimum	0.8	0.8	1.0E-12	1.0E-12	0.1	0.1
Maximum	80	47	3.5E-07	3.6E-07	50	3.5
Average	17	8	2.4E-08	1.9E-08	4.8	1.0
Median	6	3	1.8E-10	2.3E-10	1.3	0.5
Standard Deviation	25	11	8.0E-08	8.2E-08	11.7	1.01
Coefficient of Variation (COV)	1.46	1.47	3.32	4.30	2.45	1.02
Total pairs of observations	18		19		18	
Pairs with influent-to-midpoint concentration reductions	12		8		13	
Pairs with influent-to-midpoint concentration increases	6		6		4	
Pairs with equal influent and midpoint concentrations	0		5		1	
Paired sign test p-value[1]	0.11		0.40		0.02	
Statistically significant number of data pairs with concentration reductions[1]?	No (data numbers insufficient to indicate significance)		No (data numbers insufficient to indicate significance)		Yes	

[1] Non-parametric, one-tailed binomial sign test; p-values ≤ 0.05 indicate statistical significance.

Table 11. ELV Treatment BMP Statistical Analyses: Midpoint to Effluent Sample Points

Statistic	TSS (mg/l)		Dioxin (µg/l)		Lead (µg/l)	
	Influent	Effluent	Influent	Effluent	Influent	Effluent
Minimum	0.8	1	1.0E-12	1.0E-12	0.1	0.1
Maximum	47	144	3.6E-07	1.9E-07	3.5	3.7
Average	7	25	1.7E-08	9.2E-09	0.9	1.0
Median	2	14	2.3E-10	1.0E-12	0.5	0.7
Standard Deviation	11	33	7.8E-08	4.2E-08	0.94	0.93
Coefficient of Variation (COV)	1.54	1.29	4.52	4.55	1.01	0.91
Total pairs of observations	20		21		21	
Pairs with midpoint-to-effluent concentration reductions	1		13		5	
Pairs with midpoint-to-effluent concentration increases	19		0		16	
Pairs with equal midpoint and effluent concentrations	0		8		0	
Paired sign test p-value[1]	<0.001		<0.001		0.013	
Statistically significant number of data pairs with concentration reductions[1]?	No[1]		Yes		No[1]	

[1] Data show statistically significant number of pairs with increases in TSS and lead concentration.

Table 12. Overall ELV Treatment BMP Statistical Analyses (Influent to Effluent Sample Points)

Statistic	TSS (mg/l)		Dioxin (µg/l)		Lead (µg/l)	
	Influent	Effluent	Influent	Effluent	Influent	Effluent
Minimum	0.8	1	1.0E-12	1.0E-12	0.1	0.1
Maximum	80	144	3.5E-07	1.9E-07	50	3.7
Average	17	25	2.9E-08	1.2E-08	4.7	1.1
Median	6	14	1.8E-10	1.0E-12	1.4	0.7
Standard Deviation	24	33	8.1E-08	4.4E-08	11.3	0.99
Coefficient of Variation (COV)	1.40	1.29	2.8	3.7	2.40	0.89
Total pairs of observations	19		20		19	
Pairs with influent-to-effluent concentration reductions	4		10		14	
Pairs with influent-to-effluent concentration increases	14		2		4	
Pairs with equal influent and effluent concentrations	1		8		1	
Paired sign test p-value[1]	0.0154[2]		0.0193		0.0154	
Statistically significant number of data pairs with concentration reductions[1]?	No[2]		Yes		Yes	

[1] Non-parametric, one-tailed binomial sign test; p-values ≤ 0.05 indicate statistical significance.
[2] Data show statistically significant number of pairs with increases in TSS concentration.

4.4 Detention Bioswales

As BMPs of similar design, the southern and northern detention bioswales were analyzed together for purposes of evaluating treatment BMP performance. Results from statistical analyses conducted on paired data collected at the detention bioswales are presented in Table 13, indicating a statistically significant number of data pairs with reductions in concentration from the influent to the effluent for TSS, dioxins, and lead.

Table 13. Southern and Northern Detention Bioswale Statistical Analyses

Statistic	TSS (mg/l)		Dioxin (µg/l)		Lead (µg/l)	
	Influent	Effluent	Influent	Effluent	Influent	Effluent
Minimum	0.5	1.1	1.0E-12	1.0E-12	0.50	0.50
Maximum	220	36	2.1E-05	1.9E-07	23	3.5
Average	47	11	1.1E-06	1.7E-08	4.6	1.4
Median	30	9	1.2E-07	2.3E-10	3.0	1.2
Standard Deviation	51	8.9	3.8E-06	4.3E-08	4.4	0.81
Coefficient of Variation (COV)	1.07	0.82	3.6	2.5	0.97	0.57
Total pairs of observations	35		36		35	
Pairs with influent-to-effluent concentration reductions	29		32		28	
Pairs with influent-to-effluent concentration increases	6		1		6	
Pairs with equal influent and effluent concentrations	0		3		1	
Paired sign test p-value[1]	<0.001		<0.001		<0.001	
Statistically significant number of data pairs with concentration reductions[1]?	Yes		Yes		Yes	

[1] Non-parametric, one-tailed binomial sign test; p-values ≤ 0.05 indicate statistical significance.

4.5 SWTSs

Two influent sample results (for dioxins and lead) are available from each SWTS, one collected in 2021/22 and one collected in 2022/23. Available outfall sample results from the respective outfalls are considered to be representative of effluent from the SWTSs. The outfall sample results corresponding to the influent sample results available in 2022/23 represent partially treated stormwater (i.e., mix of treated SWTS discharge and pond overflow). Additional data will be collected in future reporting years. Because only two sample pairs are available from each SWTS, for dioxins and lead only (considering COCs analyzed herein), in addition to one sample pair for TSS for the Outfall 018 SWTS only, these sample results are presented in Table 14, and statistical analyses were not performed.

All available sample pairs showed a substantial decrease in concentration from the influent to the outfall (i.e., effluent). All effluent sample results for lead and dioxins, except for lead at Outfall 011 corresponding to the sample pair in 2022/23 (which represented partially treated stormwater), were not detected.

Table 14. SWTSs Sample Results

Treatment BMP	Reporting Year	TSS (mg/l)			Dioxin (µg/l)			Lead (µg/l)		
		SWTS Influent	SWTS Effluent	Outfall Discharge[1]	SWTS Influent	SWTS Effluent	Outfall Discharge[1]	SWTS Influent	SWTS Effluent	Outfall Discharge[1]
Outfall 011 SWTS	2021/22	-	ND	4.5	1.3E-10	-	ND	0.87	ND	ND
	2022/23	-	-	-	1.2E-07	-	ND	1.6	-	0.4
Outfall 018 SWTS	2021/22	-	-	-	6.1E-08	-	ND	3.2	-	ND
	2022/23	15	-	ND	4.1E-08	-	ND	1.2	-	ND

[1] Samples collected at the respective outfalls. Outfall discharge represents pure SWTS effluent in most cases; however, the ponds often overflowed during the 2022/23 reporting year due the large storms, causing outfall samples to represent a mix of both treated and bypassed flows.

4.6 Statistical Analyses Summary

A summary of statistical analyses presented above is shown in Table 15. Based on the number of sample pairs available, the table shows whether there was a statistically significant difference in the number of data pairs with a decrease in concentration from the influent to effluent locations, as compared to data pairs with an increase in concentration from the influent to effluent, as shown by the paired, non-parametric, binomial sign test.

Table 15. Summary of Performance Data, 2009-2023

Location	TSS			Dioxins			Lead		
	Total Sample Pairs[1]	Sign test p-value[2]	Statistically Significant Decrease Observed[2]?	Total Sample Pairs[1]	Sign test p-value[2]	Statistically Significant Decrease Observed[2]?	Total Sample Pairs[1]	Sign test p-value[2]	Statistically Significant Decrease Observed[2]?
CMs/Media Filters (Non-Background)	106	<0.001	**Yes**	102	<0.001	**Yes**	106	<0.001	**Yes**
CM-8 and CM-11 (Background)	21	0.011	**Yes**	11	0.31	No	10	0.035	**Yes**
Lower Lot Biofilter (Influent to Effluent)	34	0.06	No	34	<0.001	**Yes**	34	0.11	No
ELV Treatment BMP (Influent to Effluent)	19	0.0154[3]	No[3]	20	0.0193	**Yes**	19	0.0154	**Yes**
Detention Bioswales	35	<0.001	**Yes**	36	<0.001	**Yes**	35	<0.001	**Yes**
SWTSs	1	-[4]	-[4]	4	-[4]	-[4]	4	-[4]	-[4]

[1] Includes sample pairs with equal influent and effluent concentrations, which were not considered in calculation of the p-values for the sign test.
[2] Non-parametric, one-tailed binomial sign test; p-values ≤ 0.05 indicate statistical significance.
[3] Data show an influent-to-effluent increase in TSS concentration, with statistical significance.
[4] Insufficient number of data pairs to perform statistical test.

5. Results: Comparison to Permit Limits

The treatment BMPs were installed for purposes of reducing COC concentrations in stormwater prior to discharge at the NPDES Permit compliance points. The passive treatment BMPs within the Outfall 009 watershed have been observed to often achieve concentration reductions resulting in effluent concentrations below respective Permit Limits at Outfall 009, although not designed to meet the limits individually, as Outfall 009 Permit Limits are not applicable to effluent discharges from the passive treatment BMPs, themselves. However, to evaluate treatment BMP effectiveness as it relates to the Outfall 009 Permit Limits, counts of influent and effluent concentrations observed in excess of Outfall 009 Permit Limits at non-background CMs and other media filters (CM-1, CM-3 post-2016/17, CM-9, B-1 media filter, and the upper lot media filter), the lower lot biofilter, ELV Treatment BMP, and detention bioswales are presented in Table 16, Table 17, Table 18, and Table 19, respectively. Influent and effluent concentrations for the Outfall 011 and Outfall 018 SWTSs are compared to their respective outfall Permit Limits in Table 20 and Table 21, respectively.

Table 16 through Table 21 summarize the results of analyses conducted with data collected at influent and effluent sample points, regardless of whether they are individual or paired samples. This analysis only includes influent and effluent samples; samples collected at treatment BMP midpoint locations are not accounted for in this analysis. The maximum and average excess ratios represent the maximum and average ratios of observed concentrations in excess of the Outfall 009 Permit Limit to the Permit Limit. Empty cells indicate sample results were not observed above respective Permit Limits. Given the inclusion of unpaired samples, some analyses include more influent samples than effluent or vice versa. Within this section, dioxins results are referred to as "TCDD TEQ no DNQ."

As seen in Table 16, effluent dioxins and lead concentrations were observed below Outfall 009 Permit Limits more often than corresponding influent concentrations at non-background CMs and other media filters[8]. Other than the average lead concentration excess ratio observed at the B-1 media filter, ratios comparing the maximum and average observed lead and dioxin concentrations to respective Permit Limits are notably less for effluent results than influent results, indicating reductions of both lead and dioxin concentrations in stormwater are achieved by the non-background CMs and other media filters and augmenting lines of evidence of their effective pollutant reduction performance.

Dioxins results from the B-1 media filter are greatly affected by an exceptionally high influent result of 3.6E-4 µg/l observed on December 2, 2014, without which, maximum and average influent ratios fall to 94 and 16, respectively. CM-1 data are similarly affected by a March 2012 high effluent result of 4.3E-6 µg/l, without which, maximum and average effluent ratios become 35 and 7.3, respectively. A leaking seal was observed at CM-1 in March 2017 and, although quickly repaired, it is unknown whether it may have contributed to the February 17, 2017, Outfall 009 exceedance of the Permit Limit for dioxins.

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[8] With the exception of dioxins CM-3, where available influent and effluent results have not been detected in excess of Permit Limits.

Table 16. CMs and Other Media Filters: Summary of Influent and Effluent Results Compared to Reference Outfall 009 Permit Limits, 2009-2023 (CM-1, CM-3 post-2016/17, CM-9, B-1 Media Filter, and Upper Lot Media Filter)

Treatment BMP	Parameter	% Above Outfall 009 Permit Limit		Maximum Concentration Excess Ratio[1]		Average Concentration Excess Ratio[1]	
		Influent	Effluent	Influent	Effluent	Influent	Effluent
B-1 Media Filter	Lead	35%	8.7%	1.8	1.7	1.3	1.5
	TCDD TEQ no DNQ	85%	68%	12,868	10	773	3.9
CM-1	Lead	28%	16%	11	7.5	3.9	3.0
	TCDD TEQ no DNQ	58%	50%	3,149	155	150	13
CM-9	Lead	42%	22%	11	6.9	4.1	2.9
	TCDD TEQ no DNQ	49%	23%	56	5.2	8.2	3.0
Upper Lot Media Filter	Lead	11%	0%	1.2	-	1.1	-
	TCDD TEQ no DNQ	80%	54%	64	2.7	8.3	1.7
CM-3	Lead	22%	0%	1.7	-	1.5	-
	TCDD TEQ no DNQ	0%	0%	-	-	-	-

[1] An empty cell indicates sample results were not observed above the respective Permit Limit.

Influent and effluent results observed at the lower lot biofilter in excess of Outfall 009 Permit Limits are summarized in Table 17. Fewer BMP effluent lead results were above the Outfall 009 lead limit than BMP influent results, with 8.8% of influent results and 2.8% of effluent results above the lead limit. A substantially smaller portion of BMP effluent dioxins results were above the Outfall 009 dioxins limit when compared to influent results, with 82% of BMP influent samples and 8.3% of BMP effluent samples above the Outfall 009 dioxins limit. Ratios comparing the maximum and average BMP effluent concentrations of lead and dioxins in excess of respective Outfall 009 Permit Limits to Permit Limits are notably less than the corresponding ratios using maximum and average BMP influent concentrations in excess of the Outfall 009 Permit Limit, suggesting effective reduction of these COCs in stormwater through treatment by the lower lot biofilter.

Table 17. Lower Lot Biofilter: Summary of Influent and Effluent Results Compared to Reference Outfall 009 Permit Limits, 2013-2023

Parameter	% Above Outfall 009 Permit Limit		Maximum Concentration Excess Ratio		Average Concentration Excess Ratio	
	Influent	Effluent	Influent	Effluent	Influent	Effluent
Lead	8.8%	2.8%	3.8	1.1	2.1	1.1
TCDD TEQ no DNQ	82%	8.3%	17	5.2	4.0	3.3

Table 18 summarizes similar results at the ELV treatment BMP, where fewer BMP effluent lead and dioxins results were above respective Outfall 009 limits than corresponding BMP influent results, with 11% of influent lead results and 0% of effluent results above the lead limit, and with 20% of influent dioxins results and 8.7% of effluent results above the dioxins limit. Ratios comparing the maximum and average BMP effluent dioxin concentrations in excess of the Outfall 009 Permit Limit to the Outfall 009 dioxins limit are notably less than corresponding ratios using BMP influent concentrations. These trends suggest reduction in lead and dioxins through the ELV treatment BMP.

Table 18. ELV Treatment BMP: Summary of Influent and Effluent Results Compared to Reference Outfall 009 Permit Limits, 2013-2023

Parameter	% Above Outfall 009 Permit Limit		Maximum Concentration Excess Ratio[1]		Average Concentration Excess Ratio[1]	
	Influent	Effluent	Influent	Effluent	Influent	Effluent
Lead	11%	0%	9.7	-	5.9	-
TCDD TEQ no DNQ	20%	8.7%	13	6.9	4.8	4.2

[1] An empty cell indicates sample results were not observed above the respective Permit Limit.

Sample results at the detention bioswales are summarized in Table 19, showing fewer effluent lead and dioxins results above respective Outfall 009 limits than corresponding influent results, with 32% of influent lead results and 0% of effluent results above the Outfall 009 lead limit, and with 79% of influent dioxins results and 15% of effluent results above the Outfall 009 dioxins limit. Ratios comparing the maximum and average effluent dioxin concentrations in excess of the Outfall 009 Permit Limit to respective Outfall 009 Permit Limits are notably less than corresponding ratios using bioswales influent concentrations, suggesting reduction of dioxins in stormwater through treatment by the detention bioswales.

Table 19. Detention Bioswales: Summary of Influent and Effluent Results Compared to Reference Outfall 009 Permit Limits, 2015-2023

Parameter	% Above Outfall 009 Permit Limit		Maximum Concentration Excess Ratio[1]		Average Concentration Excess Ratio[1]	
	Influent	Effluent	Influent	Effluent	Influent	Effluent
Lead	32%	0%	4.5	-	1.8	-
TCDD TEQ no DNQ	79%	15%	737	6.7	46	3.1

[1] An empty cell indicates sample results were not observed above the respective Permit Limit.

Sample results at the Outfall 011 SWTS are summarized in Table 20, showing 50% (one of two) of influent concentrations for dioxins above respective Permit Limits. None of the effluent concentrations for lead or dioxins were above the Permit Limits.

Table 20. Outfall 011 SWTS: Summary of Influent and Effluent Results Compared to Outfall 011 Permit Limits, 2021-2023

Parameter	% Above Outfall 011 Permit Limit		Maximum Concentration Excess Ratio[1]		Average Concentration Excess Ratio[1]	
	Influent	Effluent	Influent	Effluent	Influent	Effluent
Lead	0%	0%	-	-	-	-
TCDD TEQ no DNQ	50%	0%	4.2	-	4.2	-

[1] An empty cell indicates sample results were not observed above the respective Permit Limit.

Sample results at the Outfall 018 SWTS are summarized in Table 21. All of the influent samples (2 out of 2) for dioxins were above the Outfall 018 Permit Limit, while none of the effluent samples exceeded the Permit Limit. All influent and effluent concentrations were below the Outfall 018 Permit Limits for both lead and dioxins.

Table 21. Outfall 018 SWTS: Summary of Influent and Effluent Results Compared to Outfall 018 Permit Limits, 2021-2023

Parameter	% Above Outfall 018 Permit Limit		Maximum Concentration Excess Ratio[1]		Average Concentration Excess Ratio[1]	
	Influent	Effluent	Influent	Effluent	Influent	Effluent
Lead	0%	0%	-	-	-	-
TCDD TEQ no DNQ	100%	0%	2.2	-	1.8	-

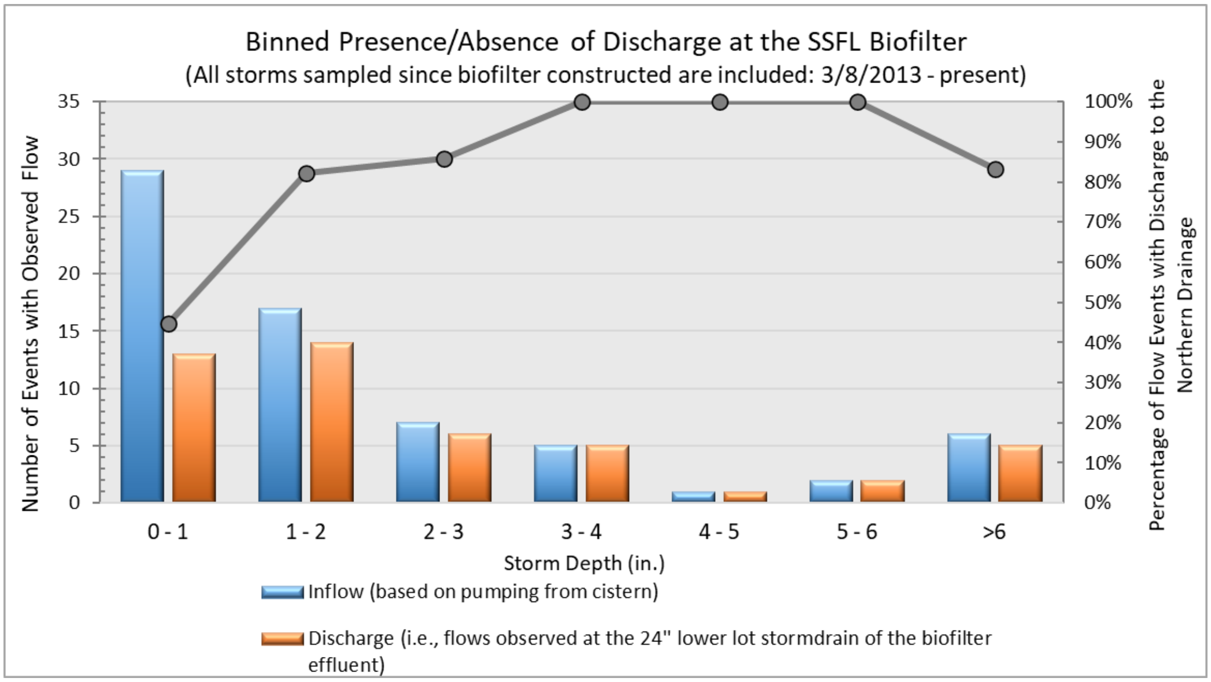
[1] An empty cell indicates sample results were not observed above the respective Permit Limit.

6. Results: Runoff Volume Discharge Analysis

In addition to water quality performance, the lower lot biofilter is designed to reduce the frequency that runoff discharges to the Northern Drainage and ultimately flows to Outfall 009 by retaining and slowly reducing flow rates and runoff volumes through detention and evapotranspiration. A 2017 analysis estimated that the average volume of runoff pumped to the biofilter per inch of rainfall increased from 52,000 gallons to 82,000 gallons following implementation of the detention bioswales, and the average percent of total runoff captured and treated by the lower lot biofilter from both the 24-inch storm drain and the lower lot drainage areas increased from 22% to 44% following detention bioswales implementation.

Figure 5 is a plot of discharging and non-discharging rain events for storms since the March 2013 implementation of the biofilter. This figure shows the quantity and types of storms in which the biofilter prevents discharge of stormwater runoff to the Northern Drainage. Storm events resulting in discharge to the Northern Drainage (via either the low-flow diversion weir bypass or treated biofilter effluent) were identified, categorized by total storm depth in one-inch increments, and compared to the total number of storms observed (where pumping from the cistern was recorded). Because stormwater runoff flows into the cistern and is then pumped to the lower lot biofilter, rain events are only counted in this analysis if pumping from the cistern occurred. The vertical axis on the right indicates the percentage of storm events that resulted in discharge to the Northern Drainage.

Smaller storms occur at a greater frequency than moderate and large-sized storms. As shown in Figure 5, it was estimated that the lower lot biofilter has successfully prevented discharges to the Northern Drainage in approximately 55% of storms of an inch or less of rainfall, 18% of storms between 1 and 2 inches of rainfall, and 14% of storms between 2 and 3 inches of rainfall.



[1] Discharging percentages of events were estimated based on sums of events with observed or model-predicted discharge.

[2] For three storm events in 2022/23, with storm depths greater than 6 inches, observations were not made during the rain event. Therefore, discharge was derived from model prediction (as described in Section 7.1)

Figure 5. Discharging and Non-Discharging Events at the Lower Lot Biofilter

7. Results: Treatment BMP Maintenance Analysis

The potential need for maintenance of the passive treatment BMPs is assessed through several methods. First, the cumulative sediment loading to the passive treatment BMPs was estimated based on TSS sample data and estimated runoff volume treated by the treatment BMPs, and these loads were compared to the sediment loading at which filter media maintenance is needed, as estimated by lab studies. Additionally, the empty bed volumes (EBVs) treated by each passive treatment BMP, since installation or reconstruction, were estimated, which can serve as another helpful tool in predicting media maintenance. Finally, observations of the function and performance of the passive treatment BMPs during and following rain events are also used to determine BMP maintenance needs.

7.1 Cumulative TSS Loading

The cumulative TSS loads captured to date by media-based passive treatment BMPs were estimated utilizing historical storm event depths, calculated runoff volumes, and measured TSS concentrations. Resulting TSS loads were compared to the cumulative sediment load shown by a lab column study of filter media performance (Pitt and Clark, 2010) to likely obstruct flows through the filter media and increase the potential for bypass flows.

Prior to 2016/17, passive treatment BMPs were assumed to treat stormwater runoff, and therefore experience TSS loading to the media, for each storm event where a sample was collected (at either the influent or effluent location). In light of reduced sampling at the majority of treatment BMPs in the Outfall 009 Watershed following 2016/17, a predictive logistic regression model was developed to estimate whether passive treatment BMPs had discharged during unsampled storm events. Average storm intensity (inches per hour), maximum storm intensity (inches per hour), total rainfall depth (inches), and antecedent dry period (days) were used to perform predictive assessments for CM-1, CM-9, the ELV treatment BMP, B-1 media filter, and the lower lot biofilter. A model could not be developed for the upper lot media filter as the quantity of data needed for input into the model was not collected prior to the sampling reduction. The number of observations in “test-and-train” datasets ranged from 21 to 49 observations, depending on how long the treatment BMP has been operational and sampled. The resulting classification accuracy, or ratio of correct predictions to total predictions, was 0.86, 0.93, 1.00, 0.82, and 0.82, for CM-1, CM-9, the ELV treatment BMP, B-1 media filter, and lower lot biofilter models, respectively.

Cumulative TSS loads captured by filter media were estimated at the passive treatment BMPs for storm events observed or predicted to have produced discharge from the passive treatment BMP, as follows:

- Average annual percent capture of runoff was estimated by BMP using the USEPA Storm Water Management Model (SWMM).
- A volumetric runoff coefficient, Rv, based on characteristics of the drainage area to the treatment BMP was estimated using SWMM and simulated over the average annual year scenario.
- BMP drainage areas were delineated in Geographic Information Systems (GIS).
- Estimated runoff volume captured by a given BMP was calculated by storm event as:

  - o Runoff volume captured =

$$Rainfall\ Depth\ x\ Rv\ x\ Drainage\ Area\ x\ Average\ Annual\ \%\ Capture$$

- Estimated TSS load captured by the BMP during an individual storm event was calculated as:
  - o Storm event TSS load captured =

$$Runoff\ Volume\ Captured\ x\ Event - dependent\ TSS\ concentration\ retained\ [Influent - Effluent\ TSS\ Concentrations]$$

- Estimated TSS loads captured by the BMP during individual storms were summed to determine the cumulative estimated TSS load captured during all storms where stormwater runoff was treated by the BMP, since its implementation or most recent filter media replacement.
- Treatment media surface area was estimated for each BMP, and the cumulative TSS load captured per unit media surface area was calculated.

At evaluated passive treatment BMPs that include pretreatment, such as the ELV Treatment BMP and lower lot biofilter, influent concentrations were represented by BMP midpoint samples results taken from the pretreatment effluent before flows enter the treatment media. In storms without a complete paired sample collected at a treatment BMP, the unsampled influent or effluent concentration was represented by the average respective concentration observed at the BMP within three years before or after the given storm.

The cumulative estimated TSS loading per unit media area was compared to the estimated sediment load that the filter media can accommodate (up to 50 kg/m^2) until maintenance or replacement of the media is recommended (Pitt and Clark, 2010). Estimated TSS loads captured per unit media surface area and percent of sediment loading capacity is shown by treatment BMP in Table 22.

The estimated time that effective media performance could be expected before filter media needs maintenance or replacement, assuming average annual rainfall (17.3 inches) and the average influent and effluent TSS concentrations from all sampled events, is also shown by treatment BMP in Table 22. Given the assumptions and estimates used to determine the cumulative sediment loading to date, as previously outlined, in addition to the unpredictability of future rainfall patterns, the information in Table 22 is intended as rough guidelines to assist, along with continued observations and performance monitoring, in informing the timing of media maintenance or replacement needs.

Based on a 2017 flow monitoring data analysis, estimates of the initial hydraulic conductivities of filter media at CM-1 and CM-9 were near or above 33 inches per hour, the “average flow rate before initial clogging” found by the lab column study (Pitt and Clark, 2010). Initial hydraulic conductivities become reduced substantially over long periods of treatment BMP operation, suggesting that filter media maintenance or replacement may benefit continued effective treatment performance of a treatment BMP. Since the media mounds of the CMs are covered with backfill and gravel, it is possible that these surface materials are clogged with sediment and the actual media itself may not be the limiting factor. Therefore, the 2017 analysis shows that media may actually be clogged more than results in Table 22 indicate.

It is acknowledged that there are large variations in TSS loading rates, in addition to the percentage of sediment loading to the media until maintenance is needed, among the treatment BMPs. As passive treatment controls were installed wherever feasible within the Outfall 009 Watershed, treatment BMPs with less media surface area like CMs were at times installed in locations that receive flow from relatively large drainage areas that can contribute to high TSS loading, thus resulting in relatively smaller estimated TSS capture capacities. Such is the case at CM-1 which receives runoff from an approximately 45-acre drainage area, roughly 3 to 4 times the sizes of drainage areas to similar CMs.

Other CMs in the Outfall 009 Watershed, including CM-3, CM-8, and CM-11, were not included in TSS loading analyses, although filter media at CM-3 may benefit from replacement in the near future given the above average rainfall observed in 2022/23 and the relatively large amounts of pervious surfaces within the drainage area as compared to drainage areas of CM-1 and CM-9. CM-8 and CM-11 are not anticipated to need maintenance in the near future.

