2019 SEDIMENT MONITORING REPORT

NPDES PERMIT NO. WA0037061

Prepared for
LOTT Clean Water Alliance

Prepared by
Herrera Environmental Consultants, Inc.

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Prepared for
LOTT Clean Water Alliance
500 Adams Street Northeast
Olympia, Washington 98501-6911

Prepared by
Herrera Environmental Consultants, Inc.
2200 Sixth Avenue, Suite 1100
Seattle, Washington 98121
Telephone: 206-441-9080

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1. INTRODUCTION

LOTT Clean Water Alliance was issued national pollution discharge elimination system (NPDES) permit No. WA0037061 on February 16, 2018, allowing for discharge of water from the wastewater treatment plant (WWTP) (Ecology 2018). LOTT Clean Water Alliance is required to conduct a sediment study to provide the Washington State Department of Ecology (Ecology) with information regarding permit conditions specified in Sections S9.A – Sediment Baseline Sampling and Analysis Plan and S9.B – Sediment Chemistry Analysis.

Ecology's Sediment Management Standards (SMS) (Washington Administrative Code [WAC] Chapter 173 204) (Ecology 2013) provides the framework for the Sediment Source Control Program (WAC 173 204 400 through 420), which provides a process for managing sources of sediment contamination from point and nonpoint source discharges through the NPDES permit program. Sediment monitoring is conducted in support of the sediment source control process. For this study, sediment monitoring will determine the potential of the discharge to cause sediment impacts and will recharacterize conditions with which past and future conditions can be compared.

The LOTT Clean Water Alliance Budd Inlet WWTP began operation in 1952 and was upgraded to a secondary treatment facility in 1982. The WWTP is a regional facility that serves portions of the cities of Lacey, Olympia, Tumwater, and Thurston County. The facility provides advanced treatment for nitrogen removal and also treats a portion of the effluent to Class A Reclaimed Water. The facility has a maximum discharge capacity of 28 million gallons per day (MGD) over any 30-day period (Ecology 2017a). The treated effluent is discharged to Budd Inlet through an outfall and multiport diffuser extending approximately 950 feet from the shoreline.

Herrera Environmental Consultants (Herrera) prepared and implemented an Ecology-approved Sampling and Analysis Plan (SAP) to collect the required sediment information (Herrera 2019). Sediment samples were collected from five locations in the proximity of the diffuser, which is 250 feet in length. In addition, sediment samples were collected from three locations in the proximity of the emergency outfall. Sediment samples were submitted for analysis of SMS chemicals of concern (COCs). Based on chemical analytical results, biological testing (bioassays) was required for one sediment sample.

This report describes the sampling activities conducted by Herrera and presents sediment characterization results to meet sediment monitoring requirements of the NPDES permit for the LOTT Clean Water Alliance WWTP. This report includes a project description and purpose, a description of sample collection and analysis procedures, and a summary of the sediment data.

2. PROJECT DESCRIPTION

The LOTT Clean Water Alliance WWTP is located on Budd Inlet in Olympia, Washington (Figure 2-1). The facility has been in operation since 1952 and currently has a maximum discharge capacity of 28 MGD in any 30-day period. Wastewater flowing to the plant currently comes from over 100,000 homes and businesses served by the sewer utilities of Lacey, Olympia, and Tumwater. The plant operates 24 hours a day with approximately 12 million gallons of wastewater flowing through the WWTP on average each day (LOTT Clean Water Alliance 2019).

Treated effluent is discharged to Budd Inlet through a 950-foot-long outfall pipe with a 250-foot-long diffuser identified as the North outfall (see Figure 2-1). The diffuser section has 55 evenly spaced 4.625-inch-diameter ports, plus a 10-inch-diameter cleanout port at the end of the diffuser (LOTT Alliance 2015).

During emergency conditions, flows can be discharged through a 48-inch-diameter, single-port outfall located at the Fiddlehead Marina (see Figure 2-1). However, discharge at the Fiddlehead outfall occurs very infrequently (Ecology 2017a). For this study, Ecology requested that sediment sampling occur at both the North outfall and Fiddlehead outfall.

It is important to note that discharge from the WWTP is not the only source of potential sediment contamination in the area. The WWTP and its outfalls in Budd Inlet are located in an area that was reclaimed through extensive fill of the marine environment to create the City of Olympia's Port Peninsula over the course of decades. This area hosted a wide variety of historical industrial activities. The Fiddlehead outfall is located in an active marina that has been operational for many years and is also used for discharge of stormwater runoff from the city of Olympia.