Table 22. Percent of Sediment Loading Capacity Reached Until Maintenance

Treatment BMP	Year of Install or Last Media Replacement	Years Since Install or Media Replacement	Cumulative TSS Captured (kg)	Cumulative TSS Captured per Unit Area (kg/m^2)	Estimated % of Sediment Capture Capacity Reached	TSS per Average Annual Rainfall Year (kg/m^2)	Estimated Average Years Remaining to Maintenance
Lower Lot Biofilter	2012/13	11	710	3.2	7%	0.8	>10
B-1 Media Filter	2011/12	12	120	6.5	13%	1.6	>10
Upper Lot Media Filter	2016/17	7	175	6.8	14%	1	>10
CM-1[1]	2018/19[1]	5	61	10.3	21%	2.5	>10
CM-9	2009/10	14	510	86	>100%	7.2	0
ELV Treatment BMP[2]	2013/14	10	2	0.09	0.2%	<1	>10

[1] TSS loading analysis was restarted in 2018/2019 after BMP reconstruction and media replacement. Prior to reconstruction (which occurred prior to the 2018/2019 rainy season, in August 2018), CM-1 was estimated to have approximately 400 kg of cumulative TSS loading (which represents approximately 136% of the estimated sediment load until maintenance is needed). CM-1 had been in operation nine rainy seasons before reconstruction occurred.

[2] The drainage layers and filtration media of the BMP were rebuilt in Summer 2021. New, clean gravel was installed at the bottom of the tank, a layer of pea gravel was added above the larger gravel, and the existing media was placed back on top of the pea gravel. Following the reconstruction, the system was flushed with potable water to reduce sediment within the system. Although this maintenance was performed, the treatment media itself was not replaced. Therefore, for purposes of this analysis, cumulative TSS loading to the media was estimated since installation of the treatment BMP.

7.2 Cumulative EBVs Treated

As another tool to aid in determining when passive treatment BMP maintenance may be needed, the EBVs treated by each passive treatment BMP, since installation or reconstruction, were estimated. The runoff volumes treated by each treatment BMP in both an average rainfall year, and cumulative since the BMPs were built or reconstructed, were estimated using the SWMM models for each treatment BMP assessed, as described in Section 7.1. For determination of the runoff volumes treated in an average rainfall year, historical rainfall data were used to model the 2009/10 through 2022/23 rainy seasons. The volume of treatment media was also estimated for each passive treatment BMP, and the EBVs (defined as the volume of treatment media, not accounting for porosity) treated in both an average rainfall year and cumulative since BMP installation or reconstruction was then estimated. Table 23 shows the results of this analysis.

Table 23. EBVs Treated in an Average Rainfall Year and Since Treatment BMP Installation or Reconstruction

Treatment BMP	Drainage Area (acres)	First Rainy Season in Operation	Approx. Runoff Volumes Treated (ac-ft) (from SWMM modeling)		Filter Media			EBVs Treated per Average Rainfall Year	Total EBVs Treated Since Installation or Reconstruction
			Average Rainfall Year	Since Constructed or Reconstructed	Surface Area (sq ft)	Depth (ft)	Volume (cu ft)		
Upper lot media filter	5.1	2016/17	2.3	20	280	1.7	460	220	1,900
B-1 Media Filter	8.6	2011/12	1.7	19	200	1.5	310	240	2,800
CM-1[1]	44	2018/19	0.98	6.5	64	2	130	330	2,200
CM-9	10	2009/10	0.65	8.9	64	2	130	220	3,000
CM-3[2]	17	2019/20	0.25	1.3	64	2	130	80	430
CM-8	2.6	2009/10	0.013	0.19	64	2	130	5	63
CM-11	5.7	2009/10	0.15	2.1	68	2	140	48	660
Lower lot biofilter	30	2013/14	8.7	89	3,200	1.5	4,800	110	1,100
ELV Treatment BMP	6.6	2013/14	2.5	25	185	1.5	280	330	3,400

[1] CM-1 was reconstructed and outfitted with new treatment media in August 2018. Prior to this reconstruction, CM-1 had treated approximately 2,500 EBVs since it was installed.

[2] CM-3 was rebuilt with a modified configuration in 2019/20. Prior to this reconfiguration, CM-3 had treated approximately 770 EBVs since it was installed.

7.3 Treatment BMP Observations During and After Storm Events

Additional analyses of treatment BMP performance observations are continually conducted, considering ponding and whether bypass flows occur to help characterize potential BMP clogging and associated maintenance needs. Approximately ten post- and during-storm inspections were completed during the 2022/23 reporting year, and a summary of relevant observations at the treatment BMPs is included in Table 24.

Table 24. Summary of Treatment BMP Observations in 2022/23

Treatment BMP	Number of Rain Events (out of 10 rain events with observations) with the Following Observations:			
	Ponding (from 72-hour post-storm observations)	Overflow	Sediment Accumulation	Filter Fabric/Weir Board Damage[1]
ELV Treatment BMP	0	0	1	3
Lower Lot Biofilter	1	0	0	0
B-1 Media Filter	0	0	0	0
CM-1	0	1	3	8
CM-2	2	0	2	0
CM-3	0	3	5	0
CM-4	0	0	4	0
CM-5	0	0	5	0
CM-6	1	0	0	0
CM-7	0	0	0	0
CM-8	0	0	1	0
CM-9	1	1	1	0
CM-10	2	0	4	0
CM-11	3	0	0	0
CM-12	0	0	1	0
Sediment Basin	2	0	0	0
Upper Lot Media Filter	0	0	0	0
Northern Detention Bioswale	0	0	2	0
Southern Detention Bioswale	0	0	2	0

[1] For the ELV Treatment BMP, represents where the filter was not properly in place.

An example of sediment accumulation (at CM-4) is shown in Figure 6.

Figure 6. CM-4 on 11/08/2022

7.4 Treatment BMP Maintenance Conclusions

Recommendations resulting from this assessment could typically include either filter media replacement or reconstruction of treatment measures to facilitate continued effective capture and treatment of design runoff volumes. Recommendations for filter media replacement or reconstruction have been implemented at CM-1, CM-3, and the ELV treatment BMP to date. However, as previously described, the treatment media itself was not replaced at the ELV treatment BMP.

The study by Pitt et al. (2022) concluded that there were no significant performance or effluent concentration differences at the treatment BMPs over time, and therefore it is not likely that chemical breakthrough has occurred at the media-based treatment BMPs. However, this analysis has not been updated to incorporate sampling data from 2022 or 2023.

No media replacement recommended at this time. However, it is recommended to remove sediment accumulated in the ponding area of the CMs. Additionally, it is recommended to rebuild the impermeable fabric wrapping on CM weir boards (such as CM-4 and CM-10).

8. Results: Paired Line Plots

The log-scale paired line plots presented below illustrate changes in measured concentrations between influent and effluent sample pairs at stormwater treatment BMPs. Paired data were obtained from CMs and other media filters, the ELV treatment BMP, lower lot biofilter, the detention bioswales, and the SWTSs. TSS, total lead, total copper[9], and dioxins data are presented by treatment BMP in Figure 7 through Figure 64, where individual paired samples are represented by an influent and an effluent point connected by a single line, and an individual result without a corresponding influent or effluent result is shown as a single point unconnected to a 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 most recent 2022/23 reporting year and data from all previous reporting years are shown in gray. Distinct influent and effluent sample locations are represented by various symbols, as presented in the legends. Samples that have been collected at the treatment BMPs during bypass or overflow conditions are denoted by red markers. Typical detection limits[10] are represented by the black dotted lines, while non-detect (ND) results are plotted at the given detection limit.

In addition to evaluating treatment 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 historical results, and upgradient improvements were added in 2013. Other examples of improvements include asphalt removal in the upper drainage area and filter fabric installation over the weir boards. For sites that were subject to such improvements impacting the quantity or quality of contributing runoff, separate graphs are shown for sample results that occurred before and after the improvements were made.

Paired line plots should serve primarily as visual aids for understanding recent and past treatment BMP performance; results of statistical tests presented in Section 4 were utilized as the basis for quantitative BMP performance evaluations. Though not applicable to effluent discharges from the passive treatment BMPs within the Outfall 009 watershed, Outfall 009 Permit Limits are plotted in dioxins, lead, and copper plots[11] as references for evaluating BMP effectiveness. The Outfall 011 and 018 Permit Limits are plotted for comparison with performance data from the Outfall 011 and 018 SWTSs, respectively.

Treatment BMP effectiveness during events having influent concentrations above the outfall Permit Limit is used as the performance criterion since any 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. The most substantial influent-to-effluent percentage reductions of COCs in stormwater have been observed when influent concentrations to the treatment BMPs are elevated above a given outfall Permit Limit.

[9] Total copper data is included in the paired line plots, though it is not listed in the 2015 Work Plan as a pollutant of concern for the Outfall 009 Watershed.
[10] Laboratory detection limits of COCs may vary slightly from year to year.
[11] A reference line is not included in TSS plots, as a Permit Limit for TSS does not exist at Outfall 009. Copper plots are included although copper is not listed as a pollutant of concern in the 2015 Work Plan.

Stormwater quality can fluctuate greatly during storms and grab sample results represent concentrations at a single point in time during the rain event. Therefore, relatively large numbers of samples collected over many storm events are expected to best represent varying conditions with reasonable statistical confidence and power. Both paired line plots and probability plots illustrate variability of influent and effluent COC concentrations observed at treatment BMPs.

8.1 TSS Paired Line Plots

Figure 7 through Figure 22 present paired line plots of TSS results at treatment BMPs. There are no red lines plotted indicative of a Permit Limit for the passive treatment BMPs within the Outfall 009 watershed, as there is not a Permit Limit designated for TSS at Outfall 009. There are also no red lines plotted indicative of a Permit Limit for the Outfall 011 and 018 SWTSs. There is a permit limit for TSS for these outfalls; however, it is only applicable to dry weather samples. There is no TSS Permit Limit in wet weather.

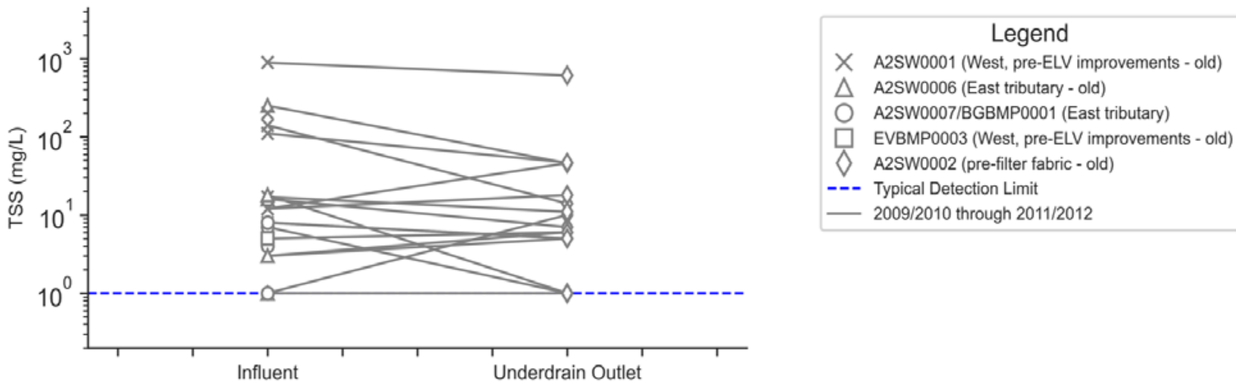


Figure 7. TSS at CM-1 Pre-Filter Fabric

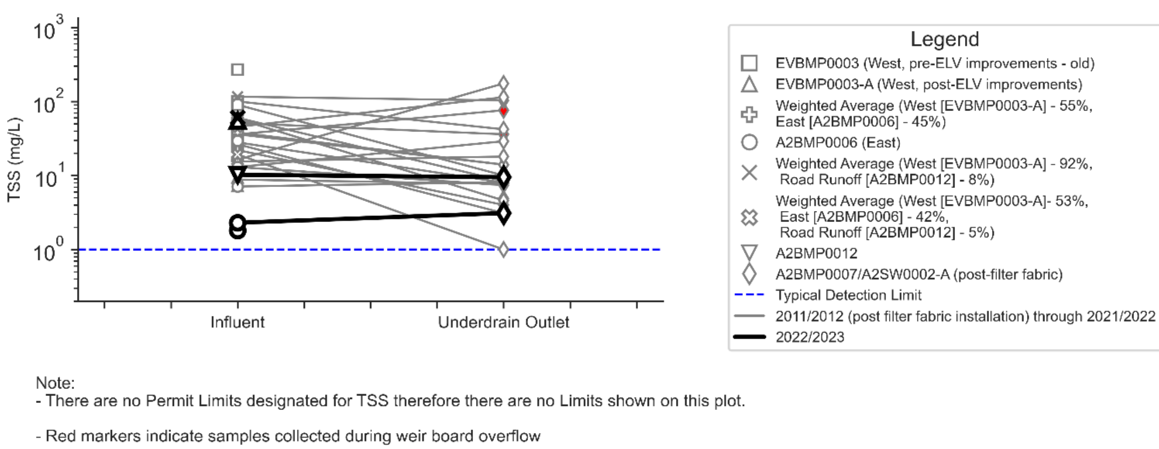
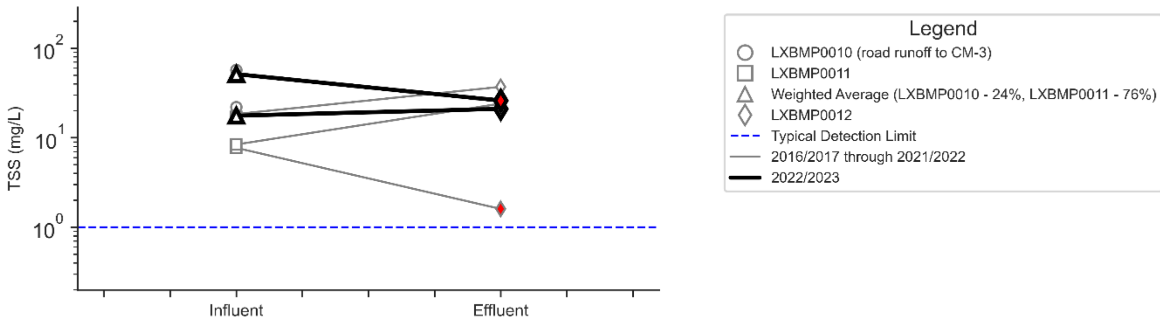


Figure 8. TSS at CM-1 Post-Filter Fabric



Note:
- There are no Permit Limits designated for TSS therefore there are no Limits shown on this plot.

- Red markers indicate samples collected during weir board overflow

Figure 9. TSS at CM-3

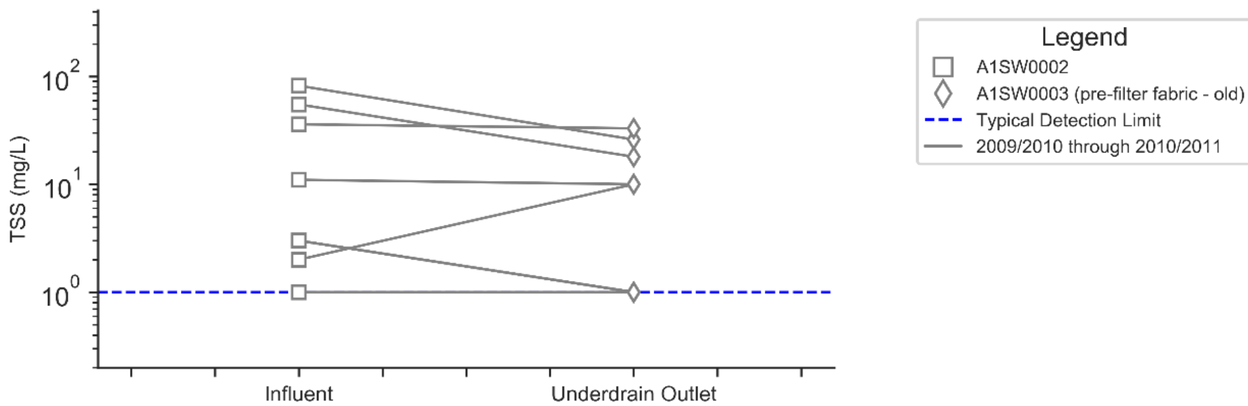


Figure 10. TSS at CM-8

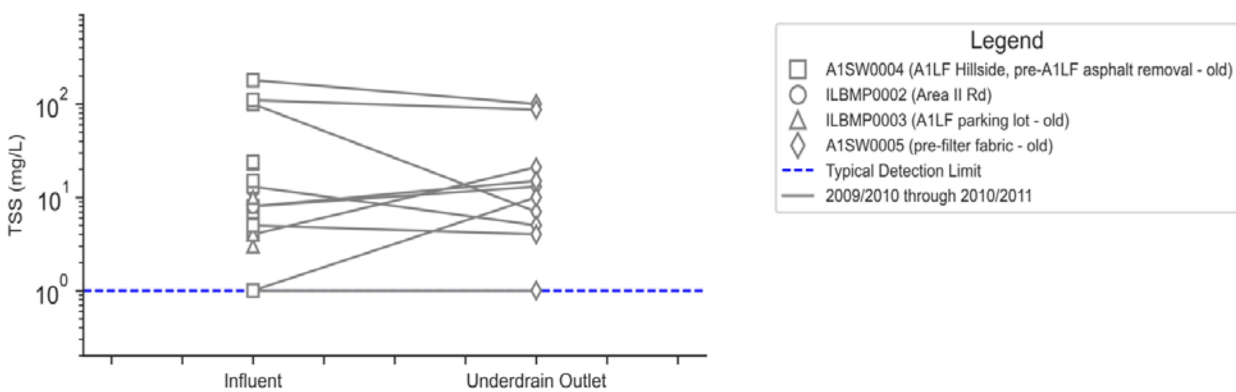
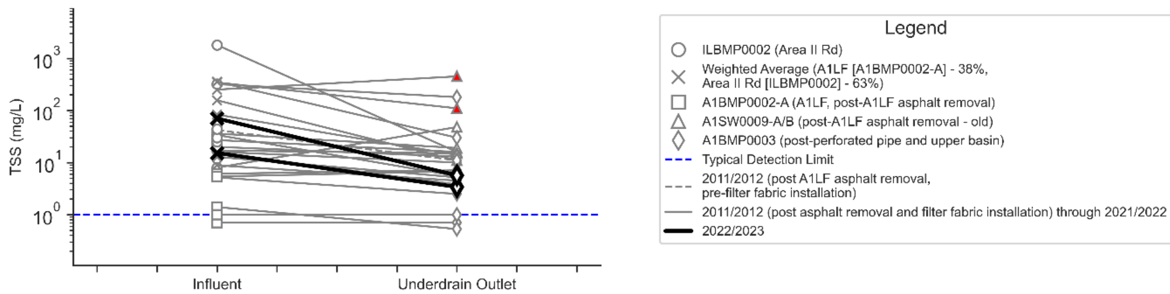


Figure 11. TSS at CM-9 Pre-Improvements



Note:
- There are no Permit Limits designated for TSS therefore there are no Limits shown on this plot.

- Red markers indicate samples collected during weir board overflow

Figure 12. TSS at CM-9 Post-Improvements

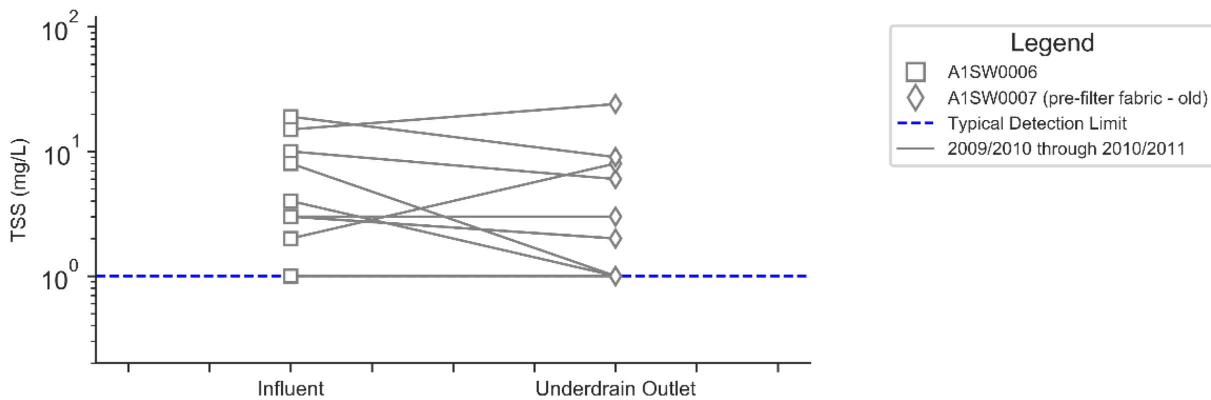


Figure 13. TSS at CM-11

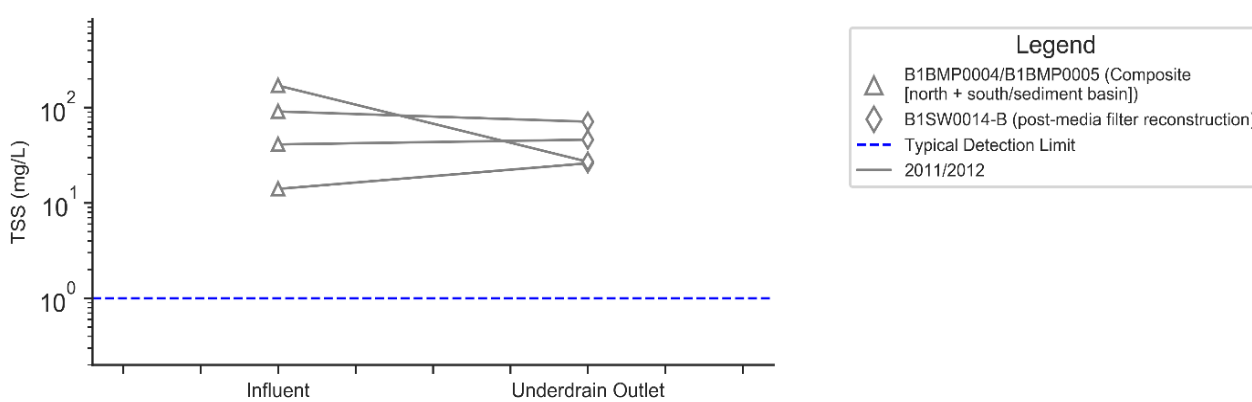


Figure 14. TSS at B-1 Media Filter Pre-Curb Cuts

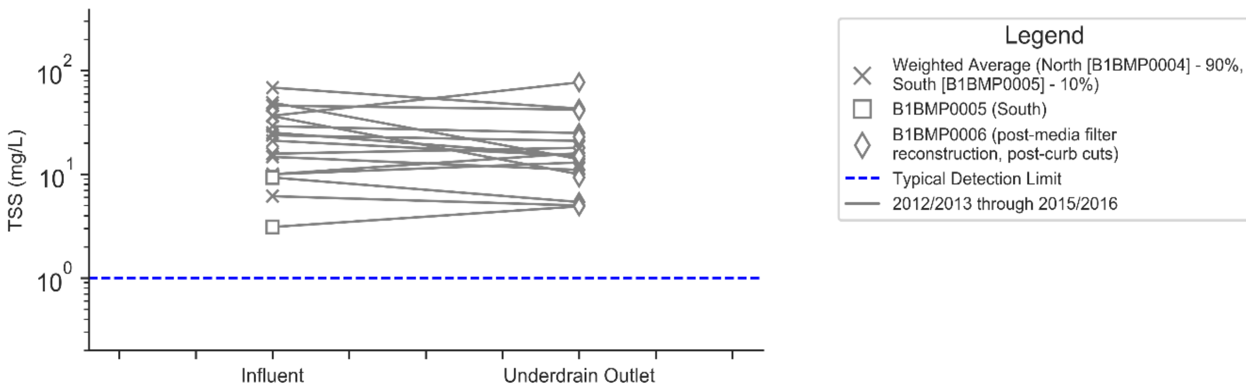
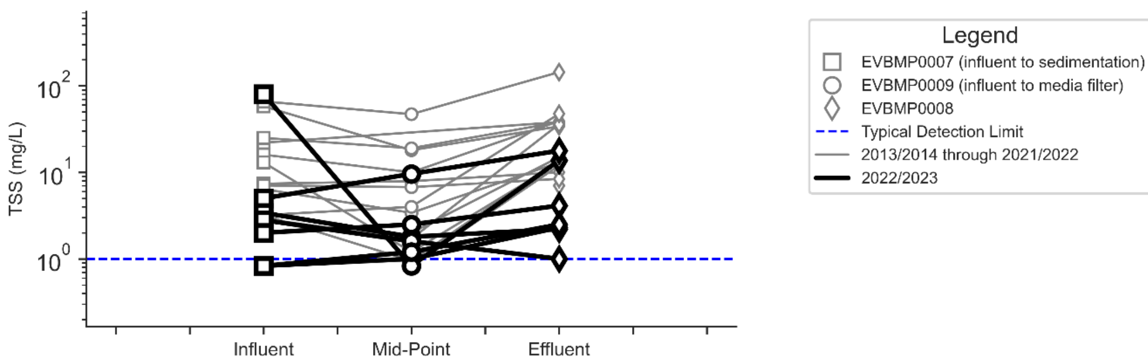
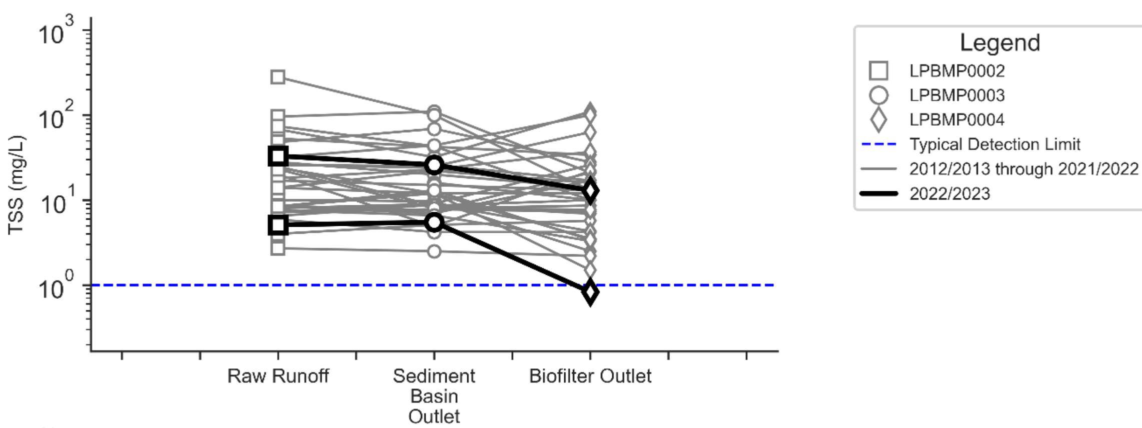


Figure 15. TSS at B-1 Media Filter Post-Curb Cuts



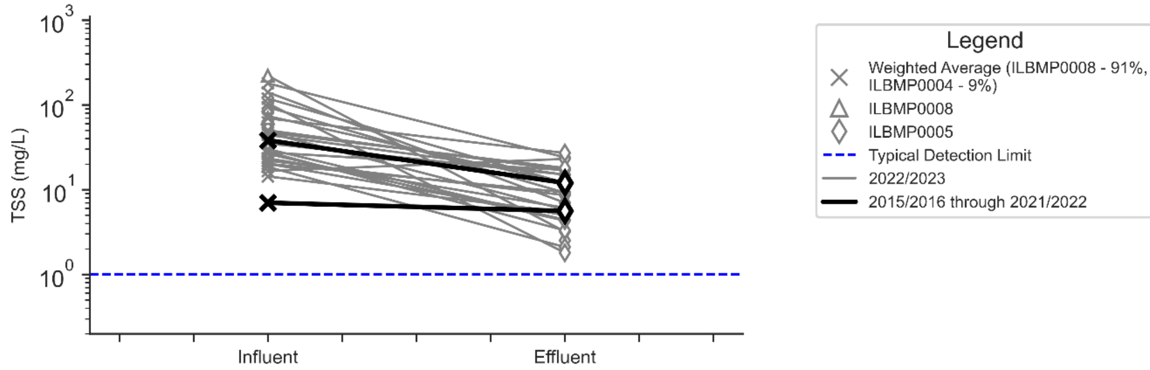
Note:
- There are no Permit Limits designated for TSS therefore there are no Limits shown on this plot.

Figure 16. TSS at ELV Treatment BMP



Note:
- There are no Permit Limits designated for TSS therefore there are no Limits shown on this plot.

Figure 17. TSS at Lower Lot Biofilter



Note:
- There are no Permit Limits designated for TSS therefore there are no Limits shown on this plot.

Figure 18. TSS at Southern Detention Bioswale

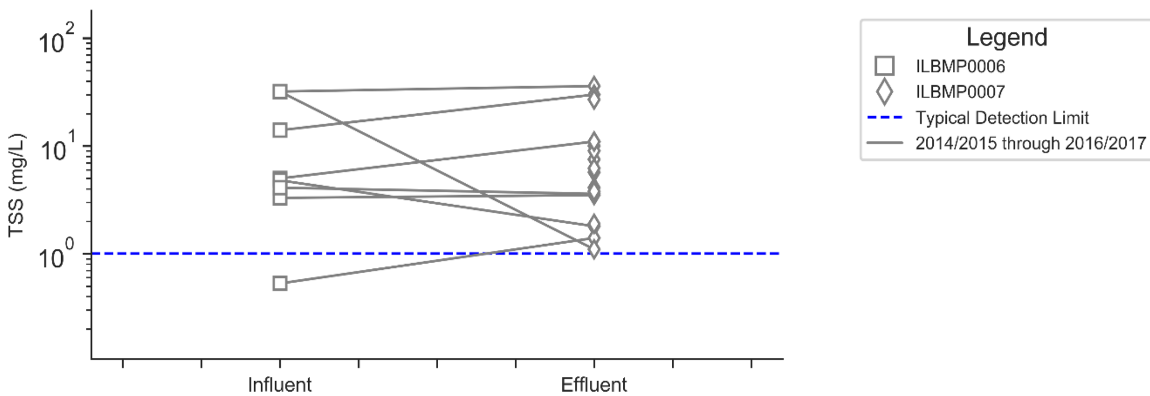
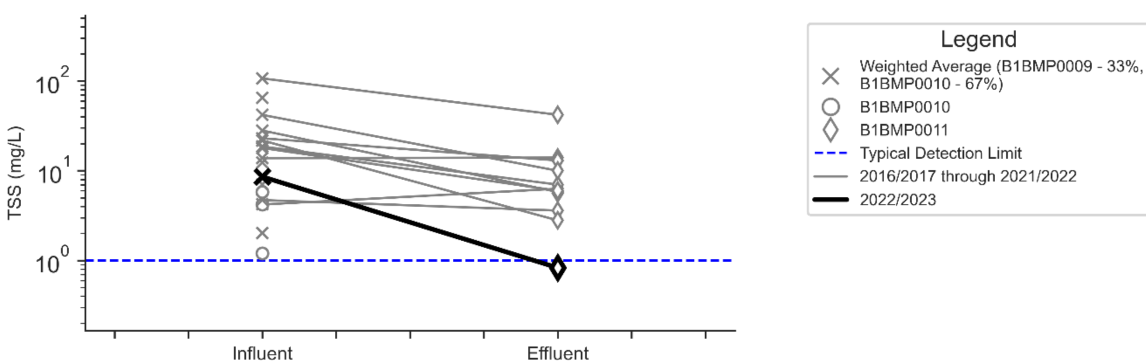
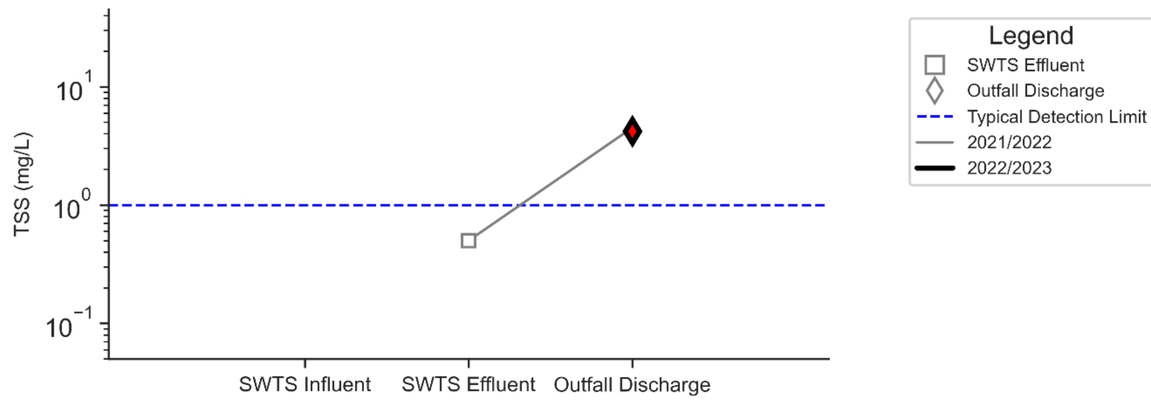


Figure 19. TSS at Northern Detention Bioswale



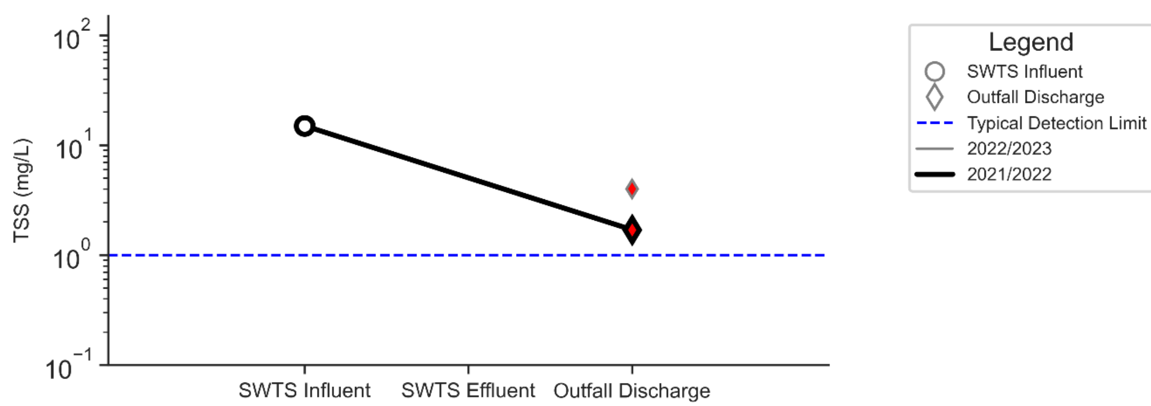
Note:
- There are no Permit Limits designated for TSS therefore there are no Limits shown on this plot.

Figure 20. TSS at Upper Lot Media Filter



Note:
- There are no Permit Limits designated for TSS therefore there are no Limits shown on this plot.
- Red markers indicate samples collected during pond overflow

Figure 21. TSS at Outfall 011 SWTS



Note:
- There are no Permit Limits designated for TSS therefore there are no Limits shown on this plot.
- Red markers indicate samples collected during pond overflow

Figure 22. TSS at Outfall 018 SWTS

8.2 Dioxins Paired Line Plots

Figure 23 through Figure 37 present paired line plots of dioxin concentrations at treatment BMPs. Undetected concentrations present in ND sample results are plotted at the detection limit of 1E-12 µg/l.

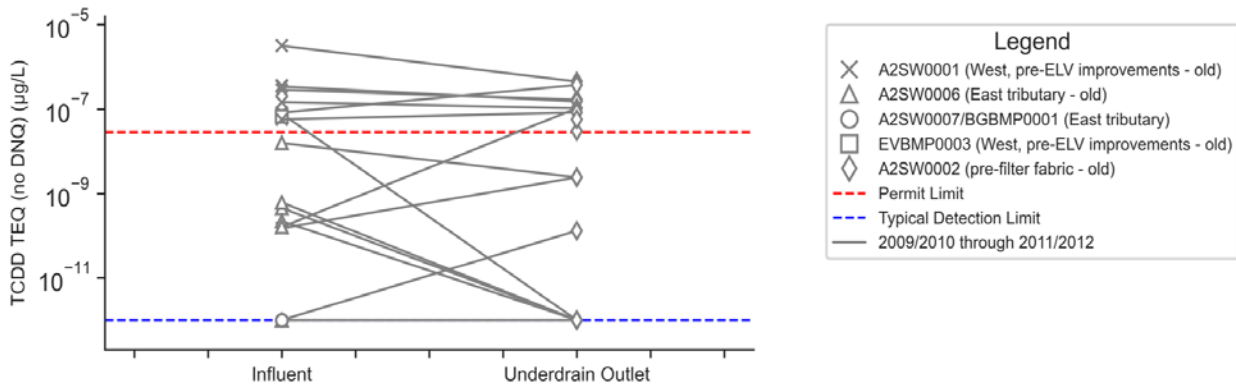
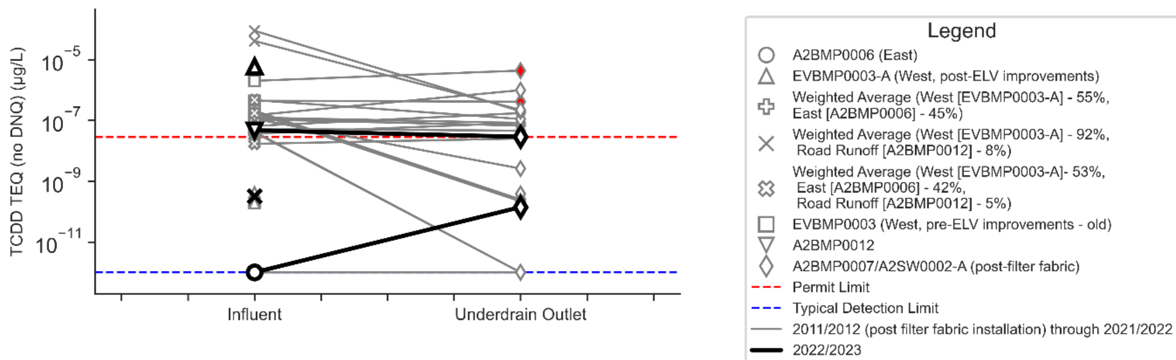


Figure 23. Dioxins at CM-1 Pre-Filter Fabric[12]



Note:
- 1E-12 ug/L is shown for ND TEQ results as this is in the range of the lowest reported TEQ results with DNQ excluded.

- Red markers indicate samples collected during weir board overflow

Figure 24. Dioxins at CM-1 Post-Filter Fabric

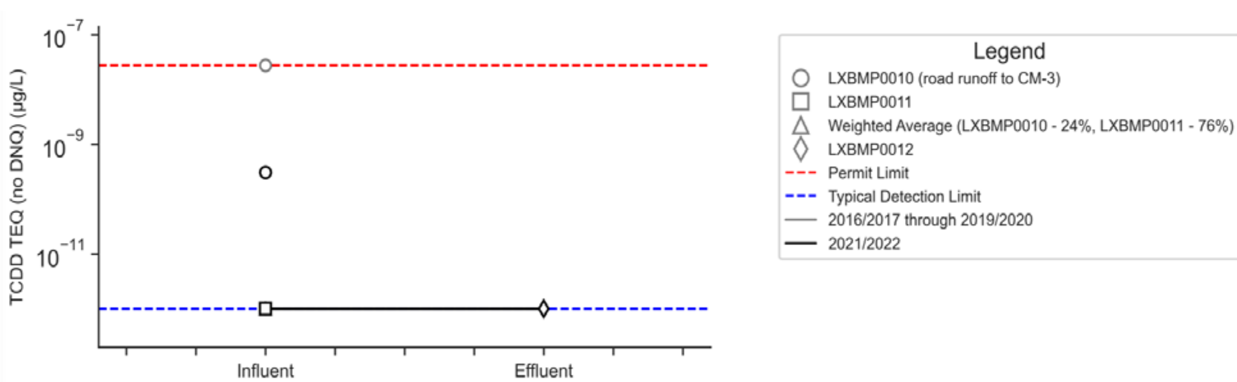


Figure 25. Dioxins at CM-3

[12] Elevated influent concentrations plotted in Figure 23 and Figure 24 may have resulted from runoff contributed by a roadway area including several treated wood utility poles.

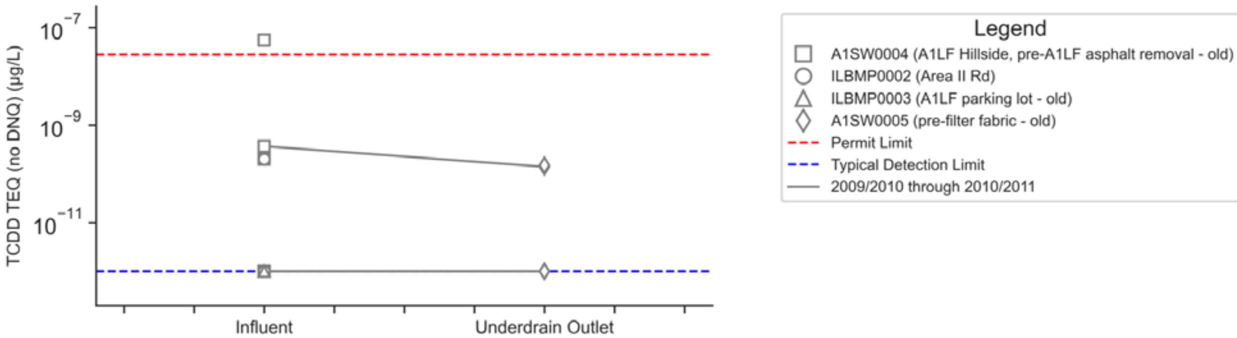
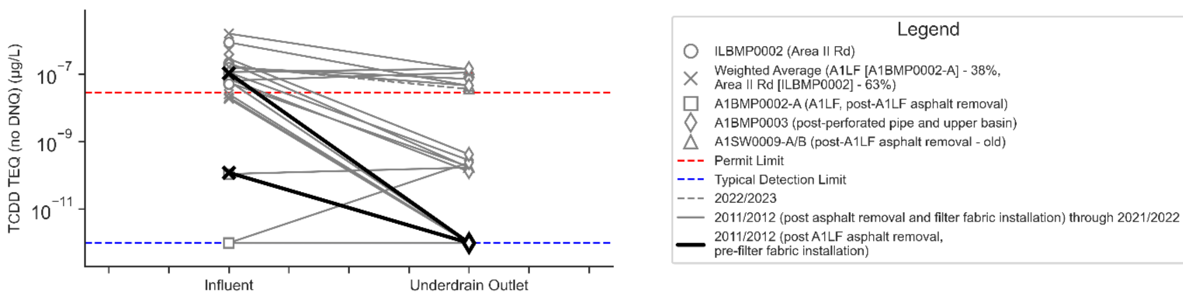


Figure 26. Dioxins at CM-9 Pre-Improvements



Note:
- 1E-12 ug/L is shown for ND TEQ results as this is in the range of the lowest reported TEQ results with DNQ excluded.

- Red markers indicate samples collected during weir board overflow

Figure 27. Dioxins at CM-9 Post-Improvements

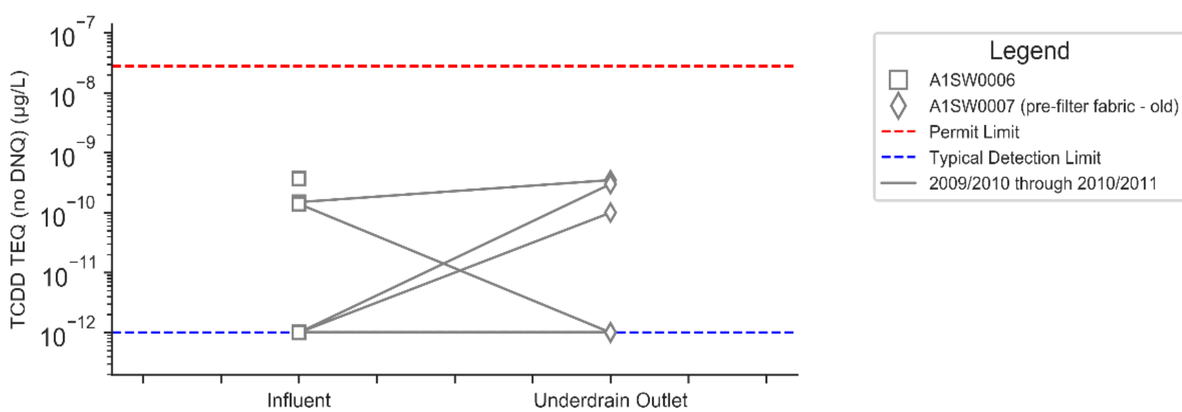


Figure 28. Dioxins at CM-11

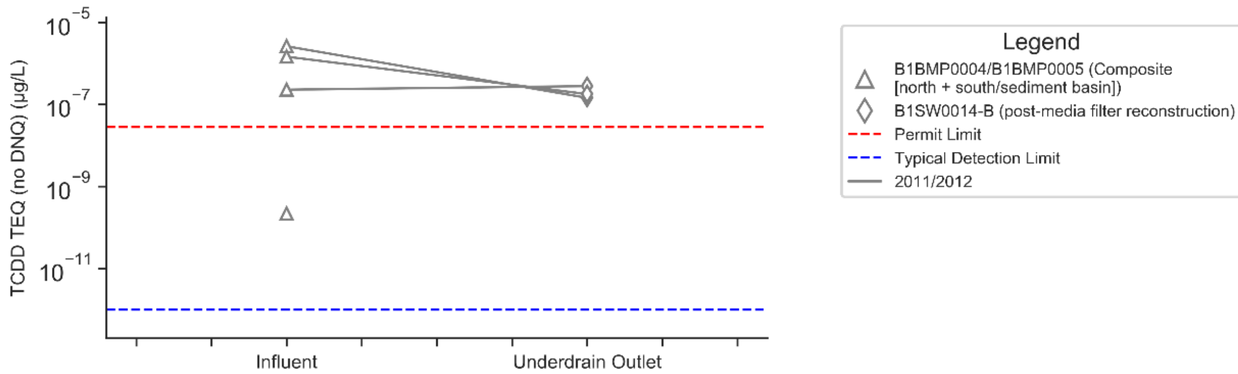


Figure 29. Dioxins at B-1 Media Filter Pre-Curb Cuts

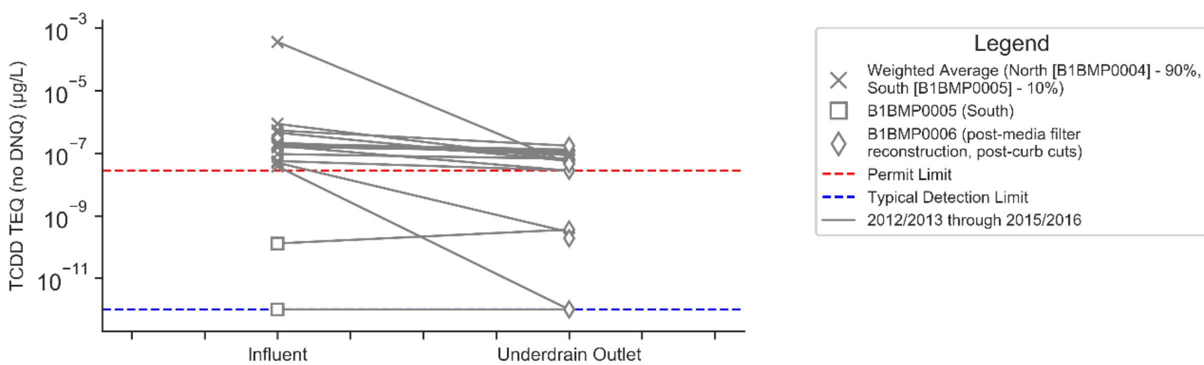


Figure 30. Dioxins at B-1 Media Filter Post-Curb Cuts

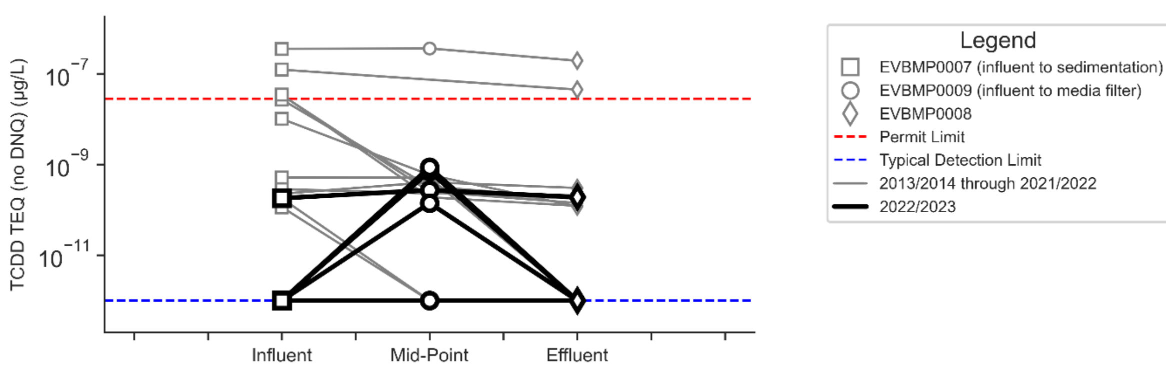
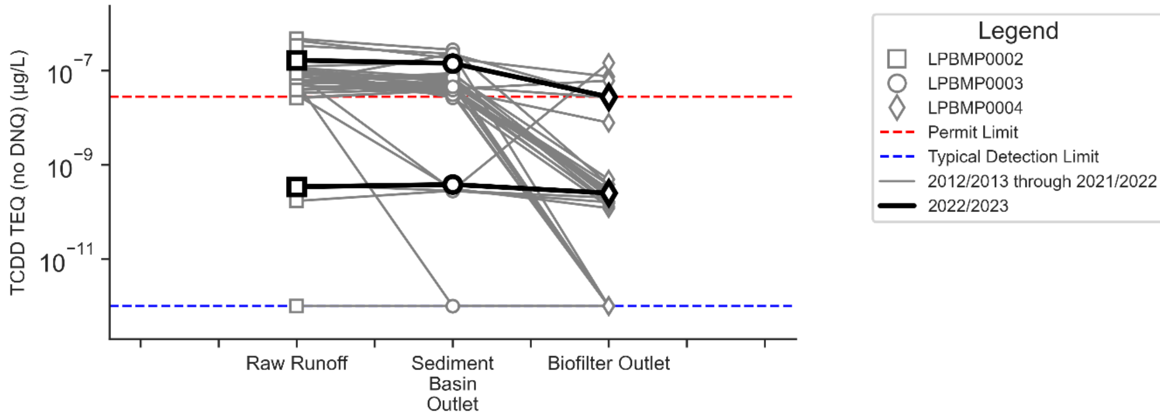
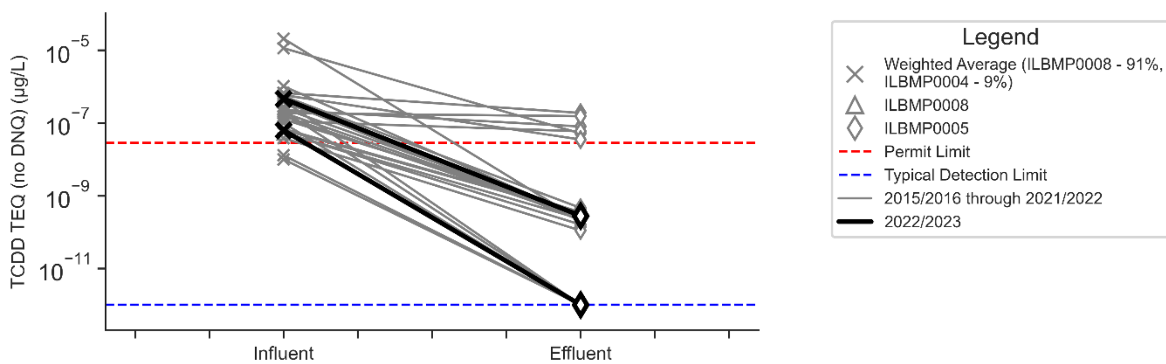


Figure 31. Dioxins at ELV Treatment BMP



Note:
- 1E-12 ug/L is shown for ND TEQ results as this is in the range of the lowest reported TEQ results with DNQ excluded.

Figure 32. Dioxins at Lower Lot Biofilter[13]



Note:
- 1E-12 ug/L is shown for ND TEQ results as this is in the range of the lowest reported TEQ results with DNQ excluded.

Figure 33. Dioxins at Southern Detention Bioswale

[13] Evaluation of the elevated effluent concentration observed in 2018/19 indicated inconsistency with typical treatment performance that has been observed at the lower lot biofilter before and after the isolated event.

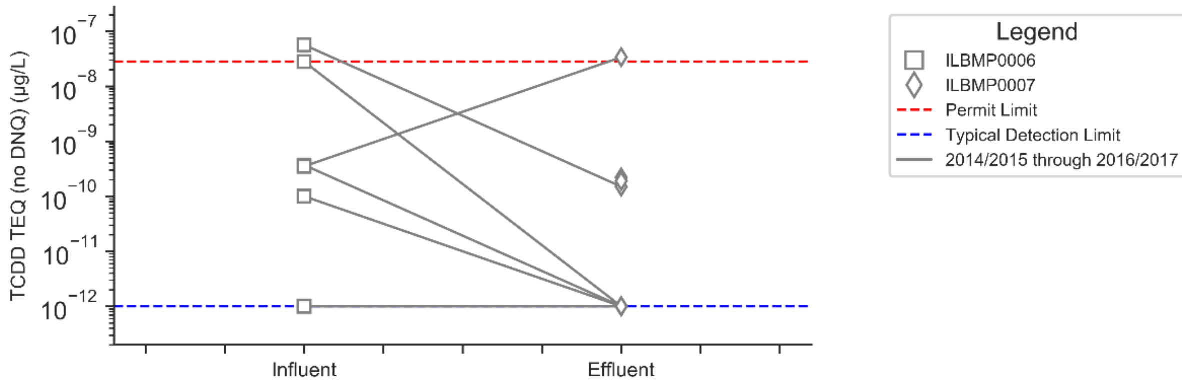
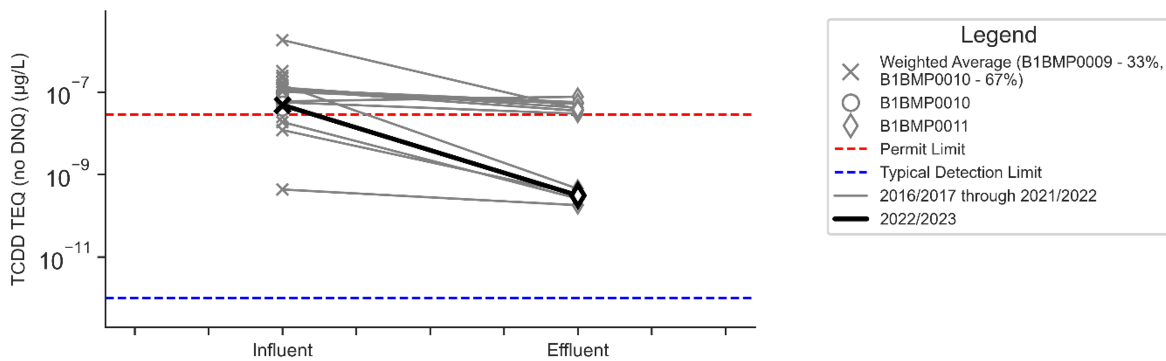
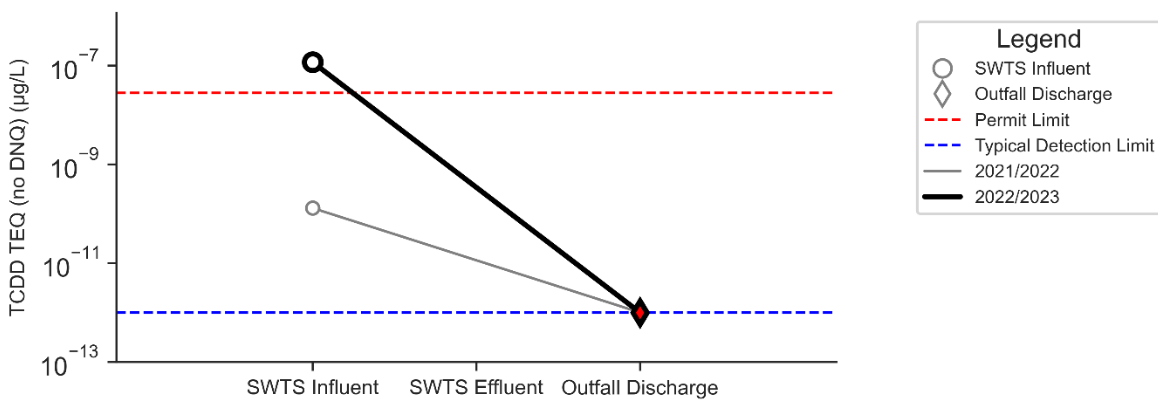


Figure 34. Dioxins at Northern Detention Bioswale



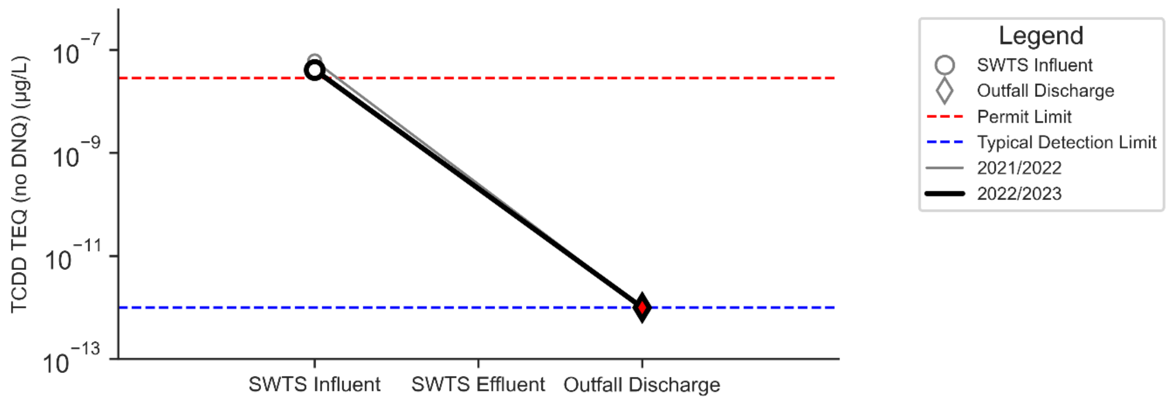
Note:
- 1E-12 ug/L is shown for ND TEQ results as this is in the range of the lowest reported TEQ results with DNQ excluded.