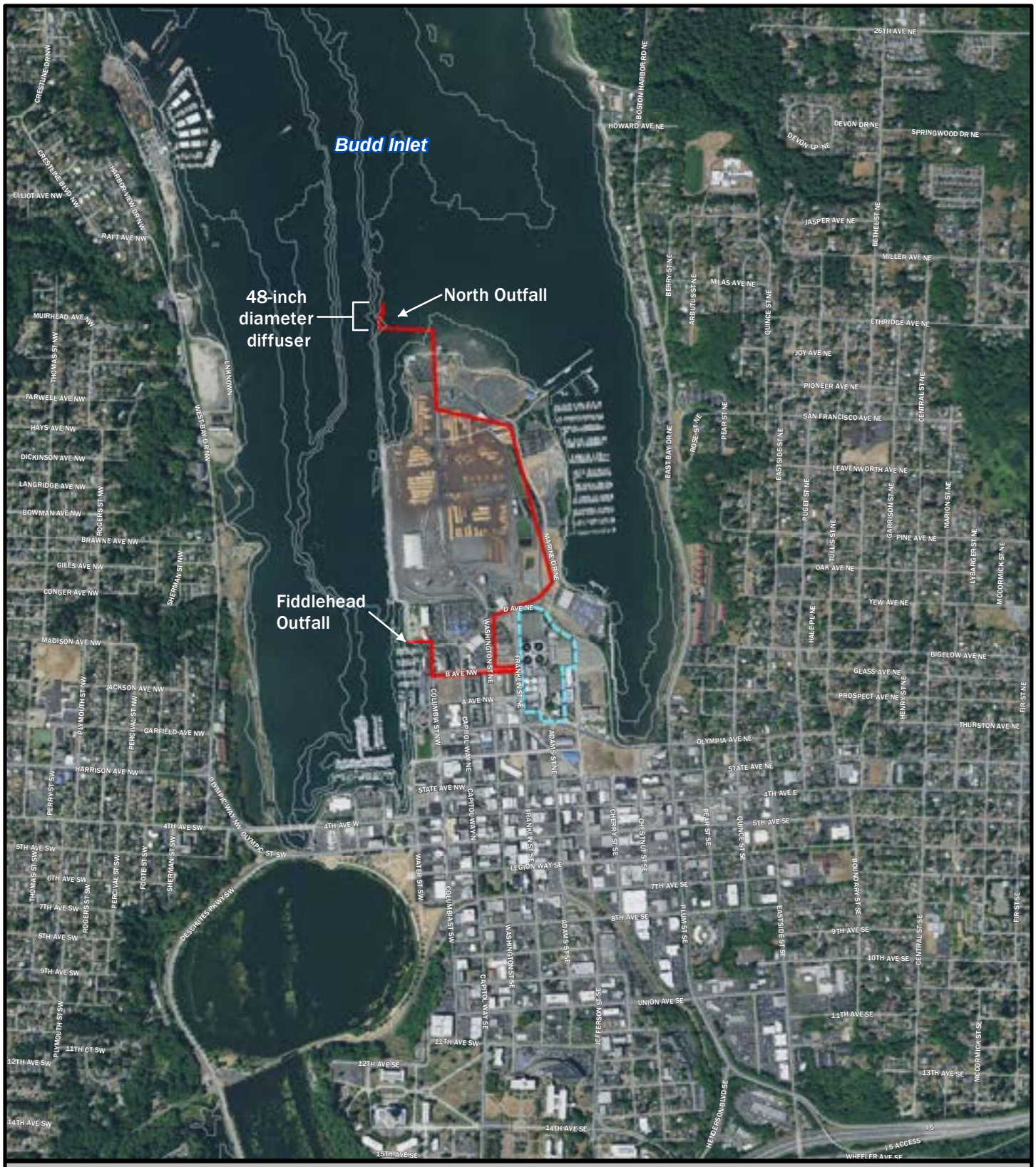

Figure 2-1.
Outfall and Vicinity Map, LOTT Clean Water Alliance Wastewater Treatment Plant, Olympia, Washington.

2.1. EXISTING INFORMATION

A search for sediment chemistry results in Ecology's Environmental Information Management System (EIM) database for the project vicinity identified a 1996 LOTT NPDES sediment monitoring study (EIM Study ID LOTT_96). A total of 10 sediment sample locations were sampled in the vicinity of the North outfall, and a total of nine sediment sample locations were sampled in the vicinity of the Fiddlehead outfall (Figure 2-2) for the following parameters:

- Conventionals (total organic carbon [TOC], total solids, total volatile solids, ammonia, and sulfides)
- Metals (arsenic, cadmium, chromium, copper, lead, mercury, silver, and zinc)
- Semivolatile organic compounds (SVOCs) including polycyclic aromatic hydrocarbons (PAHs), chlorinated benzenes (aromatics), phthalate esters (phthalates), and miscellaneous and ionizable (extractable) organic compounds
- Total polychlorinated biphenyls (PCBs)
- Pesticides
- Oil and grease

No SMS criteria exceedances were found in the samples collected near the North outfall; however, criteria exceedances were found in samples collected near the Fiddlehead outfall. Sample F-0-1 exceeded the sediment quality standard (SQS) criteria for butyl benzyl phthalate and dimethyl phthalate, and exceeded the maximum chemical concentration allowed in a sediment impact zone (SIZmax) for 4-methylphenol and bis(2-ethylhexyl) phthalate.