Figure 35. Dioxins at Upper Lot Media Filter



Note:
- 1E-12 ug/L is shown for ND TEQ results as this is in the range of the lowest reported TEQ results with DNQ excluded.
- Red markers indicate samples collected during pond overflow

Figure 36. Dioxins at Outfall 011 SWTS



Note:
- 1E-12 ug/L is shown for ND TEQ results as this is in the range of the lowest reported TEQ results with DNQ excluded.
- Red markers indicate samples collected during pond overflow

Figure 37. Dioxins at Outfall 018 SWTS

8.3 Lead Paired Line Plots

Figure 38 through Figure 52 present paired line plots of lead results at treatment BMPs.

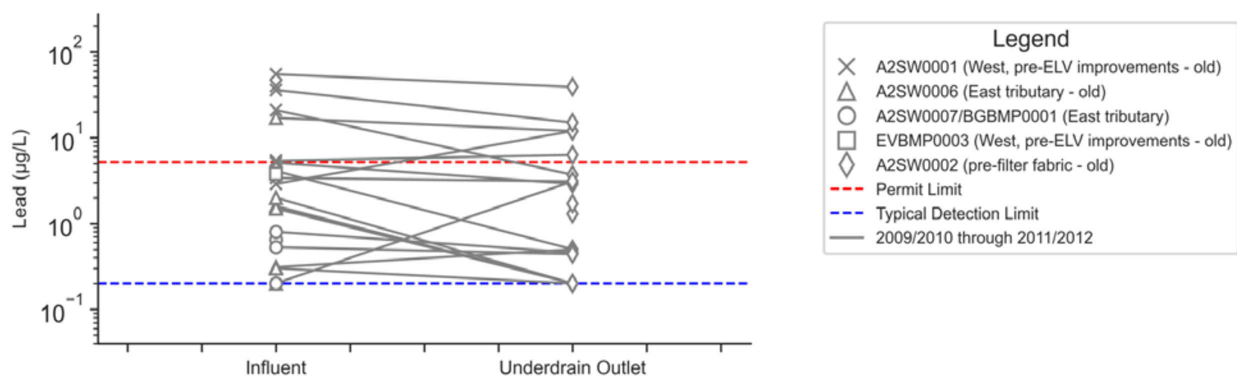
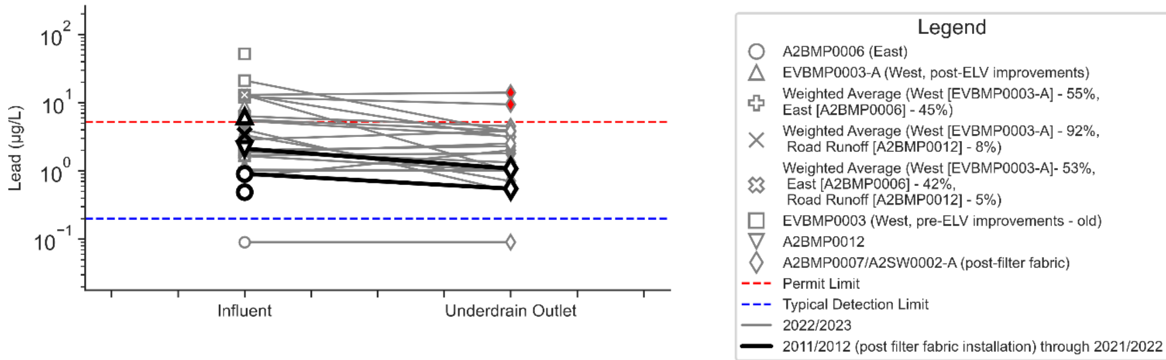
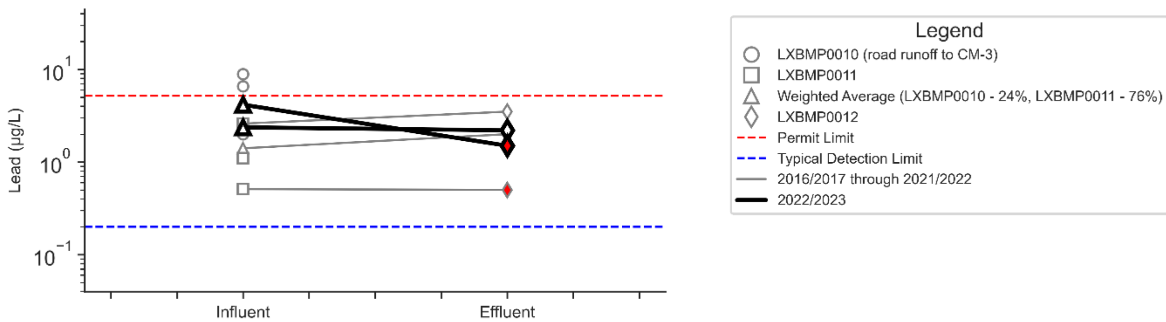


Figure 38. Lead at CM-1 Pre-Filter Fabric



Note:
- Red markers indicate samples collected during weir board overflow

Figure 39. Lead at CM-1 Post-Filter Fabric



Note:
- Red markers indicate samples collected during weir board overflow

Figure 40. Lead at CM-3

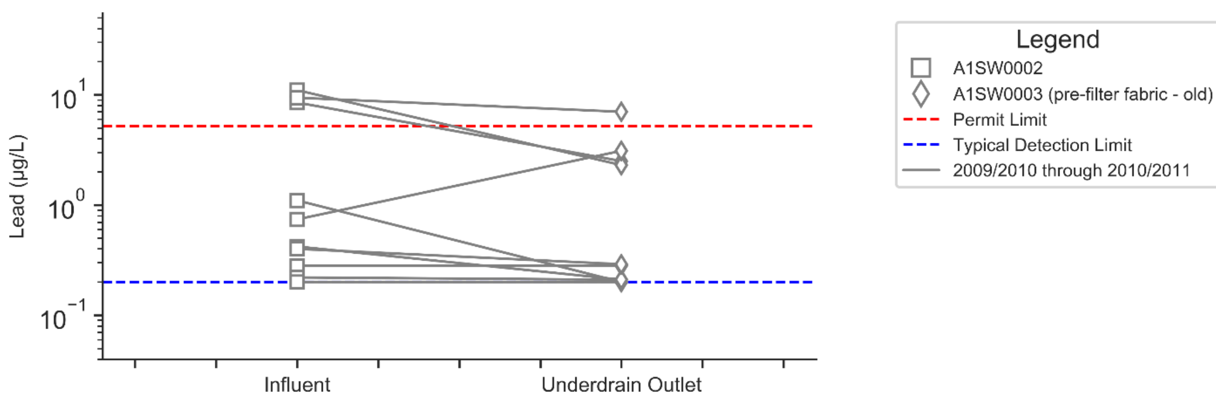


Figure 41. Lead at CM-8

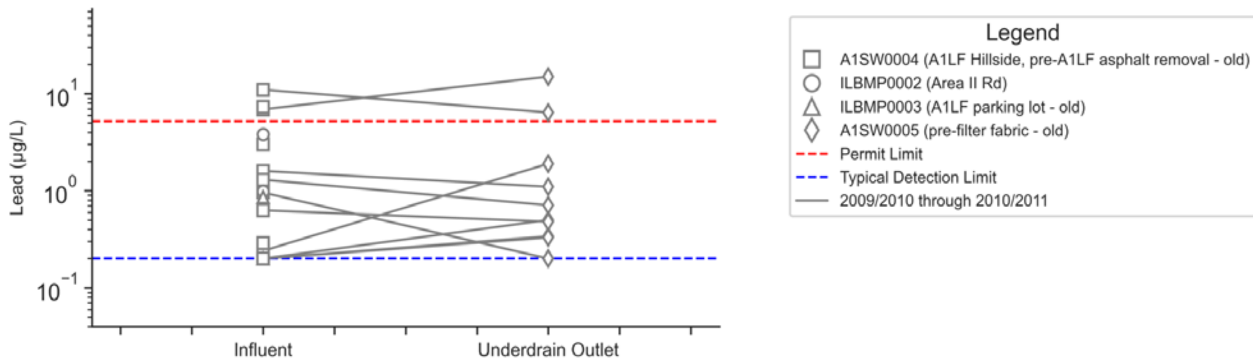
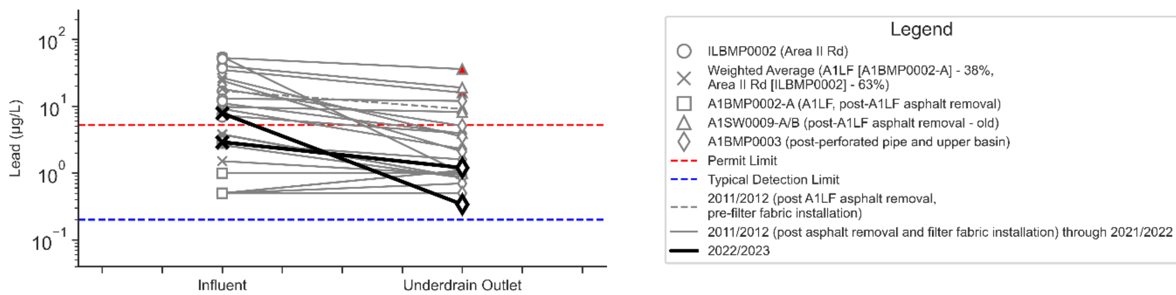


Figure 42. Lead at CM-9 Pre-Improvements



Note:
- Red markers indicate samples collected during weir board overflow

Figure 43. Lead at CM-9 Post-Improvements

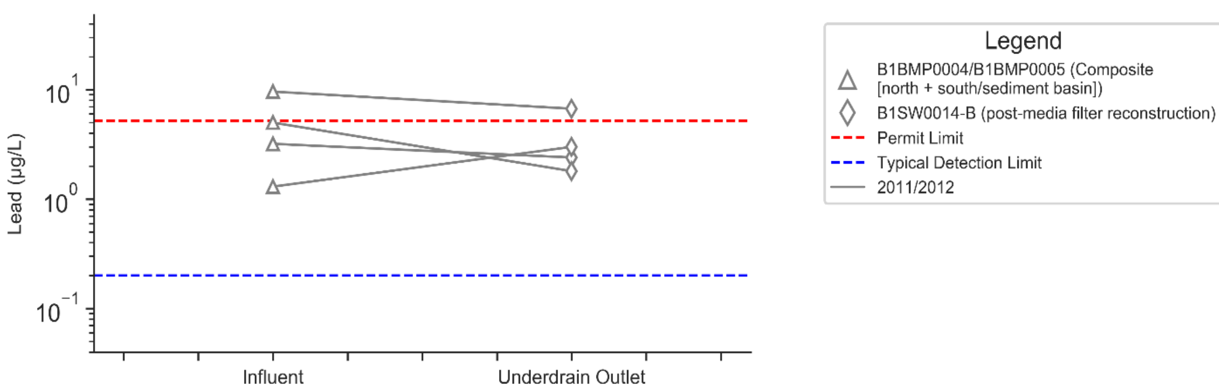


Figure 44. Lead at B-1 Media Filter Pre-Curb Cuts

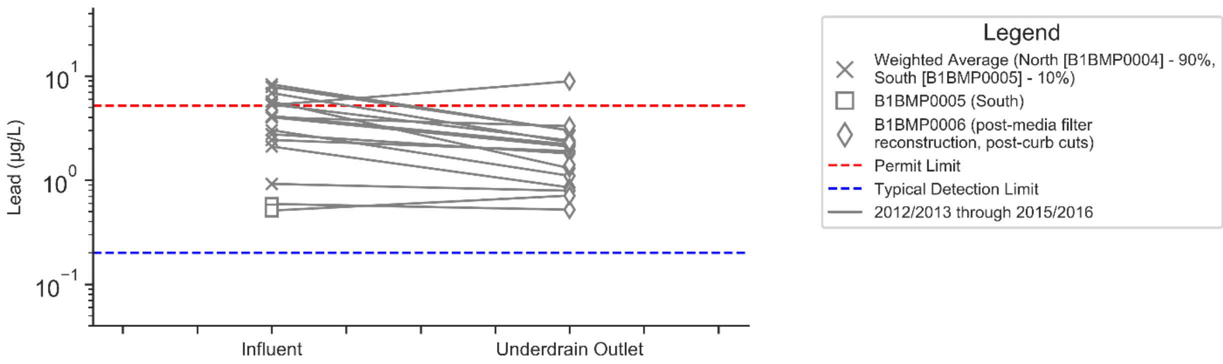


Figure 45. Lead at B-1 Media Filter Post-Curb Cuts

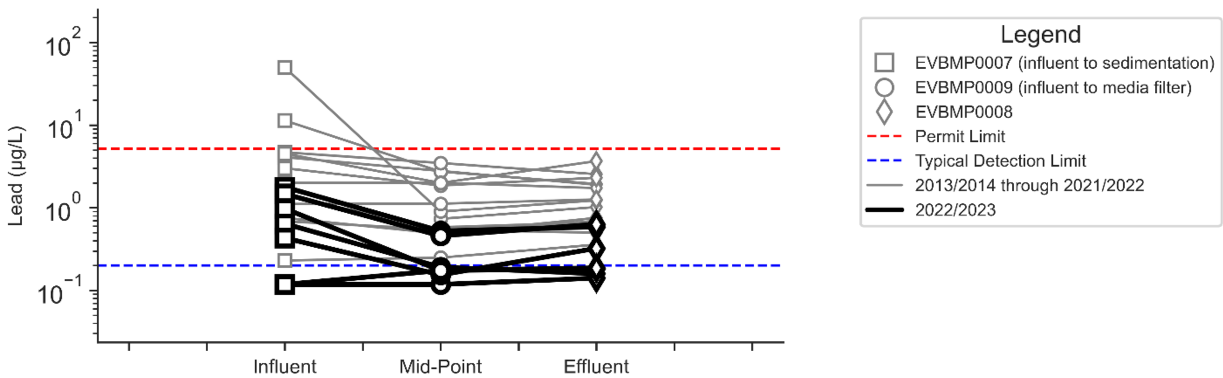


Figure 46. Lead at ELV Treatment BMP

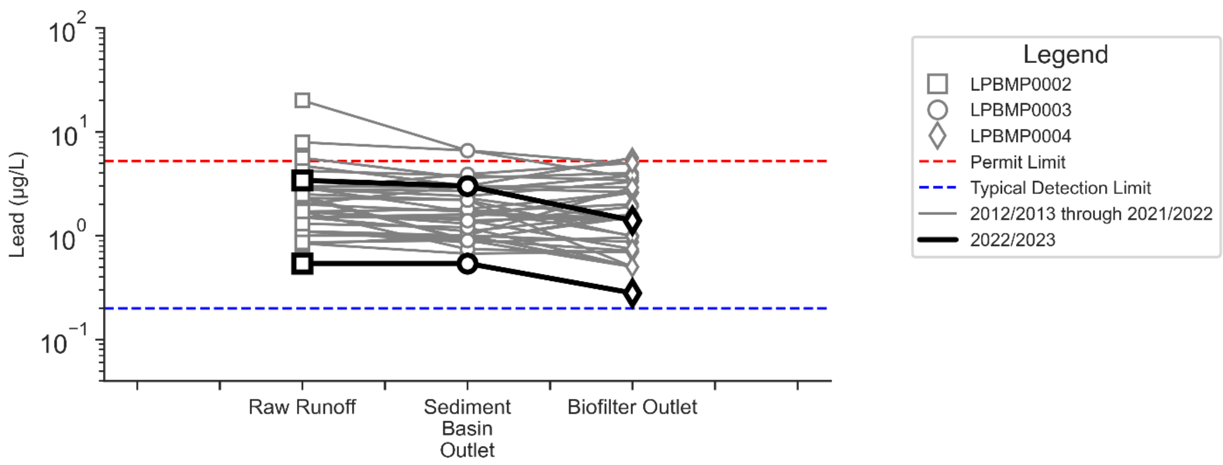


Figure 47. Lead at Lower Lot Biofilter

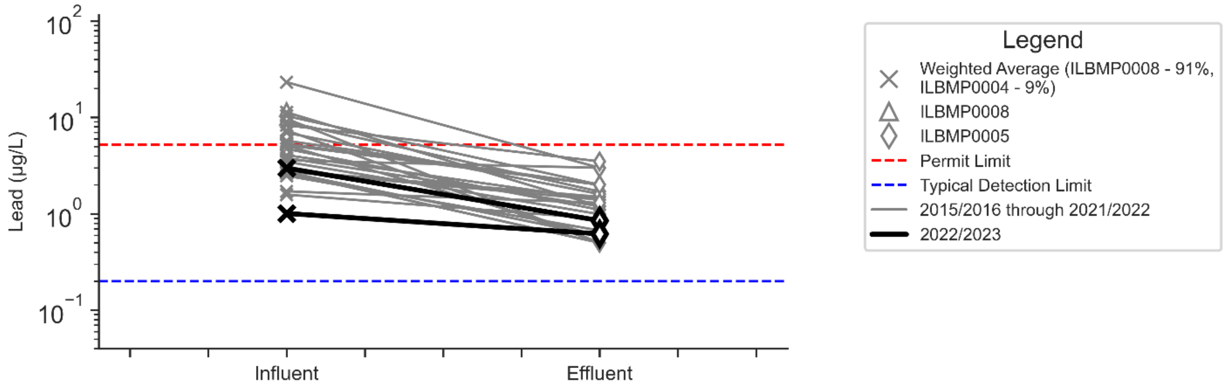


Figure 48. Lead at Southern Detention Bioswale

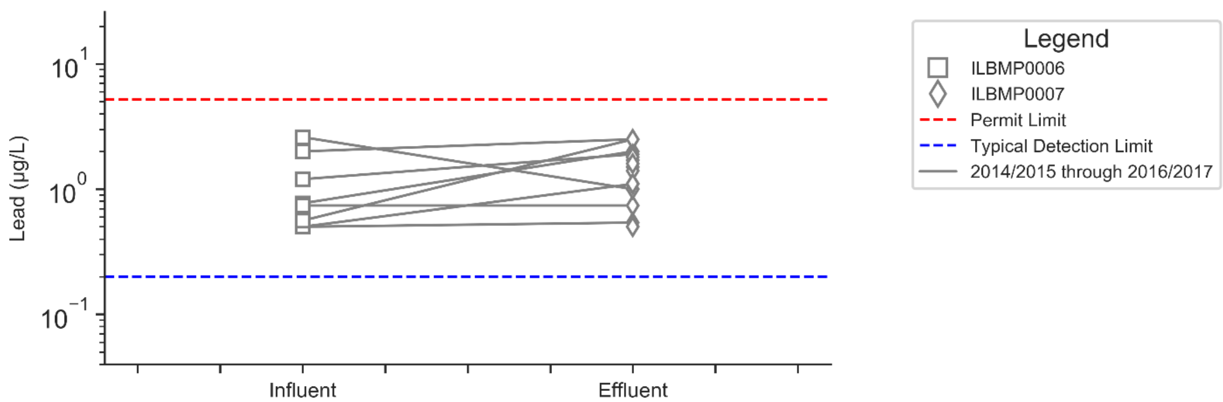


Figure 49. Lead at Northern Detention Bioswale

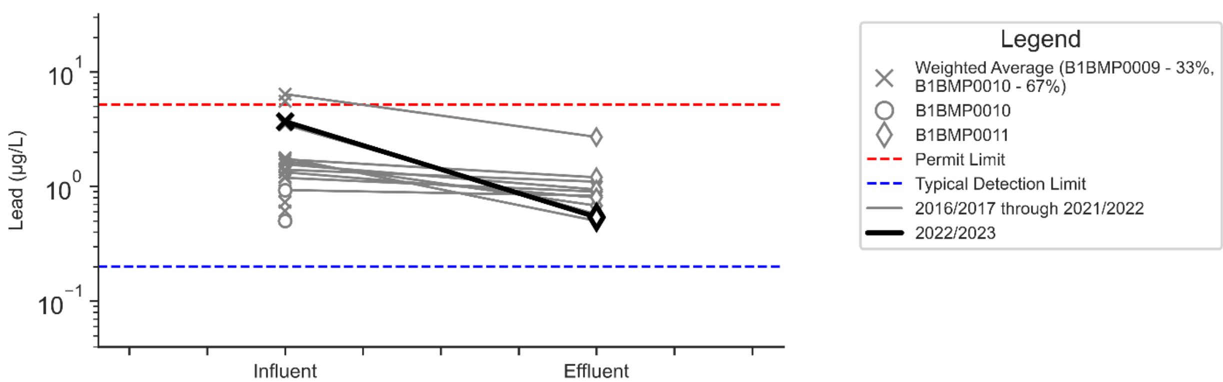


Figure 50. Lead at Upper Lot Media Filter

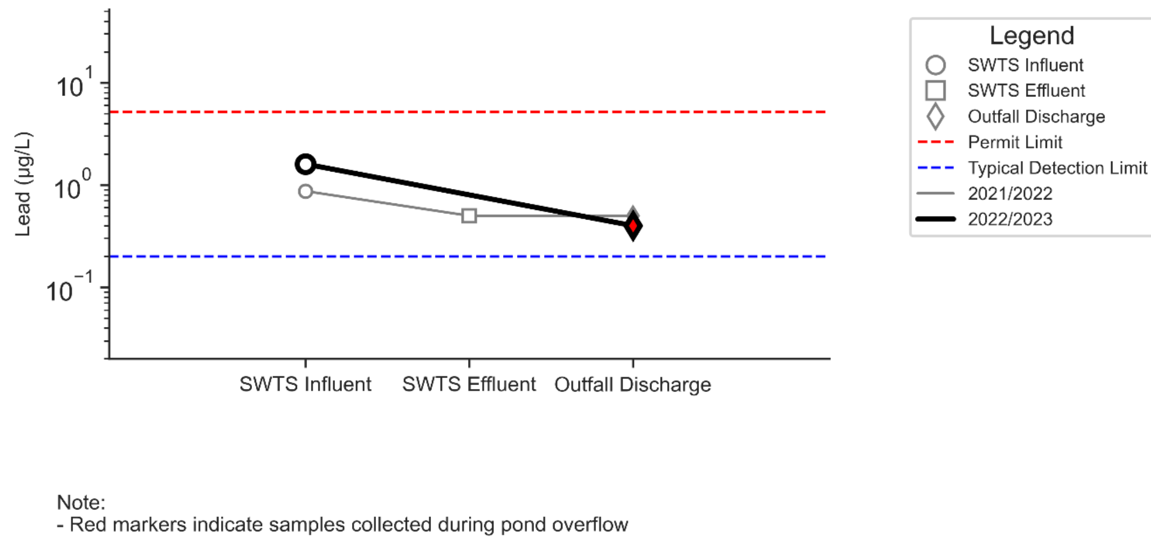


Figure 51. Lead at Outfall 011 SWTS

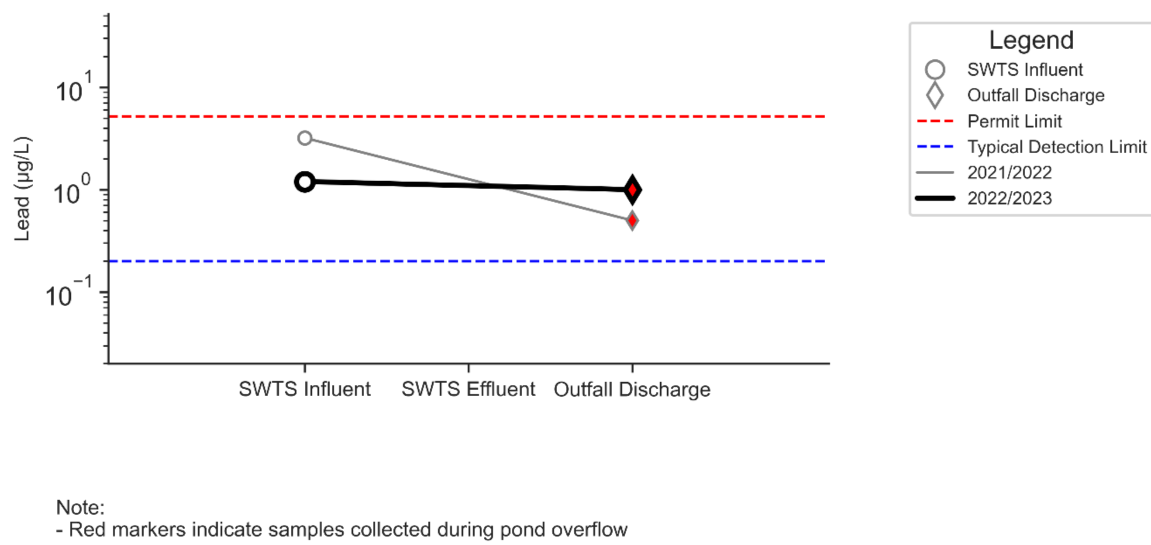


Figure 52. Lead at Outfall 018 SWTS

8.4 Copper Paired Line Plots

Figure 53 through Figure 65 present paired line plots of copper results at treatment BMPs.

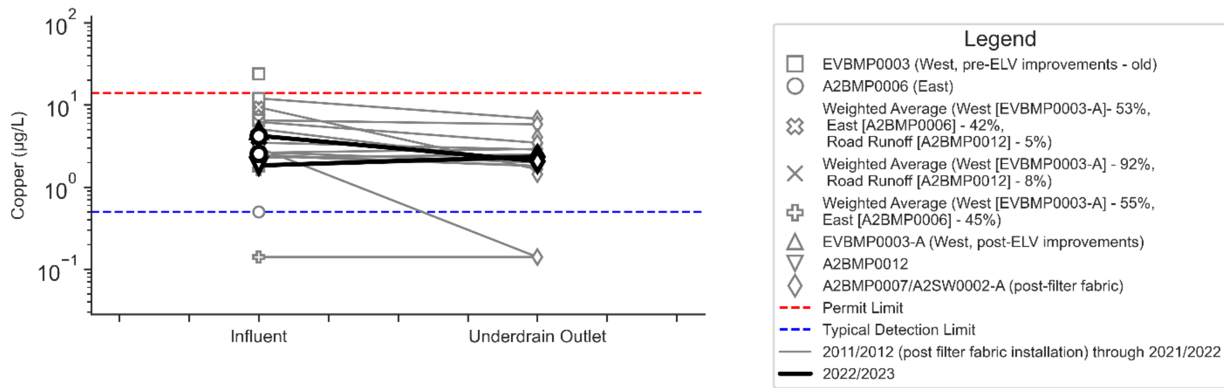


Figure 53. Copper at CM-1 Post-Filter Fabric

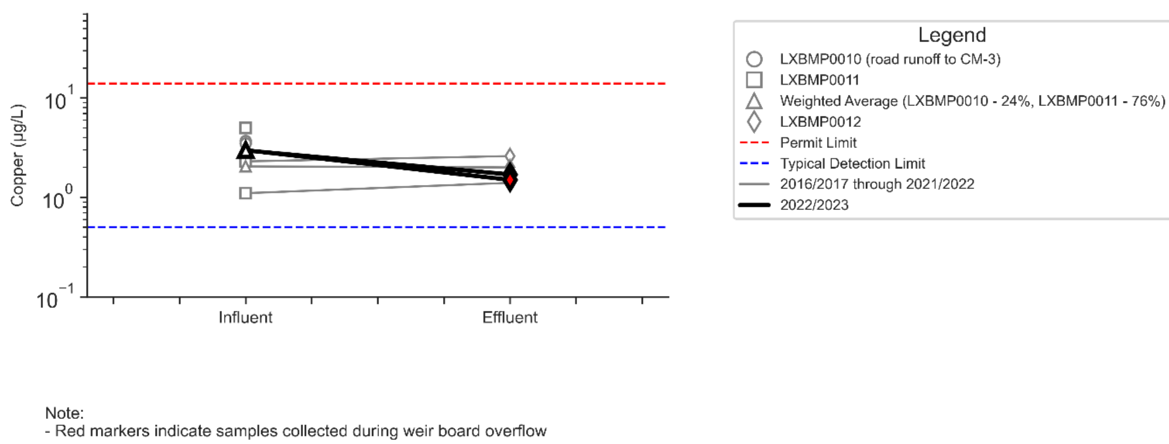


Figure 54. Copper at CM-3

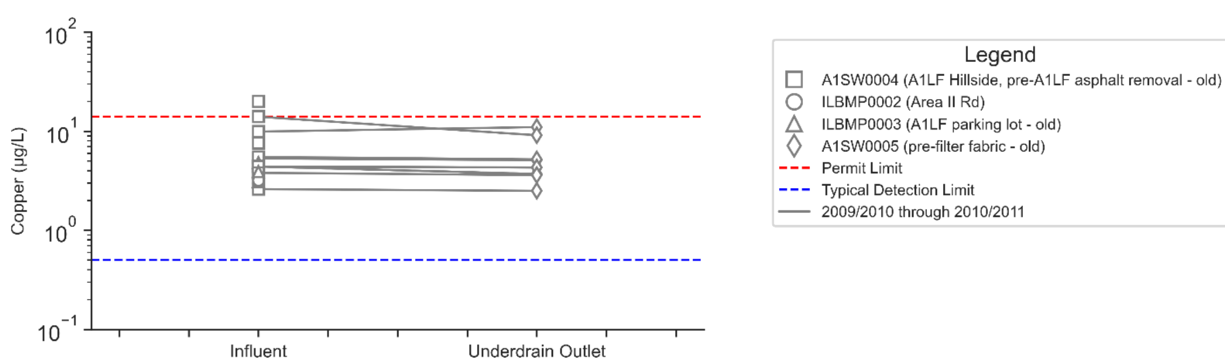


Figure 55. Copper at CM-9 Pre-Improvements

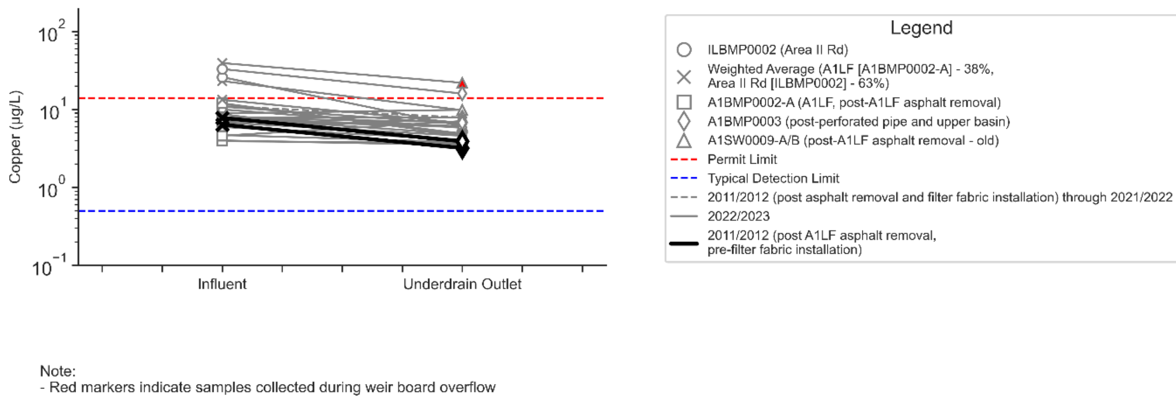


Figure 56. Copper at CM-9 Post-Improvements

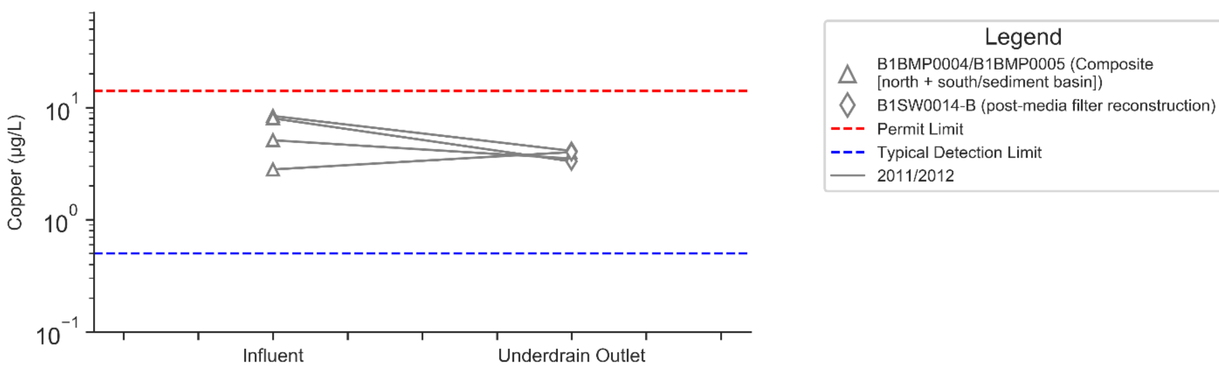


Figure 57. Copper at B-1 Media Filter Pre-Curb Cuts

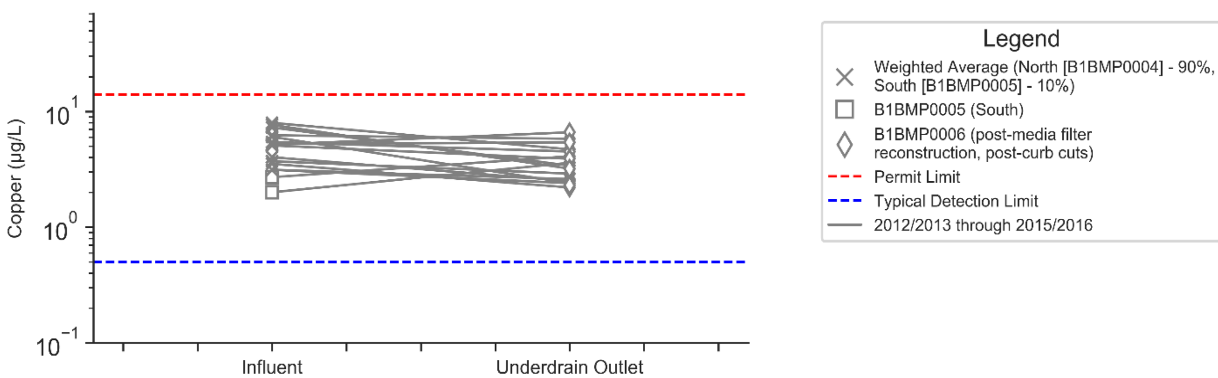


Figure 58. Copper at B-1 Media Filter Post-Curb Cuts

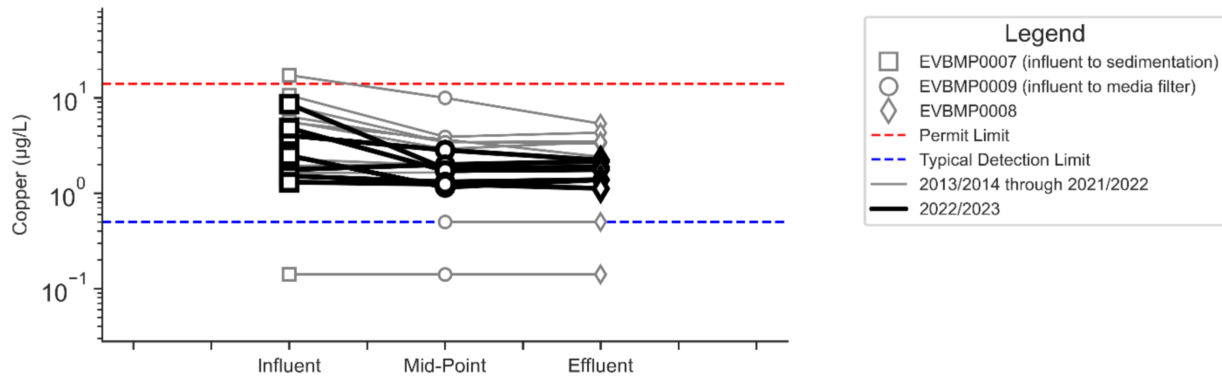


Figure 59. Copper at ELV Treatment BMP

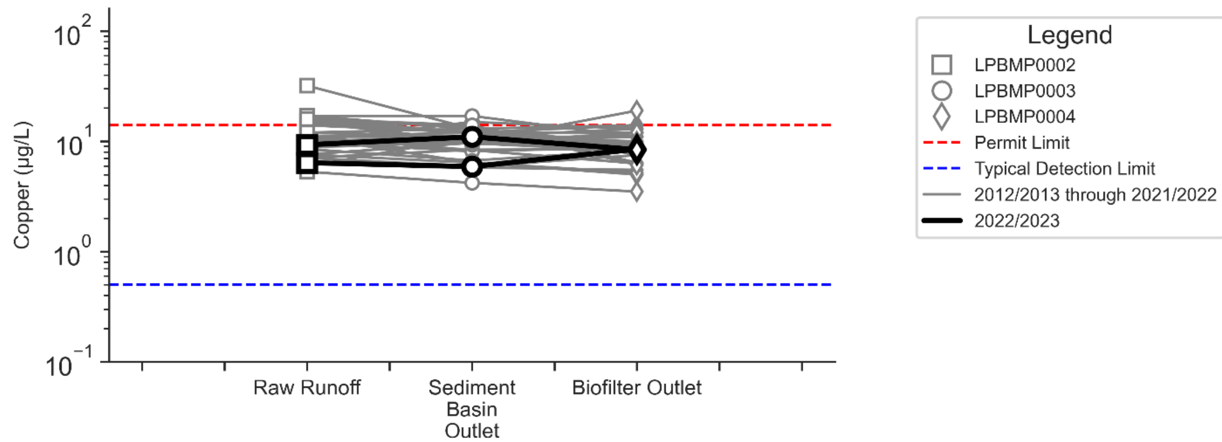


Figure 60. Copper at Lower Lot Biofilter

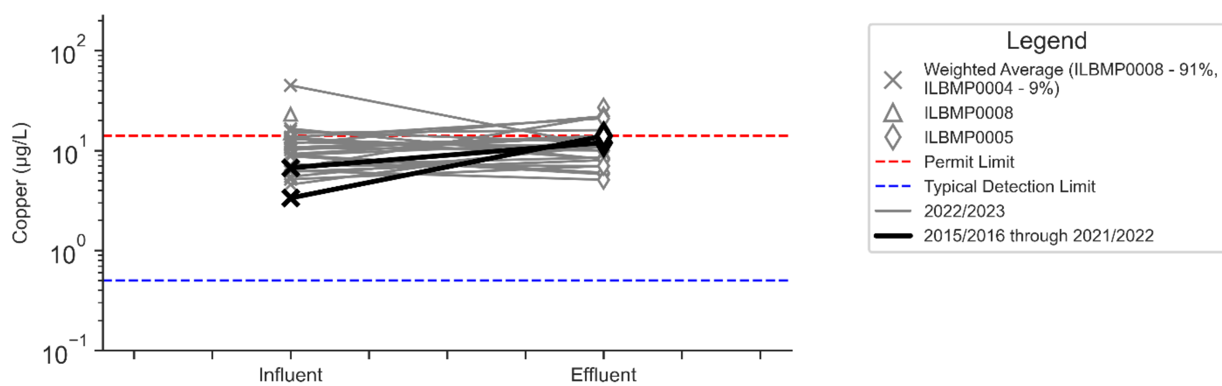


Figure 61. Copper at Southern Detention Bioswale

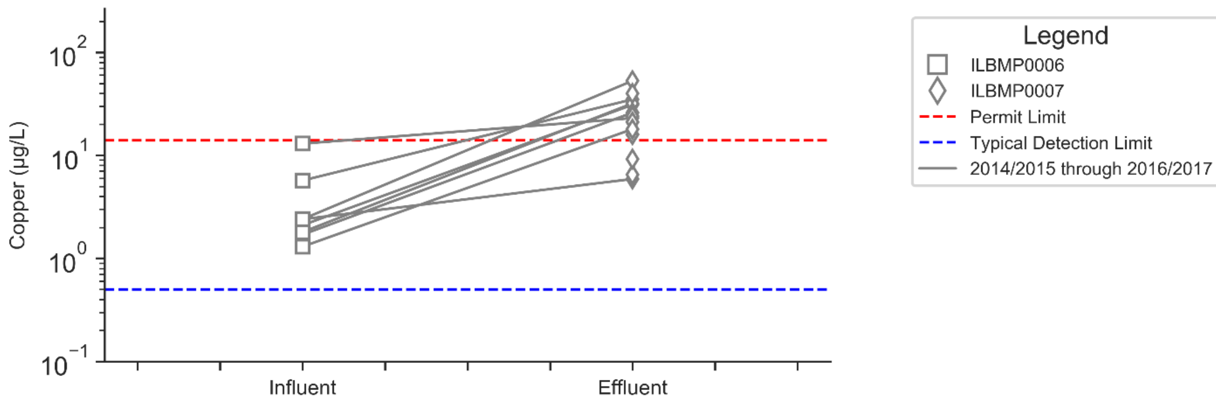


Figure 62. Copper at Northern Detention Bioswale

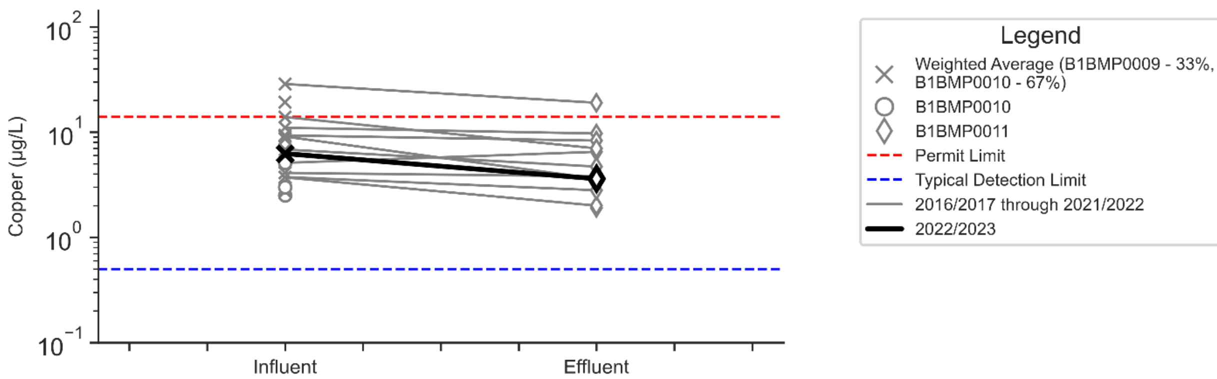
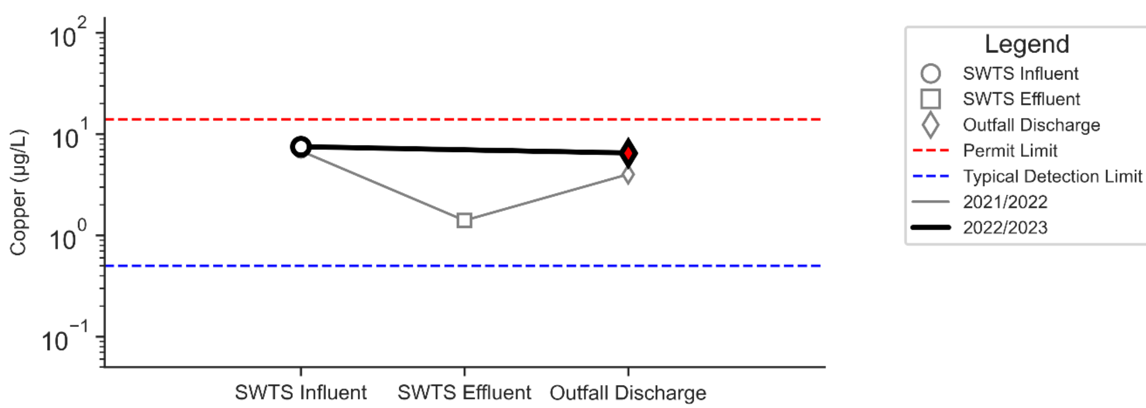
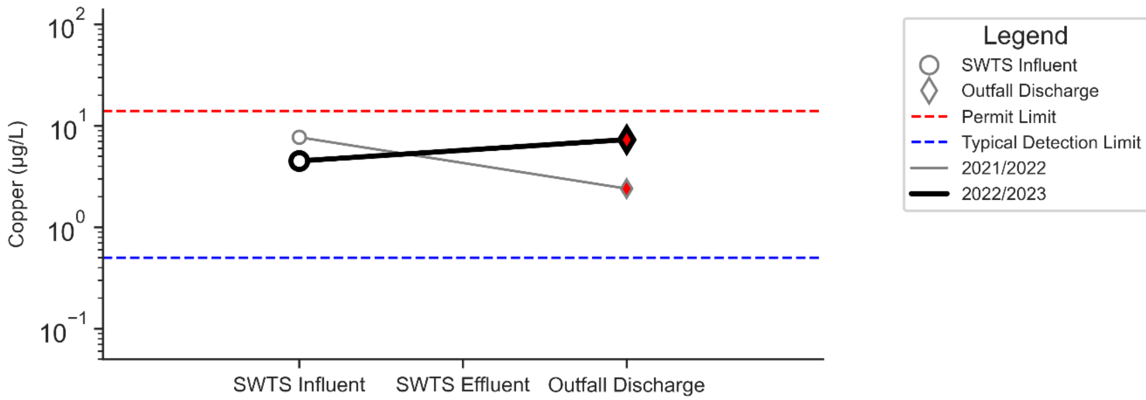


Figure 63. Copper at Upper Lot Media Filter



Note:
- Red markers indicate samples collected during pond overflow

Figure 64. Copper at Outfall 011 SWTS



Note:
- Red markers indicate samples collected during pond overflow

Figure 65. Copper at Outfall 018 SWTS

9. Results: Influent v. Effluent Correlation Charts

Figure 67 through Figure 69 compare paired influent and effluent concentrations observed at CM/media filter sites, including CM-1, CM-3 post-2016/17, CM-9, B-1 media filter, and the upper lot media filter (exclusive of background CM-8 and CM-11 locations). Correlation charts of data collected at the lower lot biofilter are shown in Figure 70 through Figure 72, at the ELV treatment BMP in Figure 73 through Figure 75, and at detention bioswales in Figure 76 through Figure 78. Due to the small number of data pairs currently available from the SWTSs, correlation charts for these active treatment BMPs are not included. Paired datasets graphed in this section were statistically analyzed in Section 4. The datasets include influent-to-effluent pairs, only, and do not incorporate any sample results from BMP midpoint locations. Points are shaded based on the sampling year they were collected, such that data collected in 2022/23 are black and data collected in previous reporting years are gray. Symbols are used to represent ND results, as depicted in the legends.

A least-squares regressions line was fit to log-transformed data $(\log(y) = m * \log(x) + b)$. Resulting equations including regression slope, m, and the y-intercept, *b*, are shown in the upper lefthand corner of the plots. The corresponding p-values, indicating statistical significance of the slopes and y-intercepts, are also shown on the plots. Regarding the p-value corresponding to the slope, the null hypothesis is that the slope (m) equals 0. The null hypothesis is rejected by a p-value less than or equal to 0.05, which suggests a non-zero slope with a 95% confidence level. Statistical significance of the y-intercept (*b*) indicates, with a 95% confidence level, that variations in concentration reduction depend upon influent concentrations, while an insignificant y-intercept suggests constant concentration percentage reductions occur irrespective of the influent concentration. Concentration percent reductions between the influent and effluent may be calculated as $(1 - m) * 100$ if the intercept term is not significant.

Data plotted below the 1:1 line indicate an influent-to-effluent reduction in concentration, while data plotted above the 1:1 line indicate an influent-to-effluent increase in COC concentration. The intersection of 1:1 and best-fit lines represents the upper bound of the ostensibly irreducible COC concentration at a given treatment BMP and serves as an indicator of influent concentrations above which BMPs are most effective, as it is generally unlikely that low concentrations would be substantially reduced by BMP treatment.

An example influent vs. effluent correlation plot is shown is Figure 66. Where a regression equation and associated parametric ANOVA[14] analysis indicated a statistically insignificant intercept given a p-value greater than 0.05, the null hypothesis was rejected, the regression was recalculated, and the intercept was set to zero. Recalculated results are plotted with intercept p-values listed as “N/A,” indicating constant concentration reductions occur generally independently of influent concentrations. If the slope term is not significant, the average effluent is assumed to be constant for all influent concentrations. Regression equations cannot be found statistically significant if neither the slope nor intercept are found

[14] ANOVA stands for Analysis of Variance.

statistically significant. In this case, the effluent concentrations are not related to the influent concentrations, and the regression equation and p-values are not shown on the plots.