A sediment characterization study of existing sediment data was completed for Budd Inlet in 2008 (SAIC 2008). As part of this study, all sediment data available in EIM for Budd Inlet were evaluated for SQS and Cleanup Screening Level (CSL) exceedances as per SMS Part V. For NPDES permit-related source control projects, SQS and SIZmax criteria are the relevant criteria as per SMS Part III and IV. However, for marine sediment the SIZmax and CSL criteria values are equivalent.

Legend

- 1996 Sample locations
- Outfall pipe
- LOTT Clean Water Alliance Wastewater Treatment Plant

Figure 2-2.
1996 Sediment Sample Locations, LOTT Clean Water Alliance Wastewater Treatment Plant, Olympia, Washington.

0 325 650 1,300 Feet

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USGS, Aerial (2015)

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Figure 2-3 shows all SMS sediment criterion exceedances for data in the EIM database prior to 2008 as reported by SAIC 2008. SQS or CSL criteria exceedances are noted in the figure and these are equivalent to SQS or SIZmax criteria exceedances, as noted above. As shown in the figure, no samples were collected in the immediate vicinity of the North outfall. South of the North outfall, COCs that exceeded SMS (SQS or SIZmax) criteria in surface sediments included chlorinated aromatics, metals, polycyclic aromatic hydrocarbons (PAHs), miscellaneous extractables, phenol, and phthalates. In the area north of the outfall, miscellaneous extractables were the only SMS COC to exceed SQS or SIZmax criteria. In the immediate vicinity of the Fiddlehead outfall, COCs that exceeded SMS (SQS or SIZmax) criteria in surface sediments included miscellaneous extractables and phthalates.

In 2013, three surface sediment samples were collected in the vicinity of the North outfall as part of a sediment investigation at the Port of Olympia Budd Inlet Sediment Site (Port of Olympia 2016) (EIM Study ID G1300053). Two of the samples were analyzed for PAHs; and the third sample was analyzed for SMS marine COCs, including metals, SVOCs, and PCBs. Mercury was the only parameter that exceeded SMS criteria.

2.2. STUDY OBJECTIVES

The goals of the 2019 sediment monitoring project were to demonstrate the potential for outfall discharge to cause adverse sediment impacts and to establish conditions with which future monitoring can be compared, if needed. One surface sediment sample was collected from each of eight stations (five near North outfall and three near Fiddlehead outfall) for analysis of the following SMS marine sediment COCs:

- Metals (arsenic, cadmium, chromium, copper, lead, mercury, silver, and zinc)
- SVOCs including PAHs, chlorinated benzenes, phthalates, and miscellaneous and ionizable organic compounds
- PCBs

To facilitate the evaluation of analytical results, the sediment samples were also analyzed for the following conventional parameters:

- TOC
- Grain size
- Total sulfides
- Ammonia
- Total solids
- Total volatile solids (TVS)