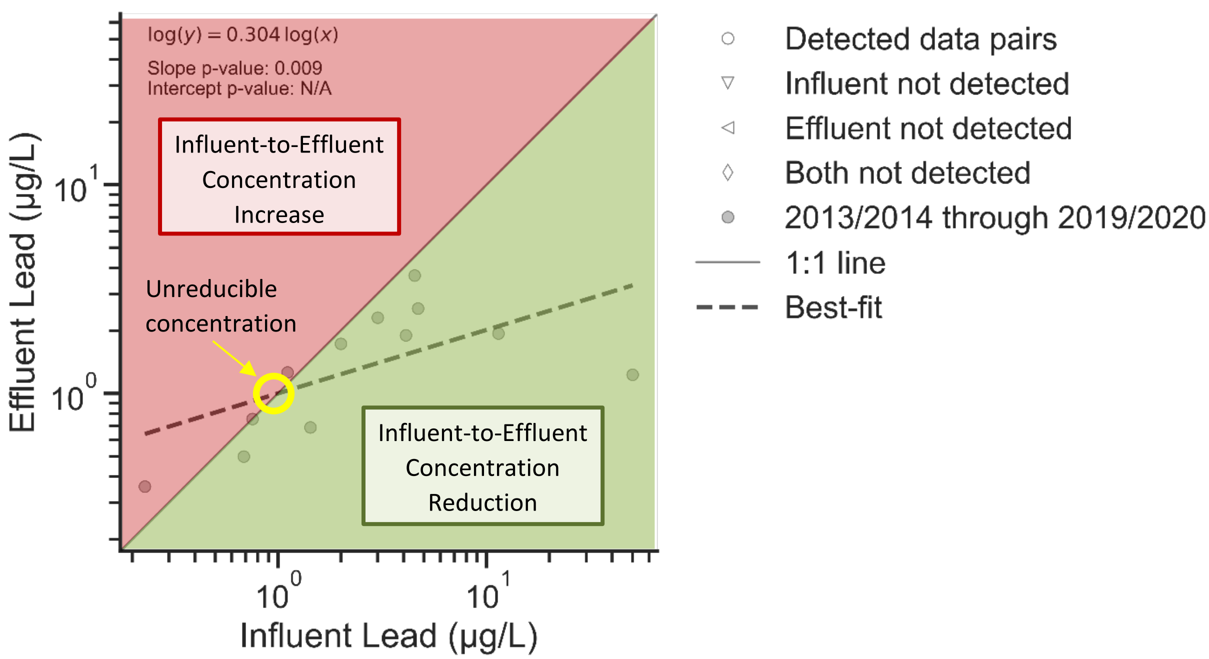


Figure 66. Example Influent vs. Effluent Correlation Plot

9.1 CM/Media Filter Influent v. Effluent Correlation Charts

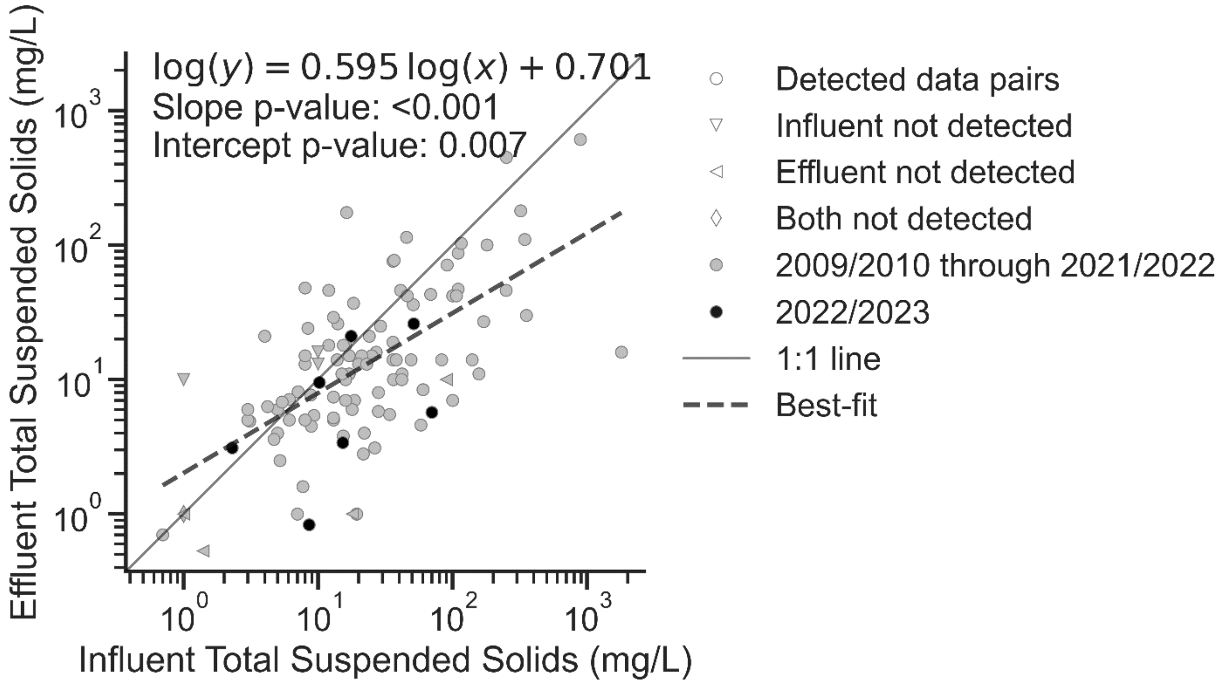


Figure 67. Paired TSS Concentrations at CMs and Other Media Filters

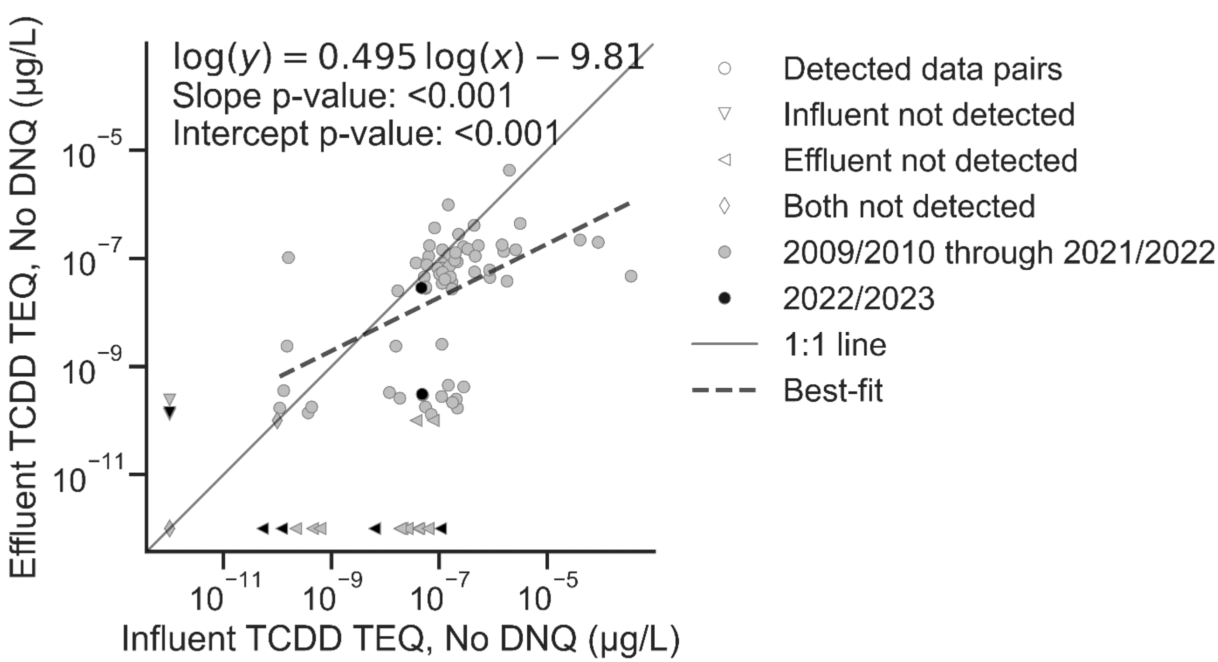


Figure 68. Paired Dioxin Concentrations at CMs and Other Media Filters

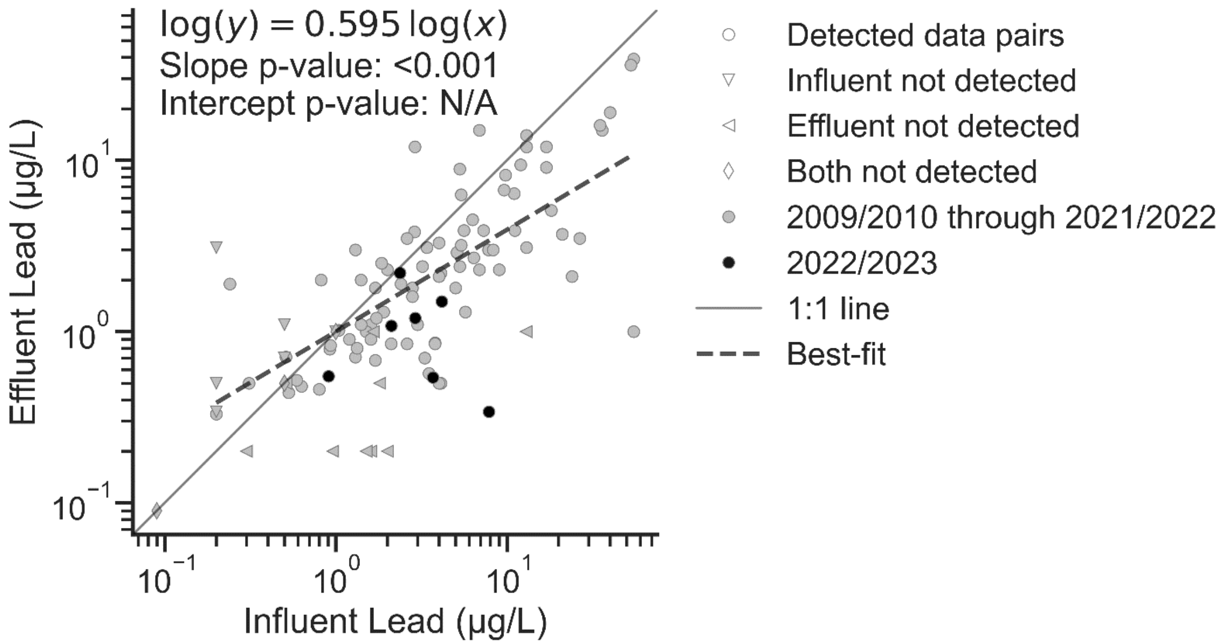


Figure 69. Paired Lead Concentrations at CMs and Other Media Filters

9.2 Lower Lot Biofilter Influent v. Effluent Correlation Charts

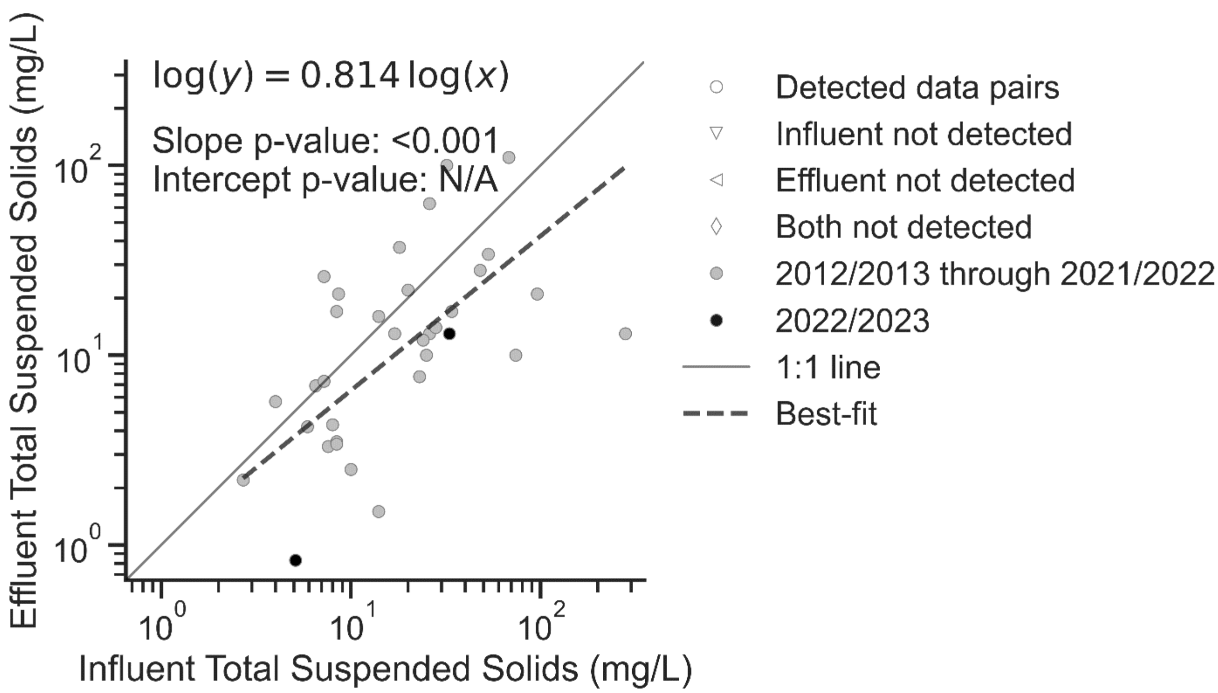


Figure 70. Paired TSS Concentrations at Lower Lot Biofilter

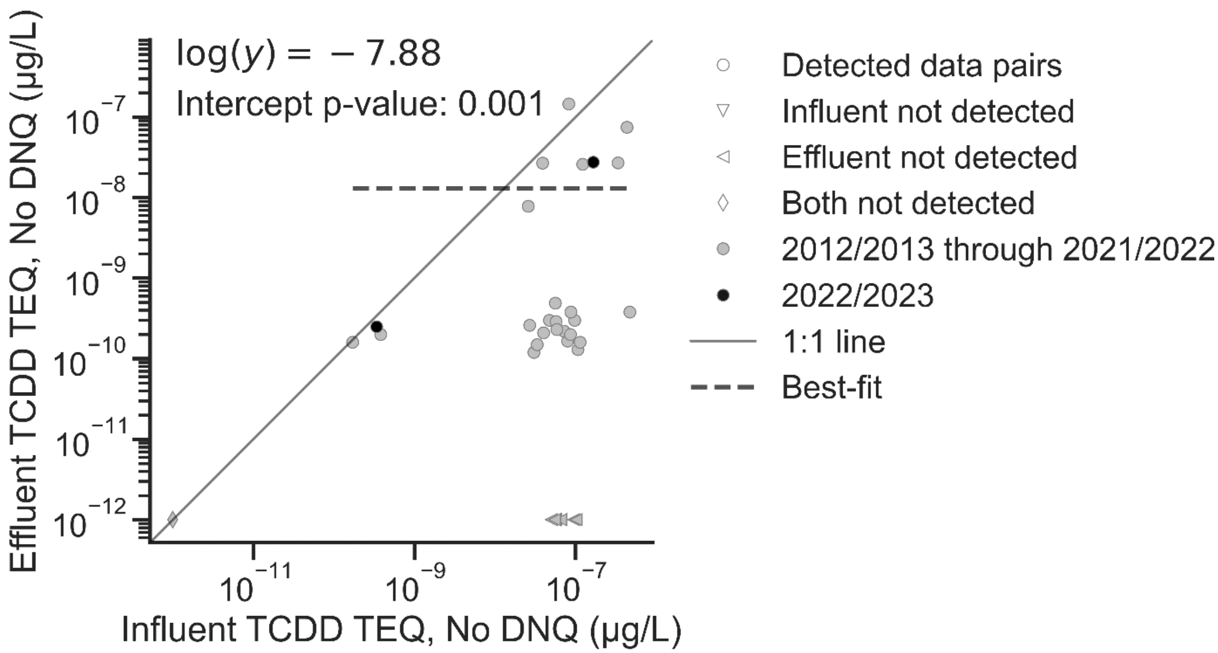


Figure 71. Paired Dioxin Concentrations at Lower Lot Biofilter

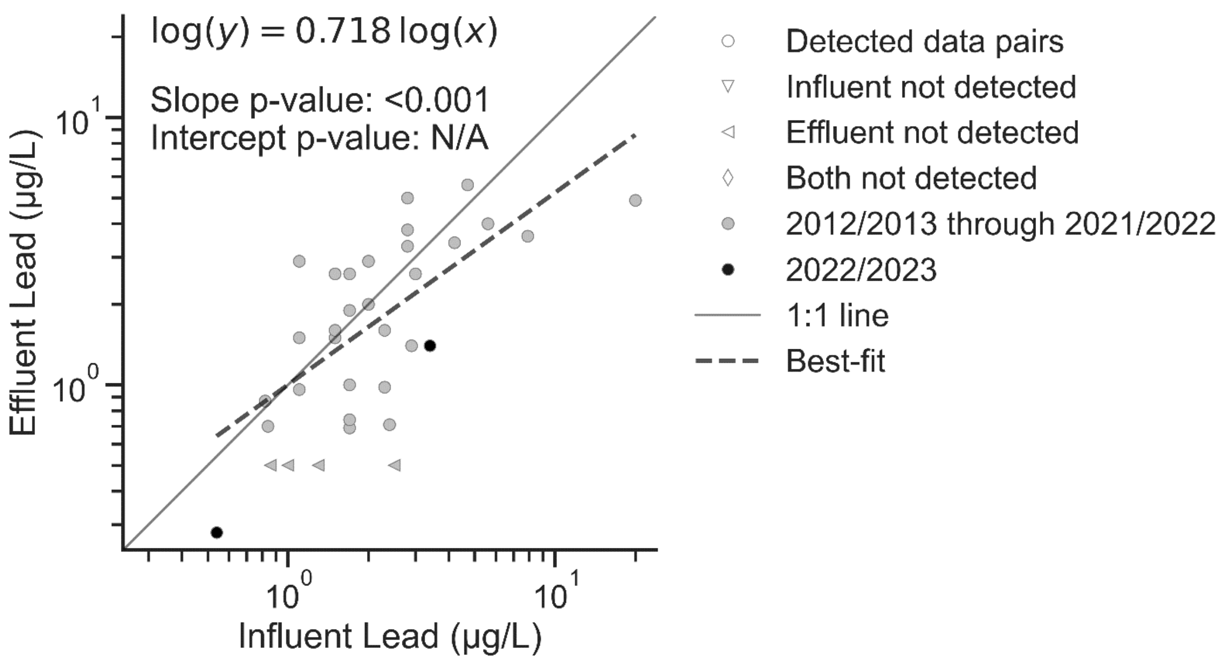


Figure 72. Paired Lead Concentrations at Lower Lot Biofilter

9.3 ELV Treatment BMP Influent v. Effluent Correlation Charts

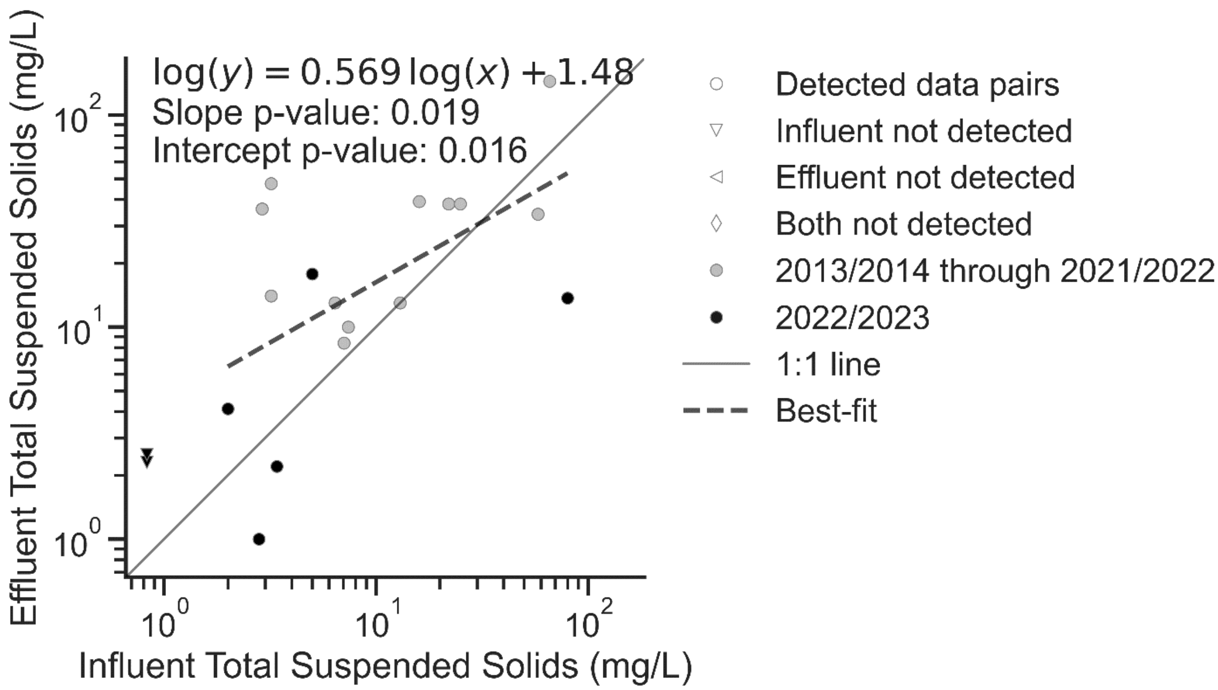


Figure 73. Paired TSS Concentrations at ELV Treatment BMP

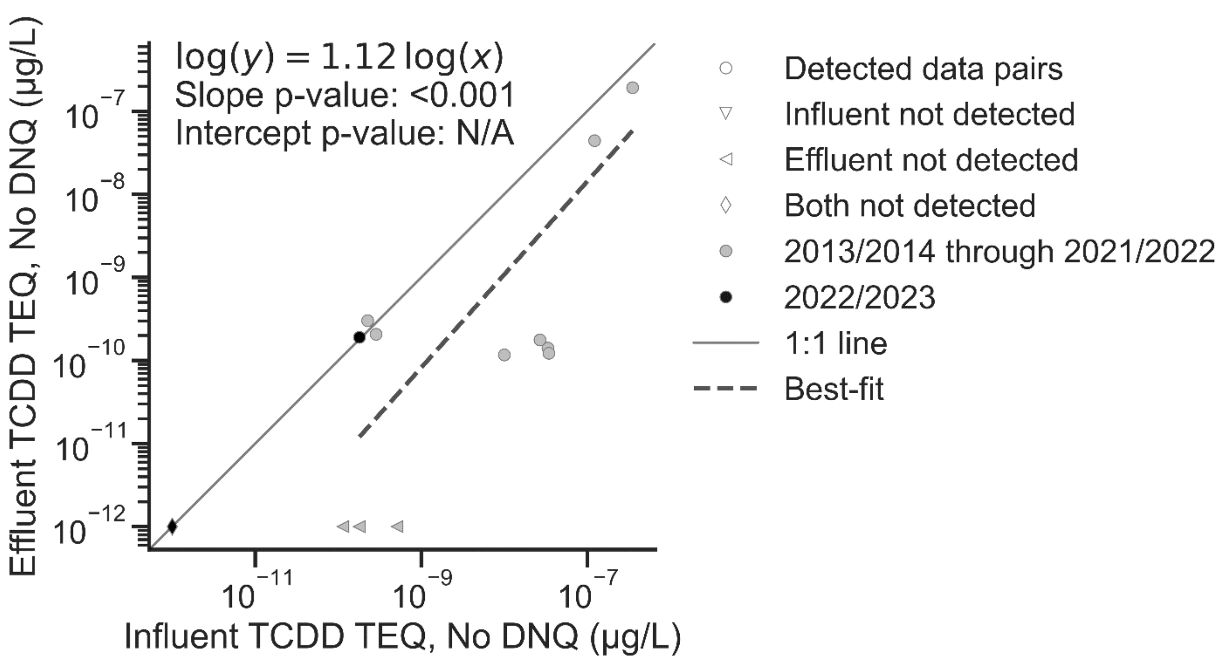


Figure 74. Paired Dioxin Concentrations at ELV Treatment BMP

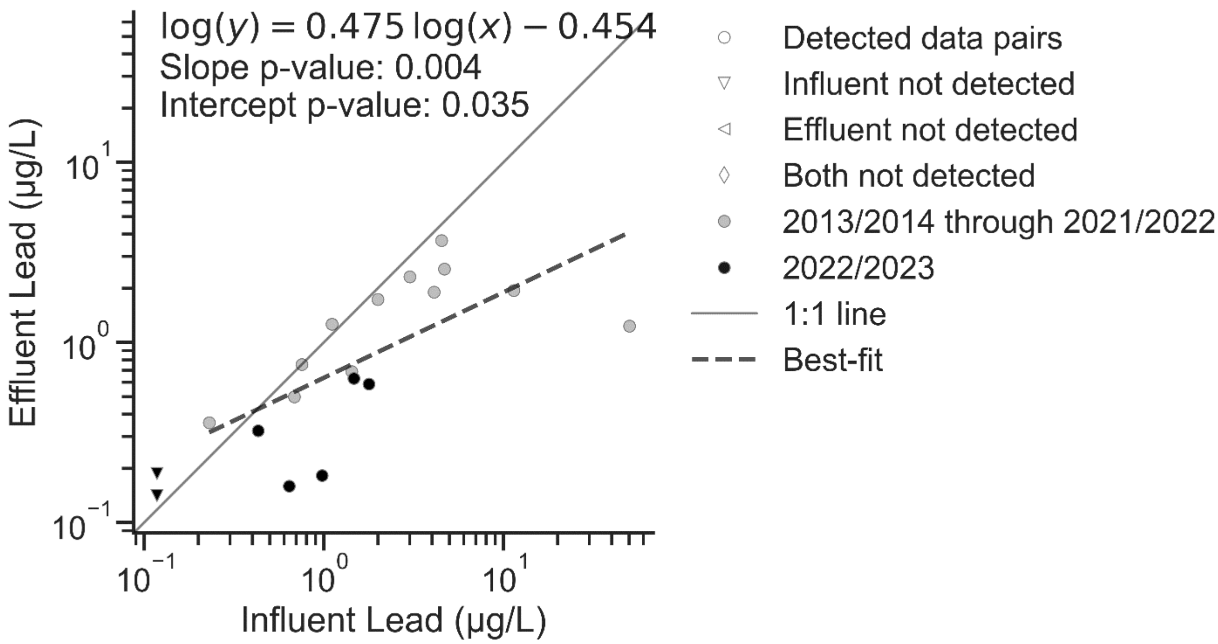


Figure 75. Paired Lead Concentrations at ELV Treatment BMP

9.4 Detention Bioswales Influent v. Effluent Correlation Charts

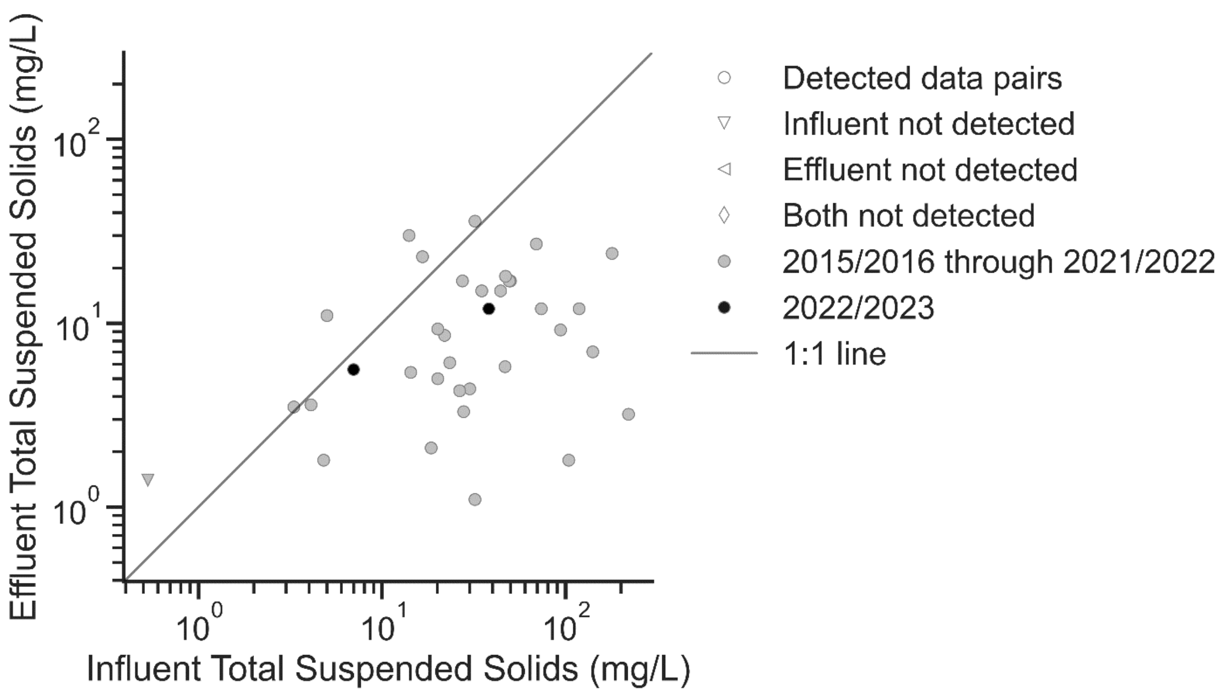


Figure 76. Paired TSS Concentrations at Detention Bioswales

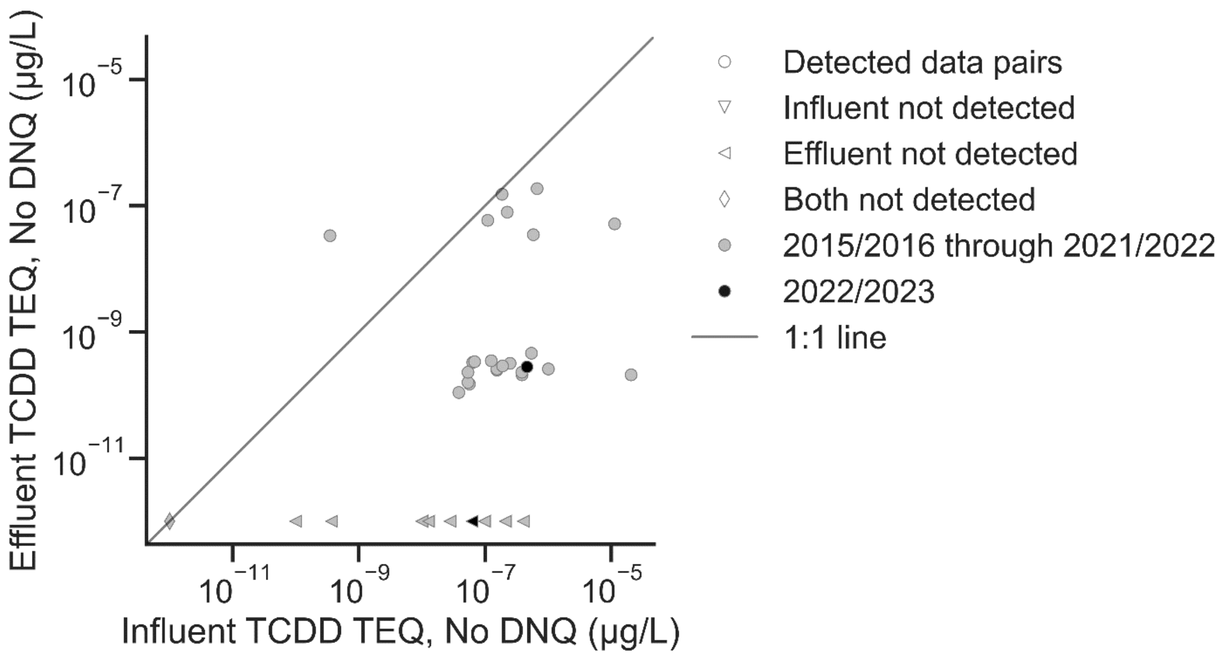


Figure 77. Paired Dioxin Concentrations at Detention Bioswales

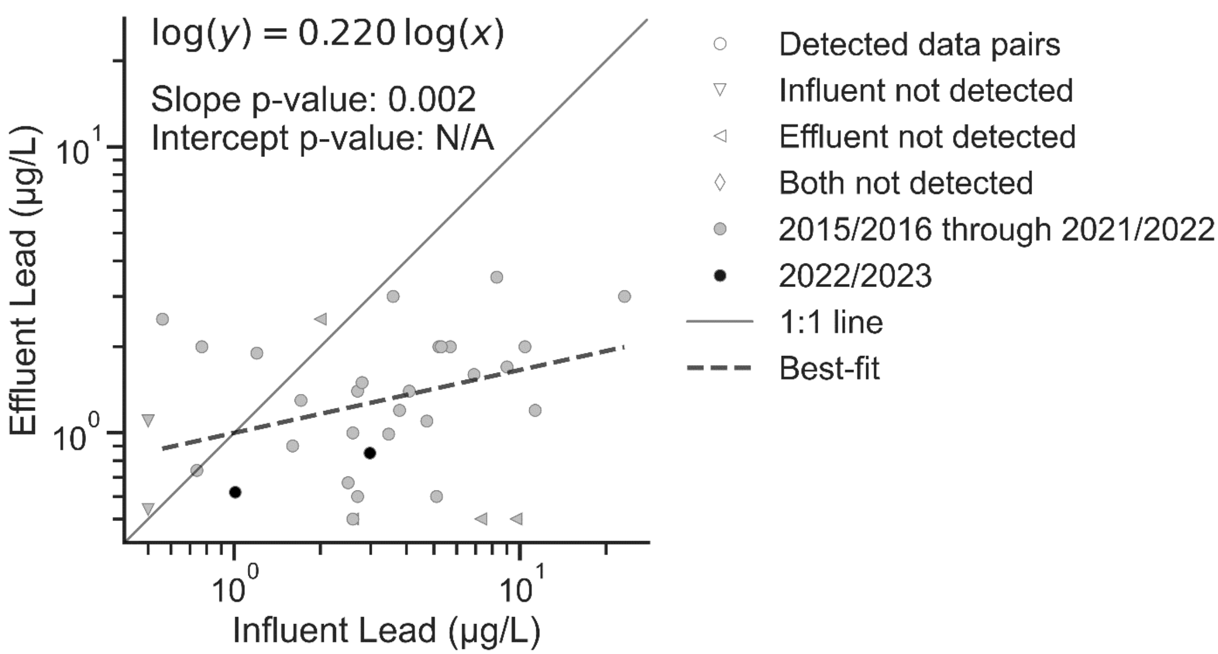


Figure 78. Paired Lead Concentrations at Detention Bioswales

10. Results: Probability Plots

Probability plots of data collected at CMs and other media filters, including CM-1, CM-3 post-2016/17, CM-9, B-1 media filter, and the upper lot media filter, are shown in Figure 79 through Figure 81. Data collected at background CM-8 and CM-11 were not plotted given their low variability. Probability plots of data collected at the lower lot biofilter are shown in Figure 82 through Figure 84, at the ELV treatment BMP in Figure 85 through Figure 87, at detention bioswales in Figure 88 through Figure 90. Due to the small number of data pairs currently available from the SWTSs, probability plots for these active treatment systems are not included in this section. The log-normal probability plots were prepared by ranking detected log-transformed results and calculating the probability that individual results are expected to occur. ND data would be assigned to the lowest plotting positions, effectively truncating the probability plots at the fraction of non-detected samples. Therefore, only detected results 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. Correlated trends of influent and effluent concentrations can serve as a useful tool for predicting the probabilities that various effluent concentrations are expected to occur given a range of observed influent concentrations.

Statistics, including the observed number of ND results and the p-value resulting from an Anderson-Darling test, are provided on the plots for the influent and effluent datasets. The null hypothesis for the Anderson-Darling test is that the data follow the log-normal distribution. The null hypothesis is rejected, with a 95% degree of confidence, by p-values less than or equal to 0.05, indicating with statistical significance that the data distribution differs from the log-normal distribution. Influent and effluent data points consistently falling within the confidence interval and a corresponding p-value greater than 0.05 indicate, with a 95% degree of confidence, that the log-normal distribution fits the data well, and the fitted line may be used to estimate concentrations at various percentiles. Effluent results falling consistently below influent results indicate water quality improvement, while the vertical distance between log-transformed influent and effluent datasets represents magnitude of the change in concentration at the treatment BMP. Plotted shapes are shaded based on the year they were collected, with data collected in 2022/23 and data collected in previous years represented by filled and unfilled shapes, respectively.

Relative differences in scatter can indicate variations in both influent and effluent COC concentrations observed at a given treatment BMP. The slope of the probability distribution serves as an additional indicator of variability, with milder slopes indicating less variation in the data. A flatter effluent slope relative to the influent signifies the treatment BMP reduces the variability of effluent concentrations independently of the corresponding influent concentrations, and a generally mild influent slope indicates less variability of COC concentrations influent to the treatment BMP.

10.1 CM/Media Filter Probability Plots

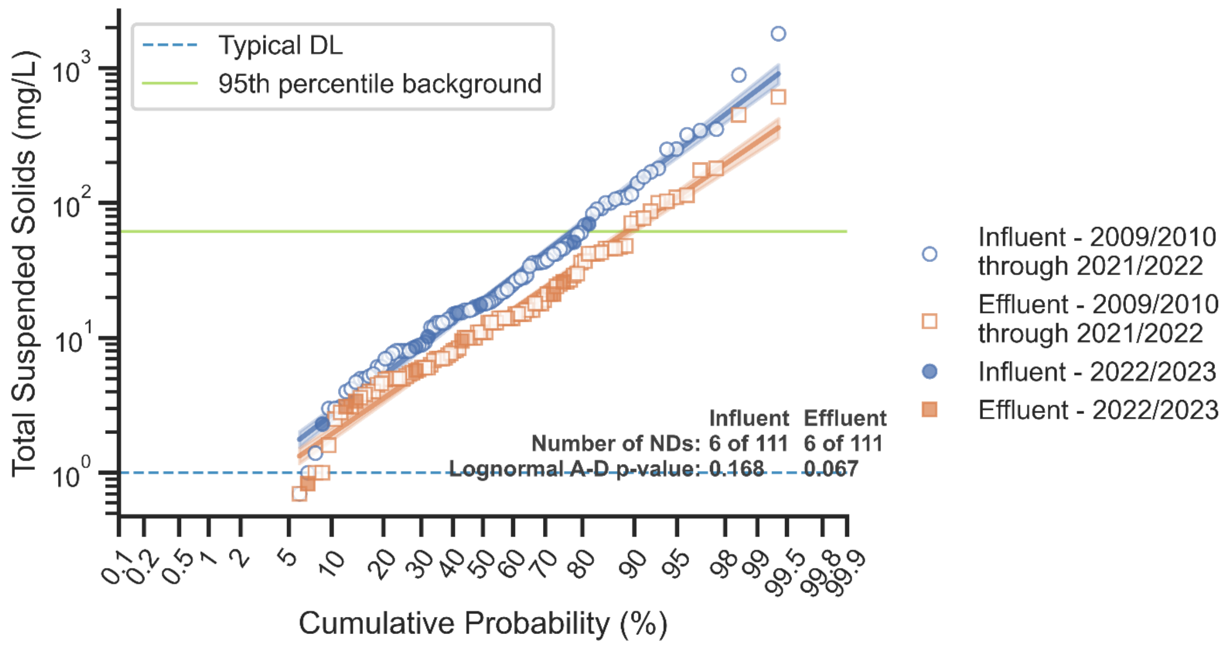


Figure 79. Log-normal Probability Plot of TSS at CMs and Other Media Filters

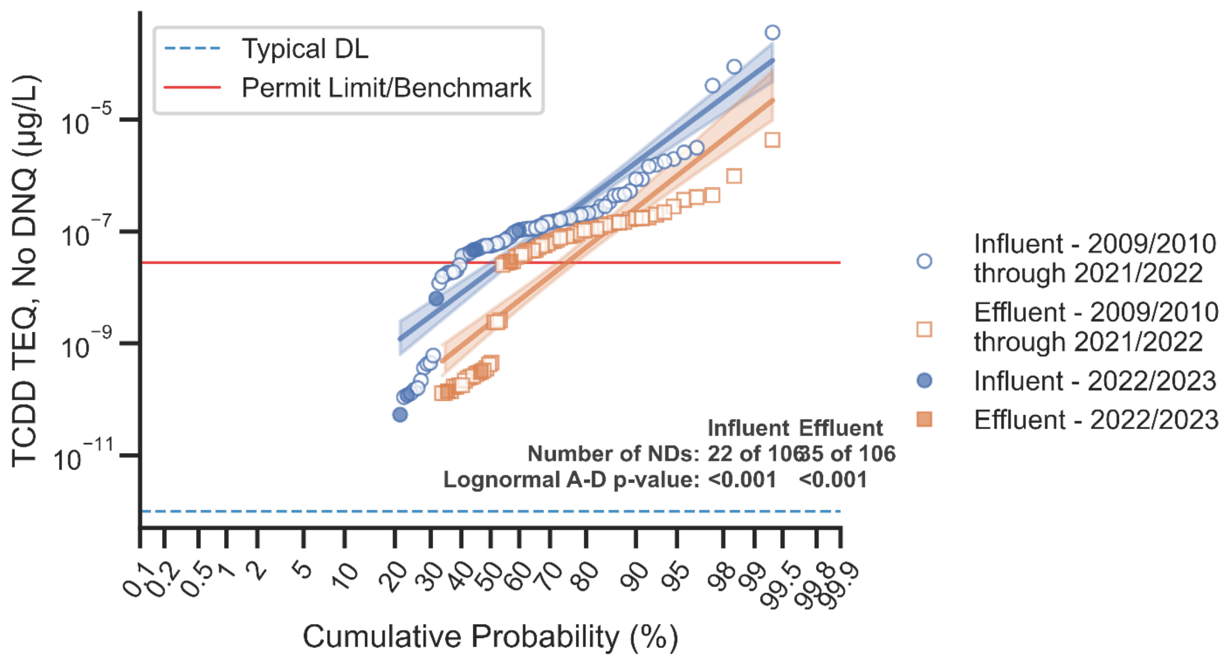


Figure 80. Log-normal Probability Plot of Dioxins at CMs and Other Media Filters

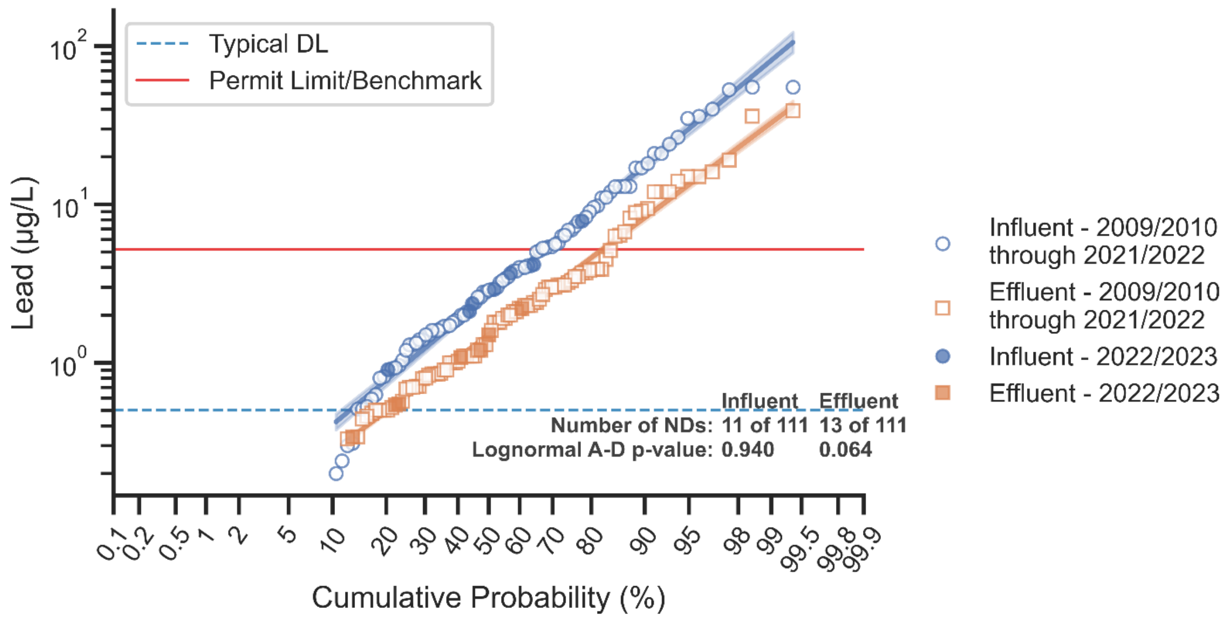


Figure 81. Log-normal Probability Plot of Lead at CMs and Other Media Filters

10.2 Lower Lot Biofilter Probability Plots

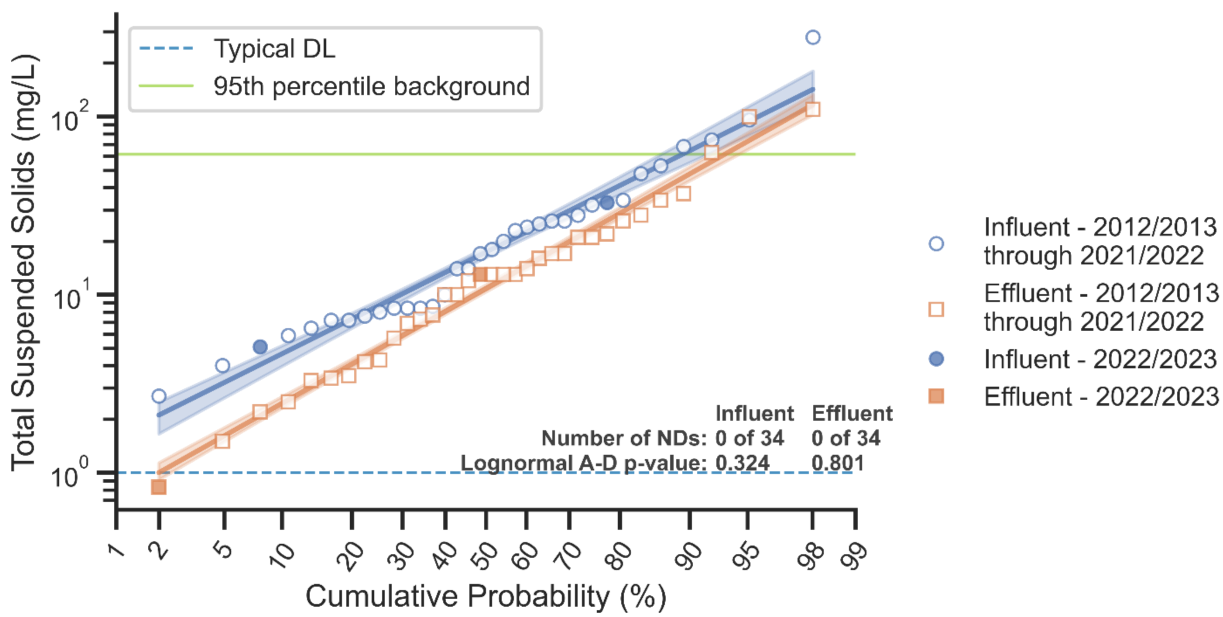


Figure 82. Log-normal Probability Plot of TSS at Lower Lot Biofilter

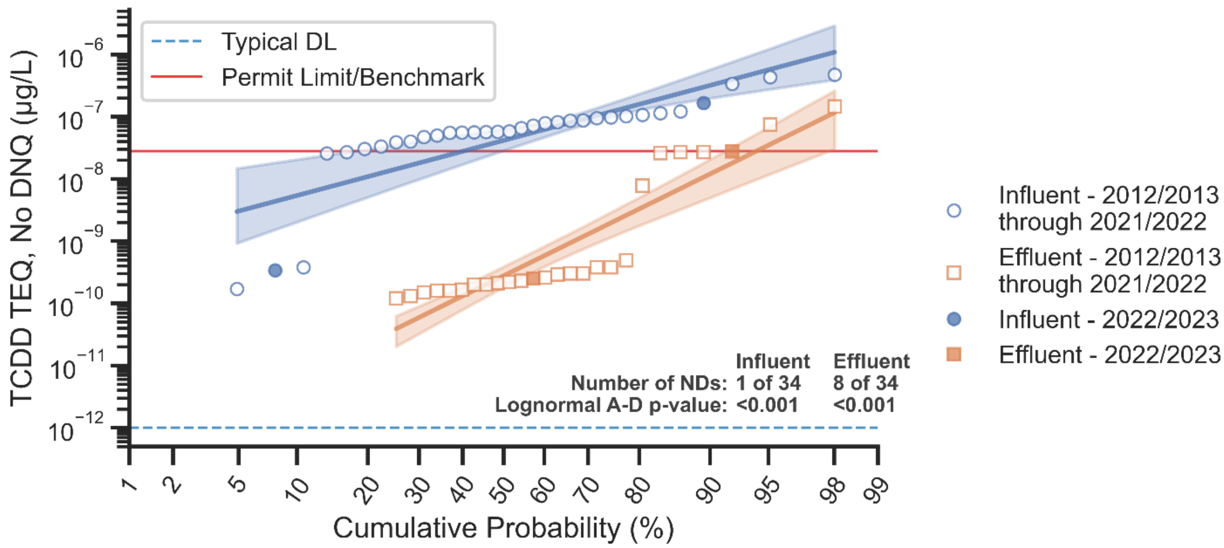


Figure 83. Log-normal Probability Plot of Dioxins at Lower Lot Biofilter

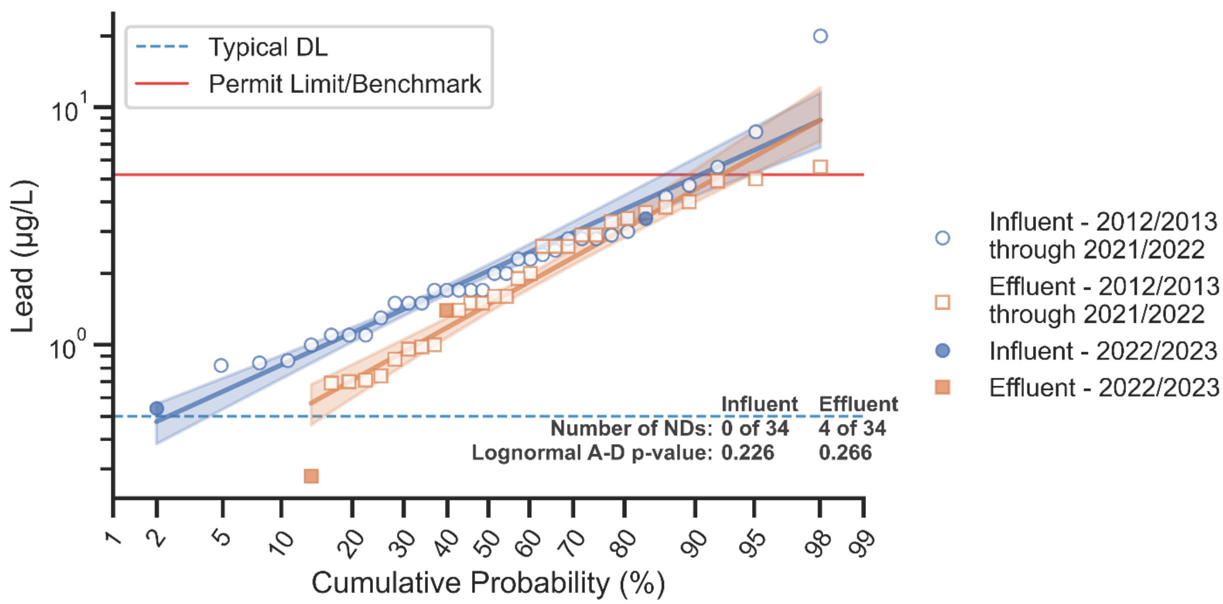


Figure 84. Log-normal Probability Plot of Lead at Lower Lot Biofilter

10.3 ELV Treatment BMP Probability Plots

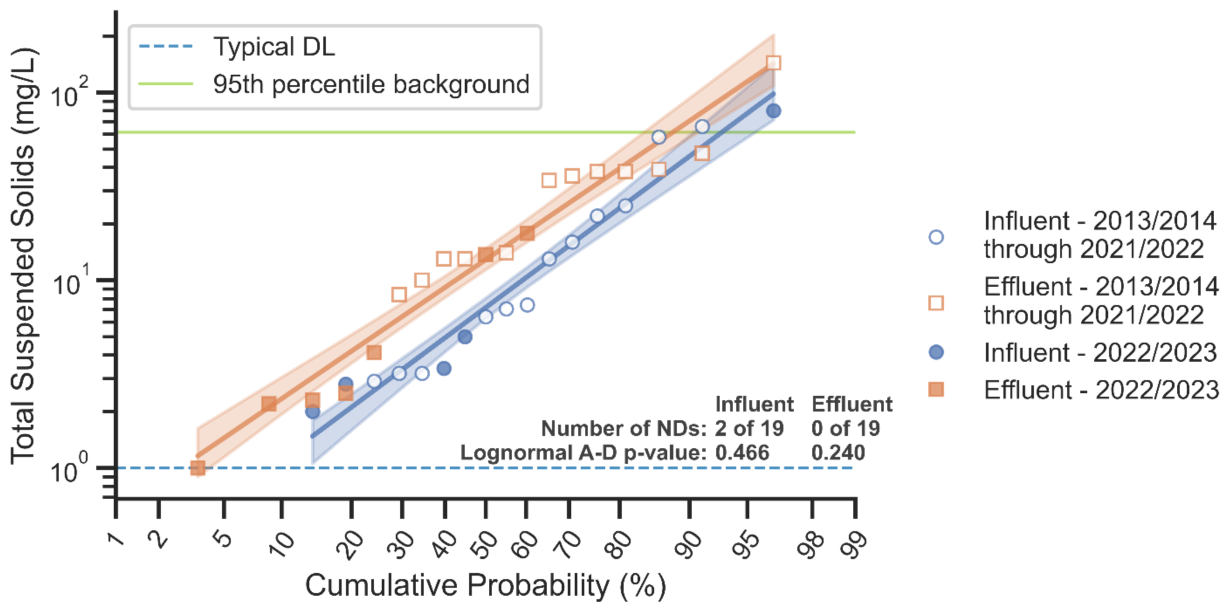


Figure 85. Log-normal Probability Plot of TSS at ELV Treatment BMP

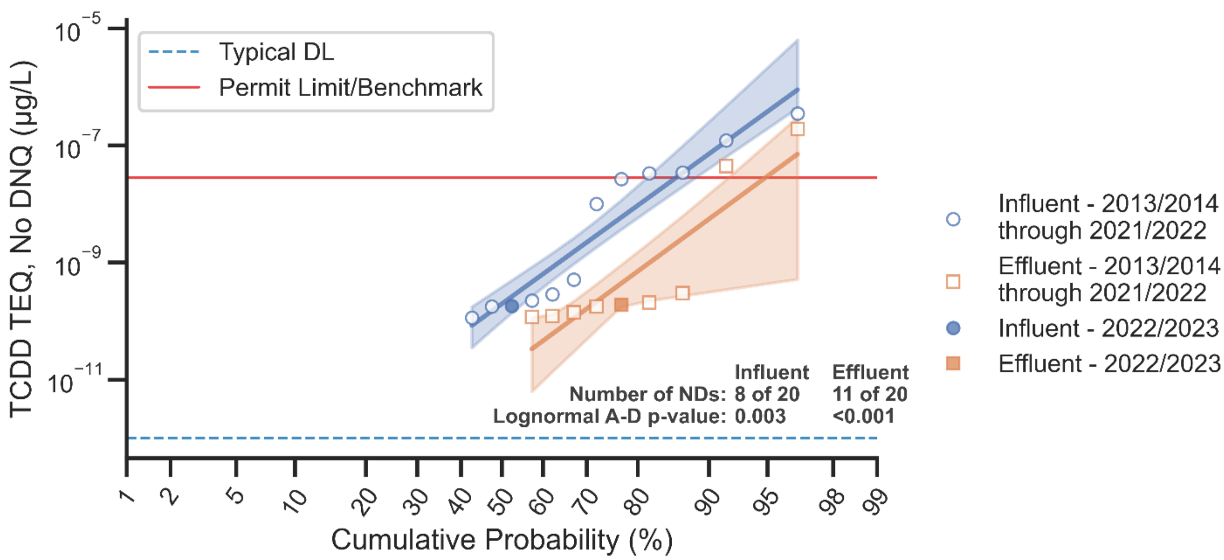


Figure 86. Log-normal Probability Plot of Dioxins at ELV Treatment BMP

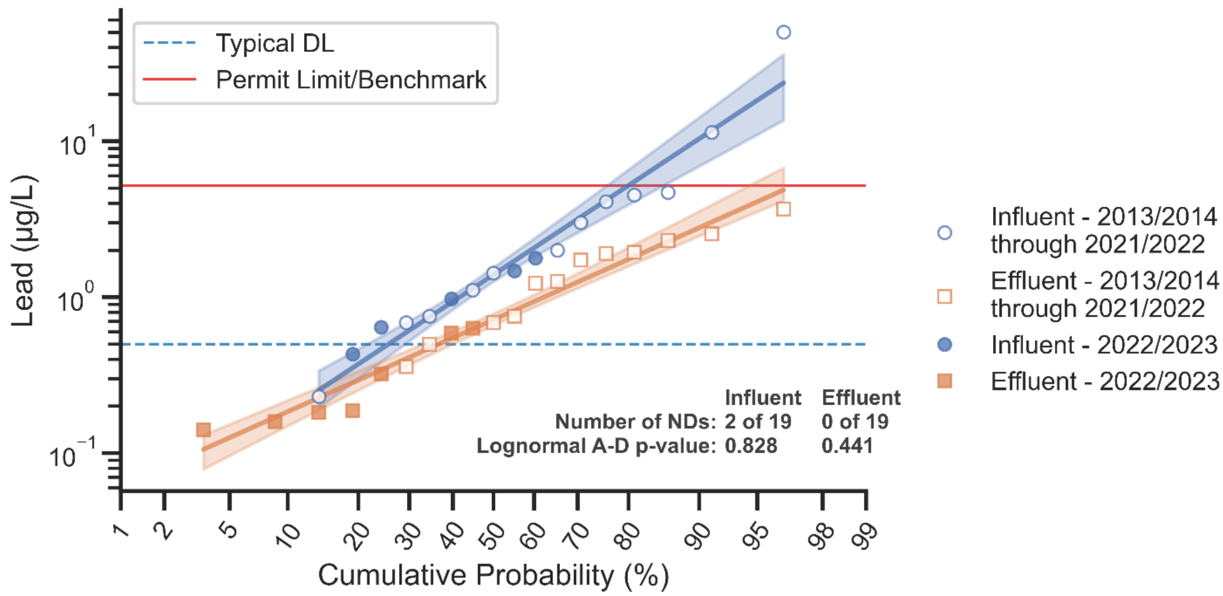


Figure 87. Log-normal Probability Plot of Lead at ELV Treatment BMP

10.4 Detention Bioswales Probability Plots

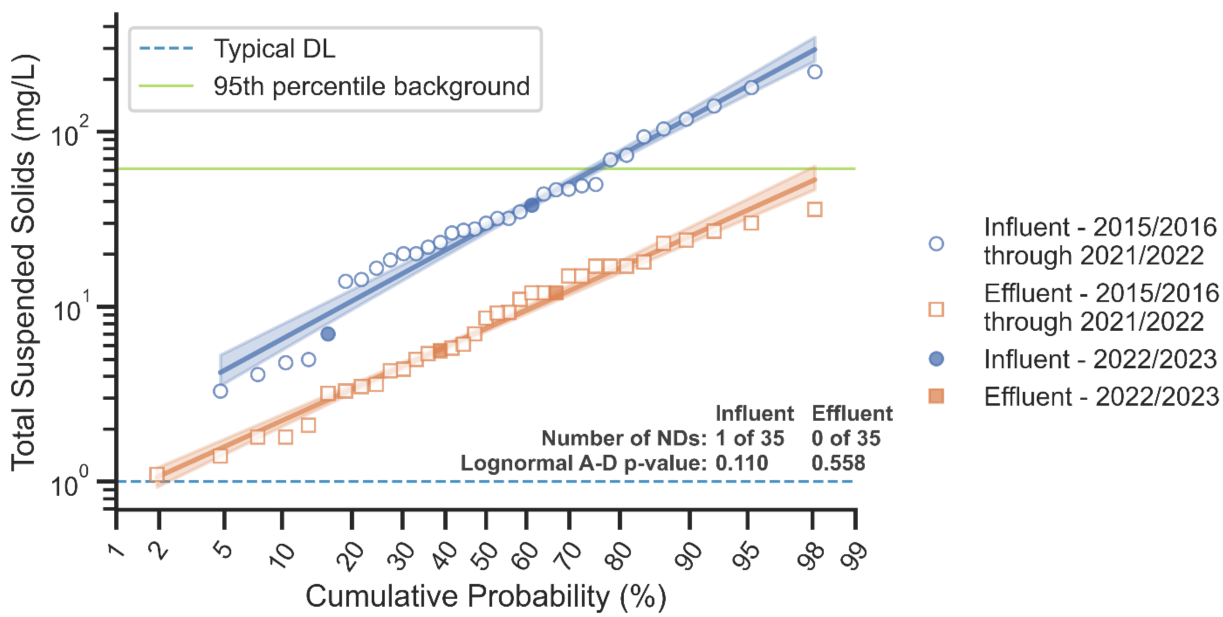


Figure 88. Log-normal Probability Plot of TSS at Detention Bioswales

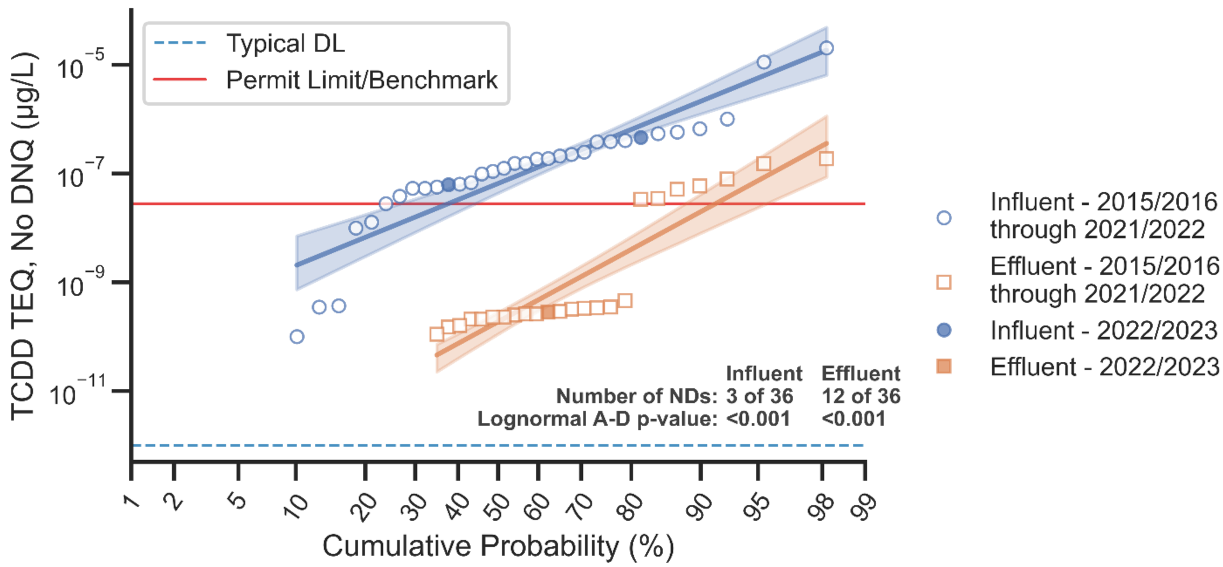


Figure 89. Log-normal Probability Plot of Dioxins at Detention Bioswales

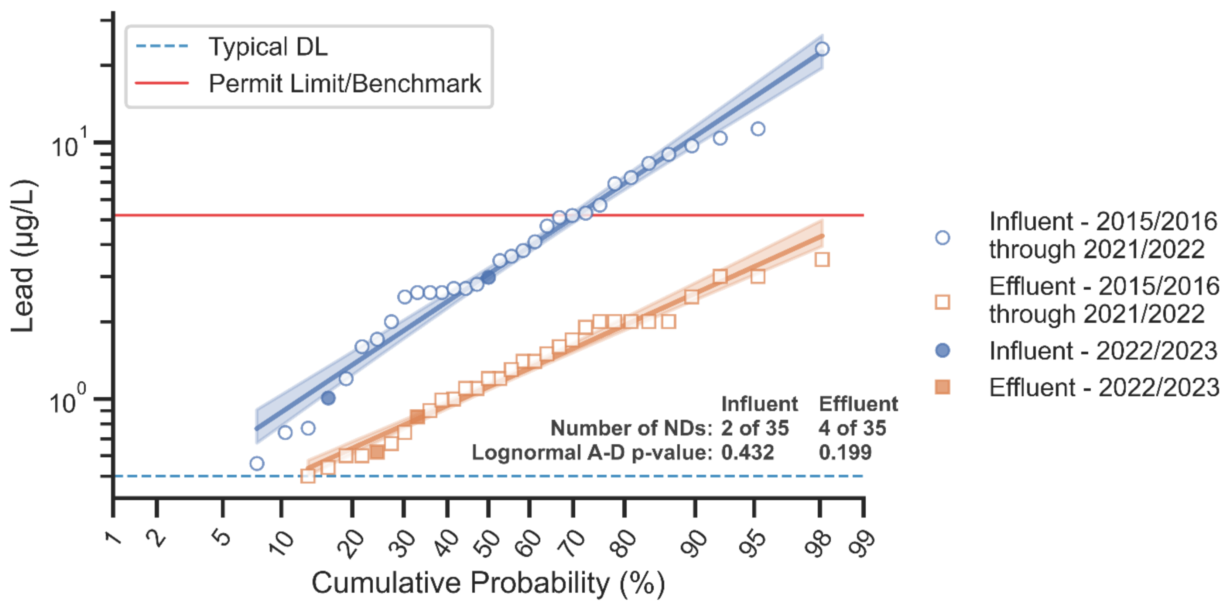


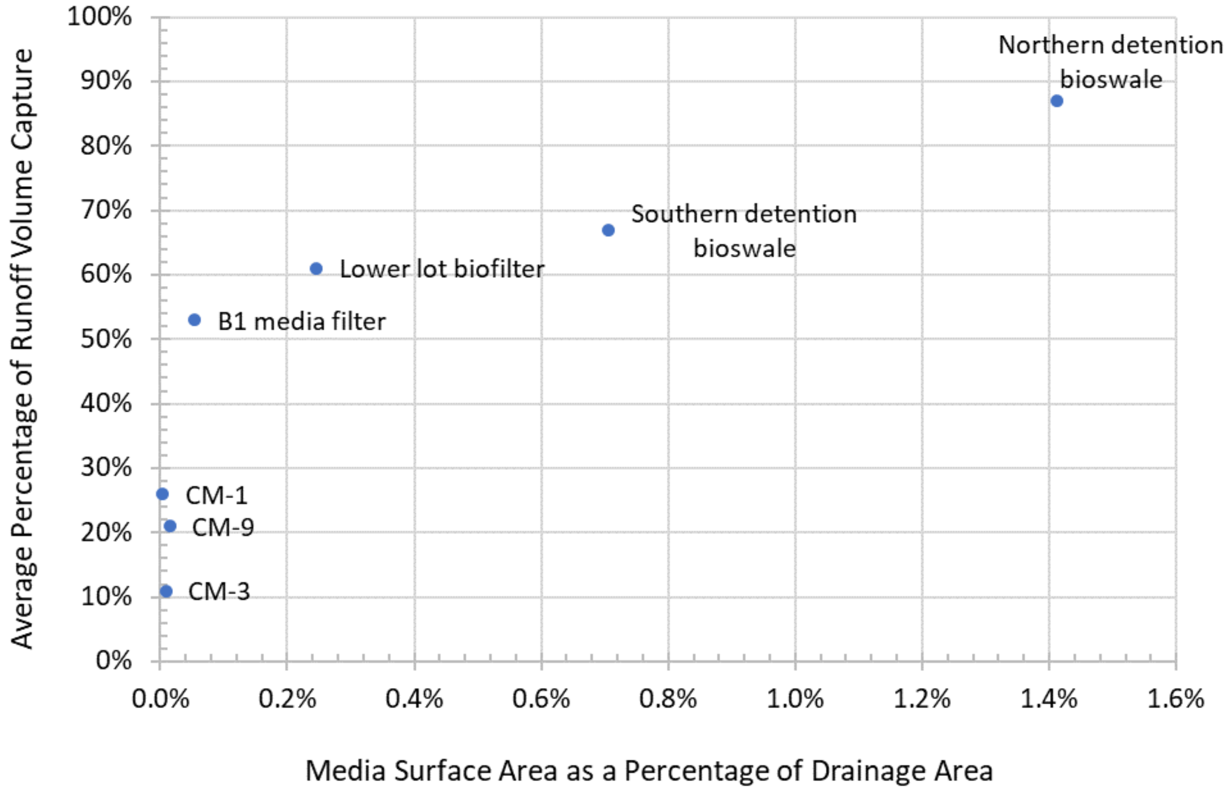
Figure 90. Log-normal Probability Plot of Lead at Detention Bioswales

11. Summary of Treatment BMP Sizing

Pitt, et al. (2022) evaluated the long-term performance of the distributed stormwater controls at the SSFL. As the relative footprint of the treatment media area compared to the drainage area increases, greater fractions of the annual stormwater flows are fully treated (compared to small treatment media areas). Figure 91 compares these treatment media/drainage area ratio values for the stormwater controls examined (except for the ELV treatment BMP, which is more efficient with a smaller footprint) to the average portion of the stormwater flows treated by the stormwater controls, as determined by SWMM modeling[15]. Media footprints of about 0.1% of the drainage area resulted in approximately half (or less) of the annual flows being fully treated, while about 0.7% was needed to provide full treatment of about 70% of the annual flows, and greater than 1% was necessary to fully treat about 90% of the annual flows. The excess flows bypassed the media treatment.