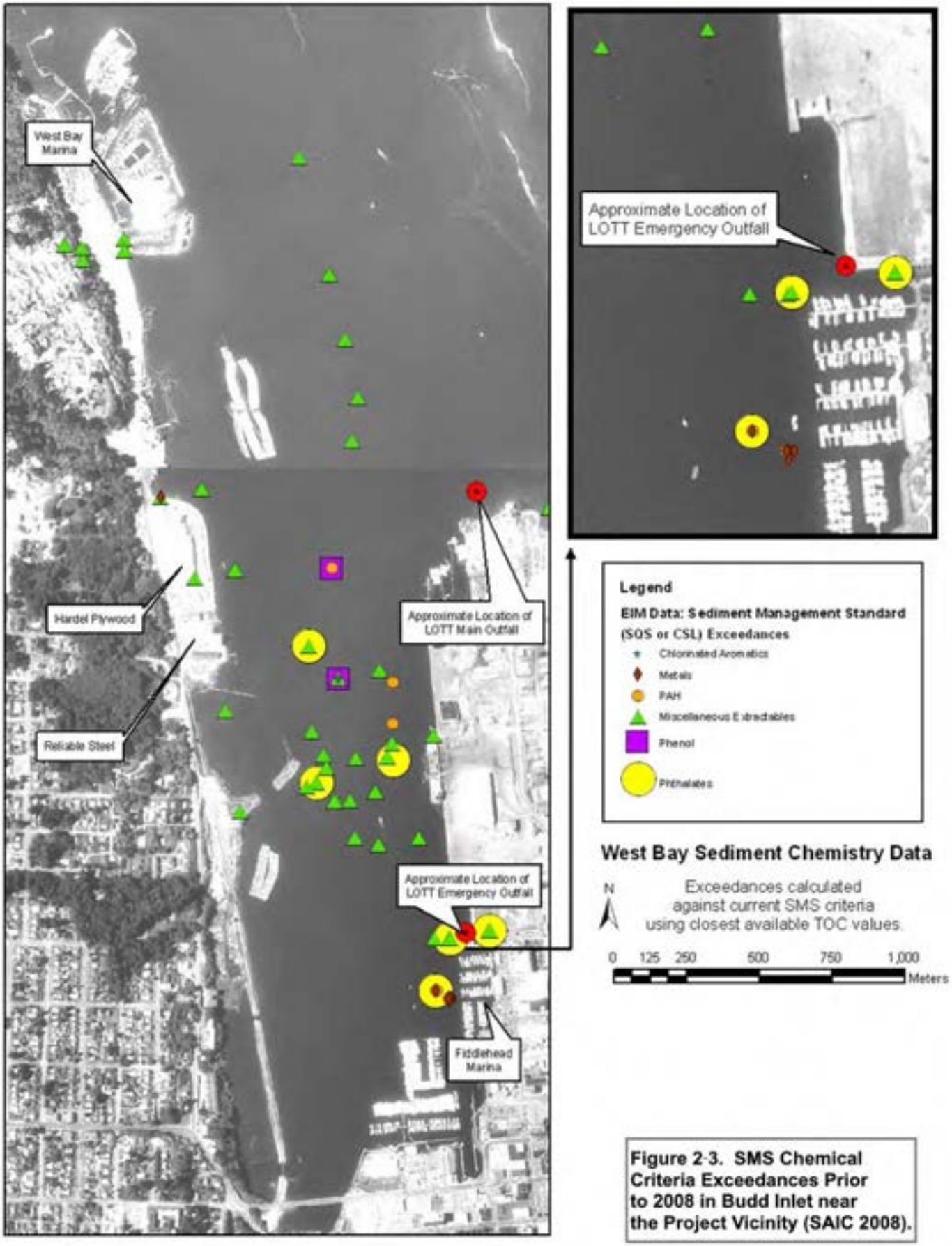


Figure 2-3. SMS Chemical Criteria Exceedances Prior to 2008 in Budd Inlet near the Project Vicinity (SAIC 2008).

The standard marine sediment chemistry suite listed above adequately characterizes potential sediment impacts from effluent discharged at the LOTT WWTP outfall based on known discharge characteristics.

Sediment chemistry data collected were compared to SMS for marine sediments. Table 2-1 presents SMS SQS (WAC 173-204-320) and SIZmax (WAC 173-204-420) chemical criteria. If one of more SQS chemical criteria were exceeded in a sample, biological toxicity (bioassay) testing was conducted for that sample location.

Three bioassay tests, including amphipod mortality, benthic larval development, and juvenile polychaete growth, were performed on sediment samples with any SMS chemical exceedances. Test interpretations consisted of endpoint comparisons to controls and reference sediment on a percentage basis, as well as statistical comparison to a reference sediment sample. The SMS biological criteria are presented in Table 2-2.

Table 2-1. SMS Chemical Criteria.		
	Sediment Management Standards (SMS)	
Chemical Parameter	Sediment Quality Standard (SQS)	Sediment Impact Zone Maximum (SIZmax)
Metals (mg/kg)		
Arsenic	57	93
Cadmium	5.1	6.7
Chromium	260	270
Copper	390	390
Lead	450	530
Mercury	0.41	0.59
Silver	6.1	6.1
Zinc	410	960
Nonionizable Organic Compounds (mg/kg organic carbon[a])		
Polycyclic Aromatic Hydrocarbons		
Total LPAH	370	780
Naphthalene	99	170
Acenaphthylene	66	66
Acenaphthene	16	57
Fluorene	23	79
Phenanthrene	100	480
Anthracene	220	1,200
2-Methylnaphthalene	38	64
Total HPAH	960	5,300
Fluoranthene	160	1,200
Pyrene	1,000	1,400
Benz(a)anthracene	110	270
Chrysene	110	460
Total benzofluoranthenes	230	450
Benzo(a)pyrene	99	210
Indeno(1,2,3-cd)pyrene	34	88
Dibenzo(a,h)anthracene	12	33
Benzo(g,h,i)perylene	31	78
Chlorinated Benzenes		
1,2-Dichlorobenzene	2.3	2.3
1-4-Dichlorobenzene	3.1	9
1,2,4-Trichlorobenzene	0.81	1.8
Hexachlorobenzene	0.38	2.3