CM-1, the first media treatment system rebuilt due to clogging, has a media treatment area to drainage area ratio of only approximately 0.003%, the smallest of the site controls. CM-9, the control with only a short useful life remaining, has a media treatment area to drainage area ratio of only 0.01%. The culvert modifications were installed early in the process in 2009 and 2010 before data were collected and analyzed, as these could be installed quickly and at relatively low cost. They were sized based on the available area at the culvert road crossings, with the understanding that they were treating larger drainage areas than desired for optimal performance. CM-9 has undergone several phases of enhancements, and CM-1 was recently rebuilt. The detention bioswales have the largest relative footprints compared to their drainage areas and have been shown to be more consistently effective than the other controls.

[15] For determination of the runoff volumes treated in an average rainfall year, historical rainfall data were used to model the 2009/10 through 2021/22 rainy seasons.



Note: the media surface area for the detention bioswales is characterized as the (bottom) ponding area of the bioswales.

Figure 91. Percentage of annual flows treated vs. media surface area as a percentage of drainage area for SSFL distributed control locations.

12. Conclusions and Recommendations

The following performance conclusions and maintenance recommendations are based on an evaluation of the aforementioned data summary charts and tables.

1. **Are the CMs and other media filters continuing to reduce the concentrations of lead, dioxin, and TSS between the untreated influent and the treated effluent?**

   Yes. 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 a 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, performance monitoring results indicate statistically significant reductions of TSS, dioxins, and lead concentrations through treatment by non-background CMs/media filter, including CM-1, CM-9, CM-3 post-2016/17, B-1, and the upper lot media filter, as a result of sedimentation and media treatment unit processes. Reductions in COC concentrations were also observed at background CMs, CM-8 and CM-11, with TSS and lead removal found to be statistically significant. Although there was not a statistically significant reduction for dioxins at the background CMs, 63% of paired samples included influent and effluent concentrations below the detection limit, indicating low concentrations of dioxins in runoff which hindered the statistical significance of the concentration reductions through the CMs.

2. **Are the detention bioswales, Lower Lot Biofilter, and ELV Treatment BMPs continuing to reduce the concentrations of lead, dioxin, and TSS between the untreated influent and the treated effluent?**

   Generally, yes. Data collected at detention bioswales show substantial and statistically significant reductions of TSS, dioxins, and lead concentrations. Statistically significant dioxins reductions were observed at the lower lot biofilter, with overall reductions of TSS and lead concentrations also achieved (based on the majority of data pairs showing a decrease in concentration from the influent to the effluent), though not with statistical significance. The lower lot biofilter receives runoff that is pretreated by the detention bioswales, so further significant influent-to-effluent reductions of lead and TSS concentrations may be difficult to achieve through lower lot biofilter treatment.

   Statistically significant reductions of dioxins and lead concentrations have been observed at the ELV Treatment BMP. Considering samples from the last two rainy seasons (2021/22 and 2022/23), seven of the eight sample pairs collected at the ELV Treatment BMP had both influent and effluent samples that were non-detects for dioxins. However, a statistically significant increase in TSS concentrations was observed at the ELV Treatment BMP. The ELV Treatment BMP was rebuilt in Summer 2021. Sample pairs were not able to be collected in 2021/22 for TSS. Out of seven sample pairs collected in 2022/23, four pairs had increases in TSS concentrations. These increases in TSS are expected to be due to washout of media from the treatment system.

Additionally, the number of results exceeding the Permit Limits for both the influent and effluent samples show an improvement in water quality between the untreated influent and the treated effluent, as described in the subsequent observation below.

3. **Are the treatment controls continuing to aid in compliance with NPDES Permit Limits at Outfall 009?**

   Yes. Collectively, the treatment controls have achieved water quality improvements toward reliable NPDES compliance at Outfall 009. Despite the significant rainfall events that occurred during the 2022/23 reporting year, treatment BMPs in the Outfall 009 Watershed have been observed to reduce the frequency of BMP effluent concentrations in excess of Permit Limits for all COC-BMP combinations. There were no exceedances of Permit Limits at Outfall 009 in 2022/23.

   Most COC-BMP combinations also showed lower average and maximum exceedance ratios (i.e., exceeding sample concentrations divided by the Permit Limit) for effluent results compared to the influent results[16]. These observations show that the treatment controls are improving storm water quality prior to reaching Outfall 009. This not only demonstrates that the treatment controls are reducing NPDES COC concentrations in stormwater upstream of Outfall 009, but 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.

4. **Is the lower lot biofilter continuing to reduce stormwater runoff from the paved Boeing administrative areas and lots to the Northern Drainage?**

   Yes. Monitoring data at the lower lot biofilter were examined to determine its ability to prevent smaller storms from discharging to the Northern Drainage and ultimately to Outfall 009. The lower lot biofilter successfully prevented discharge of stormwater runoff to the Northern Drainage in approximately 55% of storms originating in the lower lot tributary area having an inch or less of rainfall, 18% of storms between 1 and 2 inches of rainfall, and 14% of storms between 2 and 3 inches of rainfall. In summer of 2023, the Lower Lot began being used for soil stockpiling for the Shooting Range ISE interim cleanup project. However, this started after the most recent samples had been collected.

5. **Has an adequate number of samples been collected such that sampling can be potentially discontinued at some locations?**

   Yes. Following the 2016/17 reporting year, the Expert Panel evaluated the need for continued sampling at the treatment BMPs in the context of the planned decrease in construction and demolition activities within the Outfall 009 drainage area in 2017/18 and after. The resulting Panel recommendation outlined a reduction of sampling to two events per year at the upper lot media filter, southern detention bioswale, lower lot biofilter, CM-1 (west influent and effluent), and the ELV Treatment BMP. Sampling at the ELV Treatment BMP temporarily increased, but will once

[16] The only exception includes the average exceedance ratio for lead at B-1.

again decrease to two events per year in 2023/24. Influent sampling frequency of the active SWTSs will be in accordance with the NPDES permit.

The Panel planned to revisit the monitoring frequency when site activities resumed in the Outfall 009 Watershed. Until the area is stabilized, subarea sampling upstream and downstream of the shooting range interim source removal area will be increased.

Collection of additional data is expected to benefit long-term monitoring efforts, including assessments that help inform media replacement and other BMP maintenance needs not easily identified via visual inspection.

6. Is significant maintenance currently required for any of the treatment BMPs?

Yes. It is recommended to remove sediment accumulated in the ponding area of the CMs. Additionally, it is recommended to rebuild the impermeable fabric wrapping on CM weir boards (such as CM-4 and CM-10). No media replacement is recommended at this time.

The Expert Panel recommends that observations of clogging, overflow, and underdrain flows should continue to be taken at treatment BMPs when performance samples are collected during storms to verify underdrains are functioning properly and no bypass is occurring through weir boards, as well as following storms to assess whether any extended ponding is occurring, to continue to inform the timing of maintenance and replacement needs.

7. Are the SWTSs reducing COC concentrations between the influent and the treated effluent?

There are only two data pairs currently available at each of the SWTSs, for dioxins and lead only, in addition to one data pair for TSS for the Outfall 018 SWTS. The influent SWTS concentrations for lead were below the Permit Limits, while the influent concentrations for dioxins were predominately above the Permit Limit. Substantial decreases in concentration from the influent to the effluent, for lead, dioxins, and TSS, were observed. All of the available SWTS effluent sample concentrations were below the Permit Limits. Additionally, all available effluent samples were not detected for dioxins, and three of the four available effluent samples were not detected for lead.

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Appendix E: SSFL Pond Infiltration Measurement Results Memorandum

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MEMORANDUM

Date: October 18, 2023

To: Los Angeles Regional Water Quality Control Board

From: SSFL Surface Water Expert Panel, Geosyntec Consultants

Subject: SSFL Pond Infiltration Evaluation

Background

During the recent NPDES permit renewal process, public comments have included concerns regarding the potential of stormwater infiltration within the Silvernale, R-1, and Perimeter Ponds at the Santa Susana Field Laboratory (SSFL) as a possible migration pathway for stormwater constituents of concern (COC) into groundwater. The likelihood of appreciable stormwater infiltration and COC transport is low given the tendency of ponds to naturally accumulate fine silt over time which decreases the infiltration losses of the ponds, combined with the limited mobility of stormwater COCs through the underlaying material beneath the ponds. The largest pond, Silvernale, also sits atop a large, low-permeability shale layer which makes vertical movement of pond water unlikely. And the particular COCs in stormwater that occasionally exceed the NPDES permit's water quality standard-based limits and benchmarks (e.g., iron, manganese, lead, and dioxins) are predominately in particulate form, which minimize their downward migration as they are filtered and sorbed by sediments and decomposing organic materials in the ponds, and soils in the underlying vadose zone.

Even so, the Surface Water Expert Panel ("Expert Panel") recommended measurements of infiltration rates of the ponds in response to questions raised by the public. A review of previously existing information concluded that insufficient direct measurements were available to accurately quantify pond infiltration rates. The Expert Panel therefore directed Geosyntec Consultants to monitor water levels in the ponds during periods when full or partially full, estimate and subtract open water evaporation and evapotranspiration in vegetated portions of the pond fringes, and as a result, estimate the rate of water lost to infiltration through the bottom of the ponds.

Approach

To estimate pond infiltration rates, water depths at Silvernale and R-2A Ponds (above Outfall 018) and R-1 and Perimeter Ponds (above Outfall 011) were recorded during periods of the 2021/22 and 2022/23 rainy seasons. Water levels were initially recorded weekly at Silvernale Pond in Spring 2022 to support a preliminary estimation of the infiltration rate. To improve measurement accuracy and expand the analysis to include other ponds, more frequent water level data were collected at all four ponds during wet and dry weather periods between January and July 2023. Geosyntec installed pressure transducers within Silvernale and R-1 Ponds to digitally record water depth measurements as converted from pressure recordings. Continuous water depth measurements used in the calculations were recorded by the transducers at a 10-minute frequency from late January through early July 2023 at Silvernale Pond; and from mid-February through late April 2023 at R-1 Pond. Manual daily measurements of water levels were also conducted by SSFL contractors on weekdays throughout the study period. Daily measurements provided the full record of water depths at R-2A and Perimeter Pond and augmented transducer recording data at R-1 and Silvernale Ponds.

Stormwater that collects in the ponds is pumped to the onsite Stormwater Treatment Systems (SWTSs) during system operation. Over the study period, transducers and manual measurements captured rapid increases and decreases in pond water depth due to runoff during rains and SWTS pumping, respectively. Because additional uncertainty is introduced when these large pond storage fluctuations occur, infiltration calculations focused only on periods of extended dry weather, without SWTS pumping, to allow measurement of the rate of steady decline in pond water levels. Due to the historically wet winter, this resulted in only a few periods for infiltration to be calculated within the timeframe observed and in R-2A having no usable period. Without SWTS pumping, pond levels decrease as a result of infiltration plus evaporation/evapotranspiration losses. Evaporation occurs on the open water areas of the ponds, and evapotranspiration (ET) occurs on the vegetated fringes of the ponds. Both were included in the pond water mass balance analysis.

Reference ET (ETo) represents the expected evapotranspiration (ET) from a grassy and fully saturated surface, where ET is the combination of water lost to the atmosphere from surfaces (i.e., evaporation) and through vegetation (i.e., transpiration). Daily ETo data was obtained from the two California Irrigation Management Information System (CIMIS) stations[1] near SSFL. To better reflect the mix of evaporation from open water surface and ET from vegetated pond areas, the daily average ETo from the two stations was reduced by 22 to 28 percent according to the approximate ratio of vegetation to open water surface at the pond's average depth over the study period.

The infiltration rate calculations utilized a depth-based approach rather than volume-based to evaluate pond level declines due to infiltration and evaporation. The simplification avoided potential errors associated with relying on pond storage curves and allowed a direct comparison of the change in pond depth with the depth lost to evaporation/ET and depth gained from rainfall over the pond, if any. A depth-based approach inherently assumes the water surface and the wetted ground surface along pond sides and bottom are equal in surface area, although the ground surface area is realistically some degree larger than the water surface area at any given pond depth. When a rate of change like dropping water level takes place at the water surface due to infiltration below, the rate of infiltration is slower along the ground surface because it is spread out over a larger area. This depth-based water balance approach results in equal rates of change at the water and ground surfaces by assuming they are the same area and thus may overestimate the rate of infiltration through the ground.

[1] California Department of Water Resources, California Irrigation Management Information System (CIMIS). Station 217 – Moorpark, CA; Station 219 – West Hills, CA. www.cimis.water.ca.gov.

Daily rainfall depths during the calculation periods[2] were not large enough to generate runoff into the ponds. Daily infiltration depths were calculated as the difference between daily adjusted ETo and the net change in pond depth, accounting for daily rainfall depth[3] that fell over the pond during wet weather days.

Results

Daily pond water depths and precipitation amounts over the study periods are shown by pond in Figures 1 through 3 below. Periods of declining water level during very low rainfall periods that were used for the infiltration calculations are shaded gray. Summary statistics of calculated infiltration rates are included by pond in Table 1.

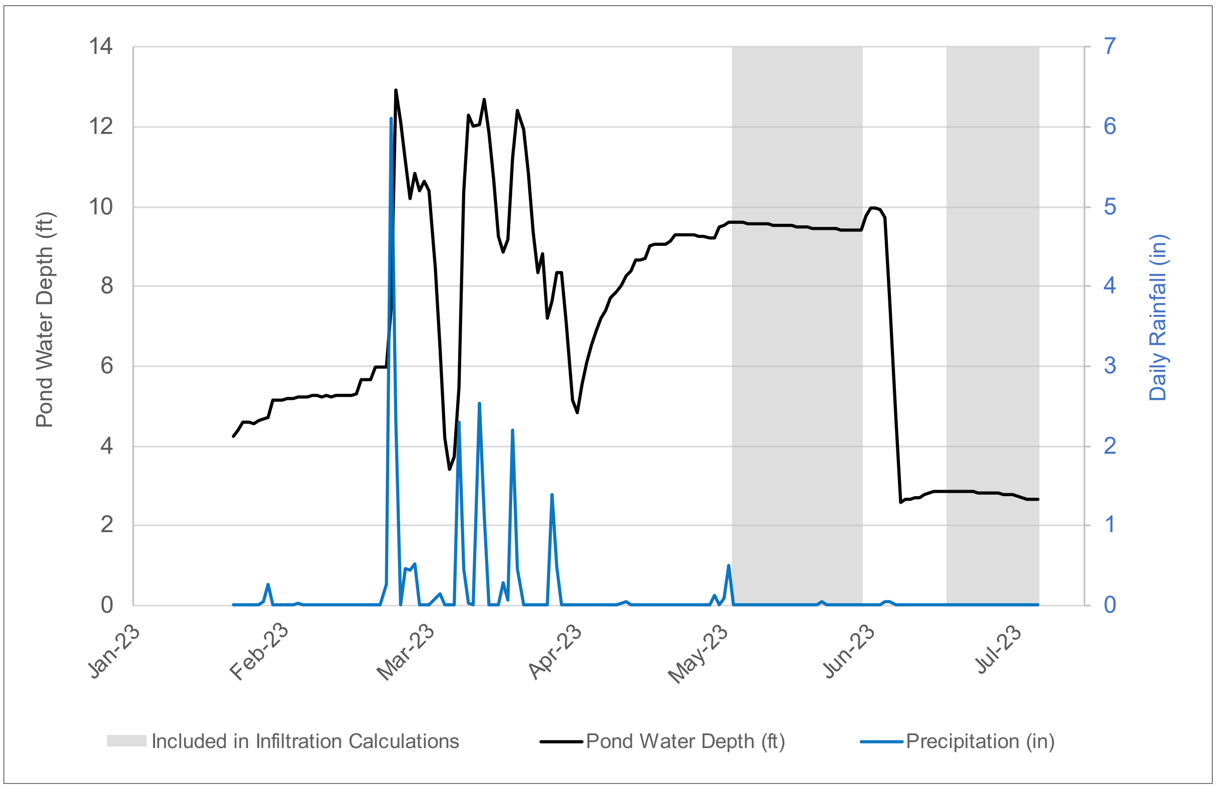

Figure 1. Water Depth and Precipitation at **Silvernale Pond**: January 23 – July 6, 2023 (gray shaded areas indicate infiltration calculation periods)

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[2] See Table 1 for the calculation period by pond.

[3] Daily rainfall data was compiled from the hourly rainfall record from the onsite rain gage in Area I of SSFL.

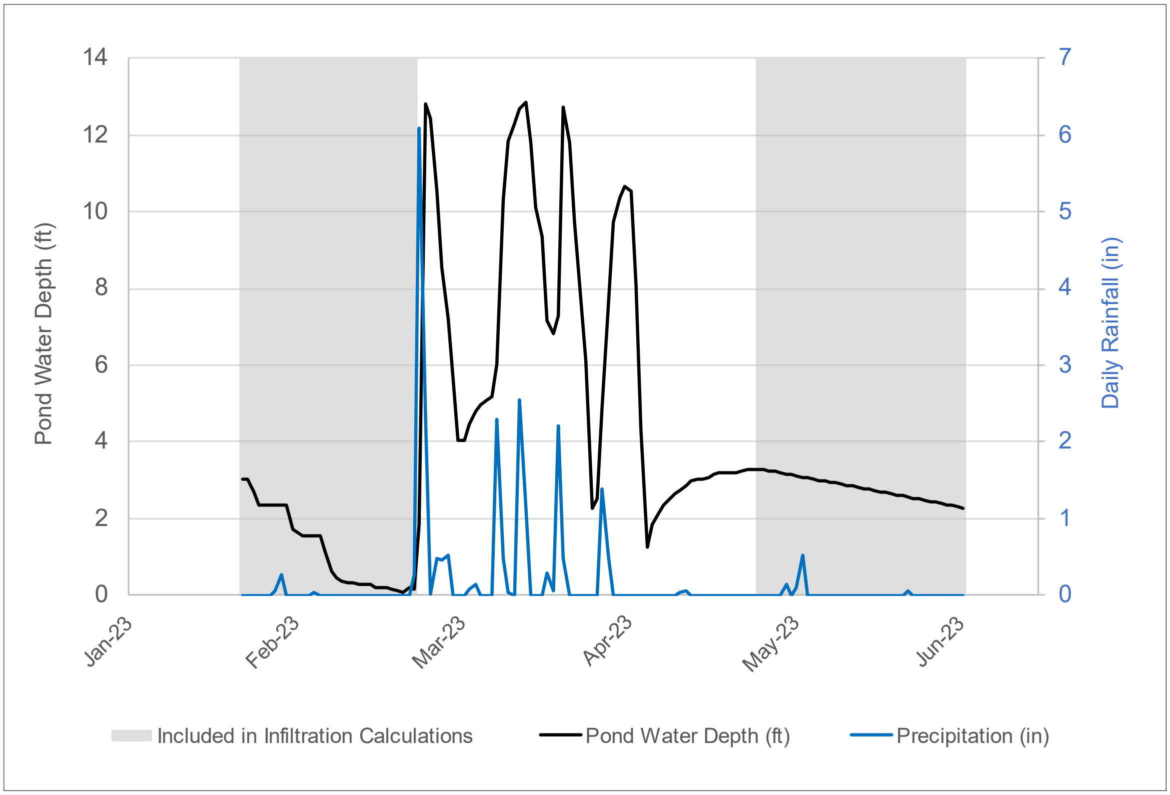

Figure 2. Water Depth and Precipitation at **R-1 Pond**: January 23 – June 2, 2023
(gray shaded areas indicate infiltration calculation periods)

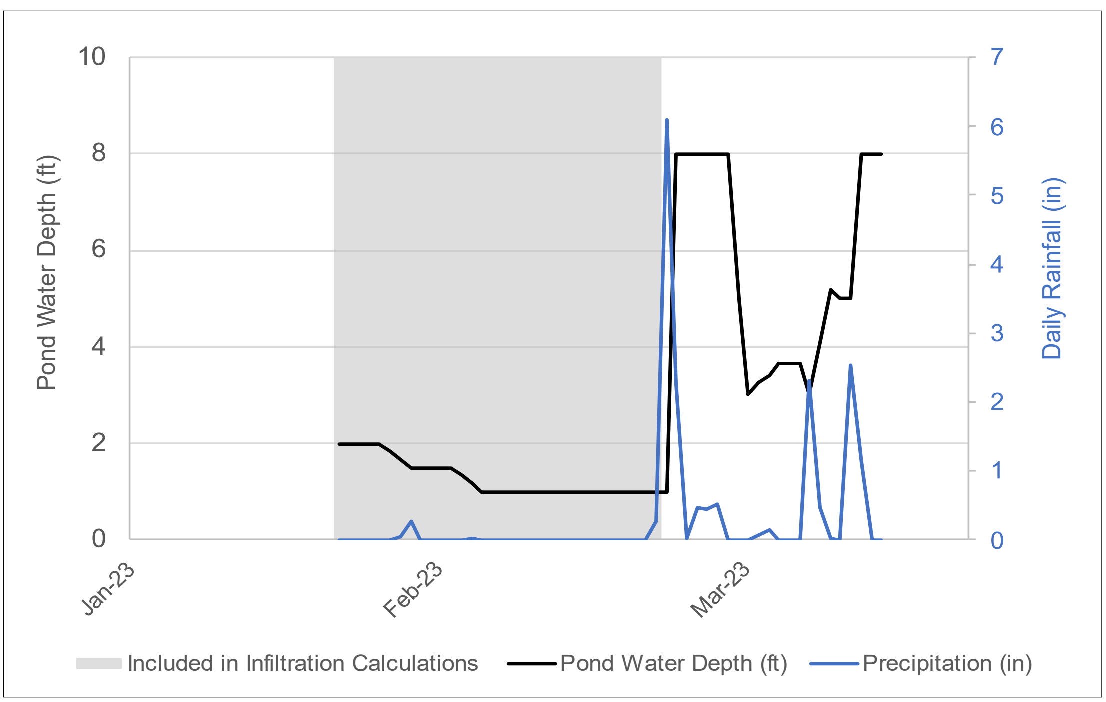

Figure 3. Water Depth and Precipitation at **Perimeter Pond**: January 23 – March 17, 2023
(gray shaded areas indicate infiltration calculation periods)

Table 1. Summary of Calculated Daily Infiltration Rates by Pond

Characteristic	Silvernale Pond[4]	R-1 Pond	Perimeter Pond
Calculation Period, 2023	5/5 – 5/31, 6/18 – 7/6	1/23 – 2/21, 4/25 – 6/2	1/23 – 2/22
Median Infiltration (in/day)	0	0.2	0
Average Infiltration (in/day)	**0.01**	**0.6**	**0.4**

The average infiltration rates summarized above in Table 1 are rates of inches per day, which, at Silvernale, R-1, and Perimeter Ponds, equate to 0.0006, 0.03, and 0.02 inches per hour respectively. The USDA Natural Resources Conservation Service (NRCS) classifies soil types into four groups, Hydrologic Soil Groups (HSGs) A through D, based on their ability to hold and transport water. HSG D soil types are clayey and the most restrictive of water transport. HSG C soil types are silty and also considered to have poor hydraulic conductivity, with saturated infiltration rates between 0.06 and 0.6 inches per hour. Average infiltration rates at the three ponds are well below 0.06 inches per hour, the standard upper infiltration rate for HSG D soils[5]. (i.e., 0.06 inches per hour is the distinction between D and C HSGs).

Conclusion

In response to recent public concerns regarding risks of stormwater infiltration within SSFL's ponds, and any associated transport of stormwater COCs to groundwater, the Surface Water Expert Panel requested water level monitoring and calculation of infiltration rates within the ponds. Results at SSFL's largest pond, or Silvernale Pond located above Outfall 018, showed water levels remained generally constant for extended periods after filling, thereby confirming that this pond is sealed and infiltration is negligible. At the two ponds above Outfall 011, R-1 and Perimeter Ponds, the average calculated infiltration rates were below the 0.06 inches per hour criteria for the least conductive hydrologic soil group (HSG D), or clay soils, therefore infiltration was very small at these ponds as well.

The SSFL Groundwater Expert Panel (GWEP) has also extensively evaluated groundwater recharge[6] sitewide. Published GWEP analyses[7] estimate that only 3.8 percent of long-term average rainfall becomes groundwater recharge at SSFL; this is a sum of all sitewide infiltration routes – i.e., on upland soils, in drainage channels, and in ponds.

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[4] Preliminary analysis referencing weekly water level measurements recorded in Spring 2022 estimated that there was no measurable infiltration at Silvernale Pond.

[5] National Engineering Handbook, Part 630. *Chapter 7: Hydrologic Soil Groups.* USDA Natural Resources Conservation Service (NRCS). Publication 210-VI-NEH, May 2007.

[6] Note that not all water infiltrated in shallow soils and sediments becomes groundwater recharge. Some is lost to soil moisture storage and evapotranspiration loss from soil root zones. Therefore, estimated quantities of infiltration and recharge will not exactly match, and infiltration amounts will typically exceed groundwater recharge amounts.

[7] Manna et al, 2016. *Groundwater recharge assessment in an upland sandstone aquifer of southern California.* Journal of Hydrology, Elsevier. July 2016.

From a surface infiltration perspective, this breakdown was further analyzed by the Surface Water Expert Panel using the preliminary LSPC watershed model, being developed and calibrated by Geosyntec Consultants in coordination with Regional Water Quality Control Board (RWQCB) staff as required under the 2022 Boeing-RWQCB Memorandum of Understanding (MOU). Using the recently measured pond infiltration rates in a multi-year hydrologic simulation, preliminary model results show that approximately 6 percent of sitewide infiltration occurs within the stormwater ponds[8] – therefore less than 0.23 percent (or 6% of 3.8%) of rainfall becomes groundwater recharge through stormwater infiltration in the ponds – which further confirms that the ponds have a marginal contribution to sitewide groundwater recharge. This result is consistent with the small percent of SSFL's area that is represented by the ponds.

Taken together, these modeling analyses and field measurements confirm that stormwater infiltration in the ponds is very low at SSFL. Furthermore, the particular COCs in stormwater that occasionally exceed the NPDES permit's water quality standard-based limits and benchmarks (e.g., iron, manganese, lead, and dioxins) are predominately in particulate form, which minimizes their downward migration as they are filtered and sorbed by sediments and decomposing organic materials in the ponds, and soils in the underlying vadose zone.

[8] This is a conservatively high estimate because the model simulation period is during pre-pumping conditions in the ponds, prior to the Stormwater Treatment Systems (SWTSs) being operational. So, there would have been longer periods of ponding and more pond infiltration during those historic periods than under existing conditions with the SWTSs in place.