Table 2-1 (continued). SMS Chemical Criteria.		
Chemical Parameter	Sediment Management Standards (SMS)	
	Sediment Quality Standard (SQS)	Sediment Impact Zone Maximum (SIZmax)
Nonionizable Organic Compounds (mg/kg organic carbon[a]) (continued)		
Phthalate Esters		
Dimethyl phthalate	53	53
Diethyl phthalate	61	110
Di-n-butyl phthalate	220	1,700
Butyl benzyl phthalate	4.9	64
Bis(2-ethylhexyl)phthalate	47	78
Di-n-octyl phthalate	58	4,500
Miscellaneous Extractables		
Dibenzofuran	15	58
Hexachlorobutadiene	3.9	6.2
N-nitrosodiphenylamine	11	11
Polychlorinated Biphenyls (PCBs)		
Total PCBs	12	65
Ionizable Organic Compounds (µg/kg)		
Phenol	420	1,200
2-Methylphenol	63	63
4-Methylphenol	670	670
2,4-Dimethylphenol	29	29
Pentachlorophenol	400	690
Benzyl alcohol	57	73
Benzoic acid	650	650

[a] Units in mg/kg organic carbon represent concentrations in parts per million, normalized to organic carbon. To normalize to TOC, the dry weight concentration for each parameter is divided by the decimal fraction representing the percent TOC content of the sediment.

mg/kg	Milligrams per kilogram, parts per million.
µg/kg	Micrograms per kilogram, parts per billion.
Total LPAH	Represents the sum of the following low molecular weight polycyclic aromatic hydrocarbon compounds: naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, and anthracene.
Total HPAH	Represents the sum of the following high molecular weight polycyclic aromatic hydrocarbon compounds: fluoranthene, pyrene, benz(a)anthracene, chrysene, total benzofluoranthenes, benzo(a)pyrene, indeno(1,2,3-c,d)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene.
Total benzofluoranthenes	Represents the sum of the concentrations of the "b" and "k" isomers.

Table 2-2. SMS Biological Criteria.		
	Sediment Management Standards (SMS)	
Biological Test	Sediment Quality Standard (SQS)	Sediment Impact Zone Maximum (SIZmax)
Amphipod Mortality	The test sediment has a significantly higher (t-test, $P \leq 0.05$) mean mortality than the reference sediment, and the test sediment mean mortality is more than 25 percent greater, on an absolute basis, than the reference sediment mean mortality.	The test sediment has a significantly higher (t-test, $P \leq 0.05$) mean mortality than the reference sediment, and the test sediment mean mortality is more than 30 percent greater, on an absolute basis, than the reference sediment mean mortality.
Larval Development	The test sediment has a mean survivorship of normal larvae that is significantly less (t-test, $P \leq 0.1$) than the mean normal survivorship in the reference sediment, and the mean normal survivorship in the test sediment is less than 85 percent of the mean normal survivorship in the reference sediment.	The test sediment has a mean survivorship of normal larvae that is significantly less (t-test, $P \leq 0.1$) than the mean normal survivorship in the reference sediment, and the mean normal survivorship in the test sediment is less than 70 percent of the mean normal survivorship in the reference sediment.
Juvenile Polychaete Growth	The mean individual growth rate of polychaetes in the test sediment is less than 70 percent of the mean individual growth rate of the polychaetes in the reference sediment, and the test sediment mean individual growth rate is statistically different (t-test, $P \leq 0.05$) from the reference sediment mean individual growth rate.	The mean individual growth rate of polychaetes in the test sediment is less than 50 percent of the mean individual growth rate of the polychaetes in the reference sediment, and the test sediment mean individual growth rate is statistically different (t-test, $P \leq 0.05$) from the reference sediment mean individual growth rate.

3. SAMPLING AND ANALYSIS

This section describes the procedures for positioning, sample collection, processing, sample identification, documentation, equipment decontamination, and waste handling for the field investigation, as described in the Sampling and Analysis Plan (SAP) (Herrera 2019). Samples were collected for sediment chemistry and biological toxicity (if needed) testing. Laboratory methods for chemical and bioassay toxicity analyses are presented in Section 4.

On September 23, 2019, Herrera collected sediment from eight stations located in Budd Inlet (Figures 3-1 and 3-2). Five sampling stations were established to recharacterize sediment along the North outfall; three sampling stations were established to recharacterize sediment in the vicinity of the Fiddlehead outfall. The following sample locations range from approximately 50 to 450 feet from the North outfall pipe:

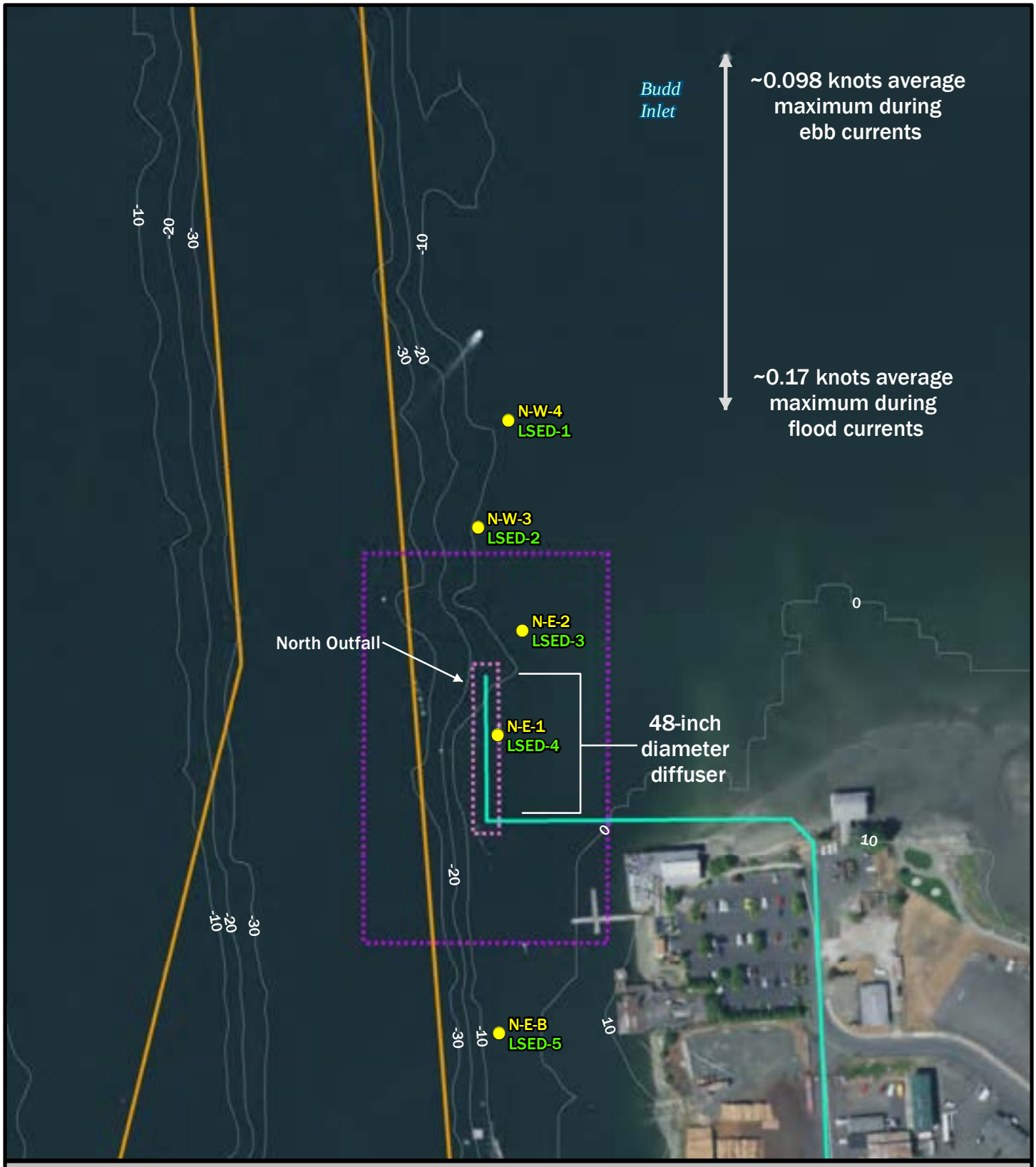
- Stations LSED-1, LSED-2, LSED-3, and LSED-5 were located in line with the diffuser pipe and the predominant current direction, which both align in a north-south direction. These stations correspond to 1996 sample Stations N-W-4, N-W-3, N-E-2, and N-E-B, respectively. Samples were collected approximately 450, 250, and 100 feet north of the diffuser pipe end (Stations LSED-1, LSED-2, and LSED-3, respectively), and 300 feet south of the beginning of the diffuser pipe (Station LSED-5).

- Station LSED-4 was located perpendicular to the diffuser pipe alignment and predominant current direction. The sample was collected 50 feet to the east of the diffuser pipe at previous sample Station N-E-1.

The following sample locations range from approximately 25 to 150 feet from the Fiddlehead outfall pipe:

- Station LSED-6 was located within 25 feet of the end of the outfall pipe and corresponds to 1996 sample Station F-0-1.

- Stations LSED-7 and LSED-8 were located approximately 150 feet to the west and southwest of the outfall pipe, respectively. Stations LSED-7 and LSED-8 were located at 1996 sample Stations F-N-2 and F-S-2, respectively.



Legend

- Outfall pipe
- Mean lower low water (MLLW) contour (feet)
- Near-bed current speed and direction
- 1996 2019 Sample location
- Navigational channel
- Mixing zone
- Acute Zone

Note: Current speeds are derived from LOTT (2009)

Figure 3-1.
Sediment Sample Locations, North Outfall, LOTT Clean Water Alliance Wastewater Treatment Plant, Olympia, Washington.

0 120 240 480 Feet

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USGS, Aerial (2015)

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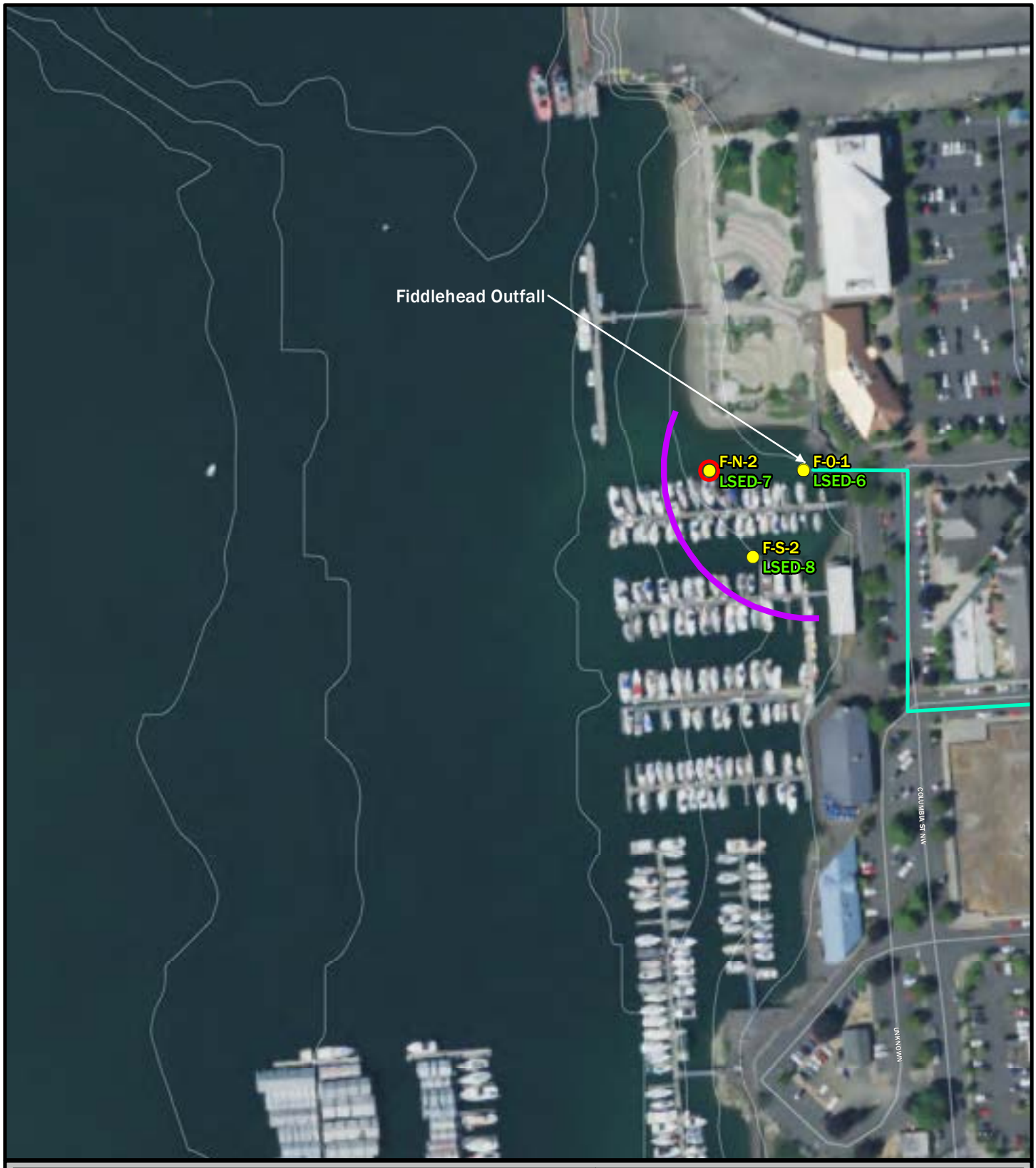

Legend

1996
2019 Sample location

Mixing zone boundary

Outfall pipe

Chemical criterion exceedance (see note)

Note for station LSED-7:

Butylbenzylphthalate result (288 ug/kg) exceeded SQS criterion of less than 63 ug/kg. Toxicity testing at this station passed all SMS criteria.

Figure 3-2.
Sediment Sample Locations, Fiddlehead Outfall, LOTT Clean Water Alliance Wastewater Treatment Plant, Olympia, Washington.

0 90 180 360 Feet

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USGS, Aerial (2015)

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3.1. STATION POSITIONING

Station positioning was accomplished using the R/V Tieton's onboard Trimble Differential global positioning system (DGPS) with Hypack Navigation. This system employs a ground-based reference station that sends carrier-phase corrections to an onboard GPS receiver to achieve sub-centimeter accuracy. The DGPS system was linked to the local Washington State Real-Time Network, which used the Puget Sound base station network. For off-pier stations, the antenna for the onboard GPS receiver was located at the end of the grab sampler deployment boom, directly above the sampling location. Station coordinates were recorded in latitude and longitude as decimal minutes with a minimum precision of four decimal places based on the North American Datum of 1983 (NAD 83). The depth of water at each of the stations was recorded from the boat's fathometer. Measured coordinates and depths are presented in Table 3-1; the navigation report is presented in Appendix B.

Table 3-1. Sample Station Coordinates and Depth, LOTT NPDES Outfall Sediment Characterization.

Sample Station	Coordinates[a]		Approximate Depth[b] (feet)
	Latitude	Longitude	
LSED-1	47.06068	-122.90618	-10
LSED-2	47.06016	-122.90637	-10
LSED-3	47.05967	-122.90604	-10
LSED-4	47.05917	-122.90619	-10
LSED-5	47.05774	-122.90611	-10
LSED-6	47.04988	-122.90420	10
LSED-7	47.04987	-122.90469	0
LSED-8	47.04957	-122.90445	0
Diffuser Outfall			
Beginning of diffuser	47.05875	-122.90625	-10
End of diffuser	47.05945	-122.90629	-10

[a] Coordinate system is NAD 1983 HARN State Plane Washington North FIPS 4601 feet. Coordinates are approximate.

[b] Mean lower low water (MLLW).

3.2. SAMPLE COLLECTION

Surface sediment samples were collected and processed as described in the SAP. Grab samples were collected using a power grab. Surface sediment was collected from the 0 to 10 centimeter (0 to 4 inch) depth interval. More than one grab sample was collected at some sample stations to obtain an adequate sample volume for all analyses required. The number of replicate grab samples and sediment characteristics were recorded on a field form (Appendix A).

Samples were always retained in the field crew's custody until samples were delivered to the laboratory by Herrera personnel. Chain-of-custody forms were initiated at the time of sample collection to ensure that all collected samples were properly documented and traceable through storage, transport, and analysis. Sample containers were placed in plastic bubble-pack bags or wrapped in bubble pack and secured with packaging tape

Samples for chemical analyses were hand-carried in a cooler with ice to the analytical laboratory at the completion of the sampling event and accompanied by the chain-of-custody records, which identified the cooler contents.

Sediment was collected for toxicity testing from all stations, pending chemistry results. All samples for toxicity testing were delivered in a cooler with ice to EcoAnalysts on September 25, 2019, for proper storage until chemistry results were available to determine if any samples required toxicity testing.

3.3. CHEMICAL ANALYSIS

The specific chemical and conventional parameters, sample preparation methods, analytical methods, and target detection limits are discussed in detail in the SAP (Herrera 2019). All samples collected for chemistry analyses were submitted to Analytical Resources, Inc. (ARI), located in Tukwila, Washington. ARI performed all chemical method analyses.

Samples were submitted for the following analyses (see Section 2):

- Conventional parameters
- Metals
- SVOCs
- PCBs

3.4. BIOASSAY ANALYSIS

Sediment Sample LSED-7 (Figure 3-2) was submitted to EcoAnalysts for biological toxicity (bioassay) testing because it failed the SQS criterion for butyl benzyl phthalate. No other chemistry results exceeded SQS or SIZmax criteria in this or any other sample.

Percent fines content (i.e., the total of the silt and clay grain size fractions) is used for pairing the appropriate reference sediment with a given test sediment. Ecology directs that test sediment percent fines should be within 20 percent of the selected reference sediment. EcoAnalysts collected a reference sediment sample (CARR 47) from Carr Inlet on October 11, 2019. Carr Inlet is an Ecology-approved reference site, and the specific sample location was selected to match

percent fines in the test sediment. Total fines content for the reference and test sediments were within 2 percent (Table 3-2).

Table 3-2. Fines Content in Reference and Project Sediment Samples for the LOTT NPDES Outfall Sediment Characterization Study.

Sample ID	Total Fines (percent)[a]
CARR 47 (reference sediment)	47
LSED-7	45

[a] Wet sieve results by bioassay lab.

The specific procedures for the suite of bioassays used for SMS biological analysis are described in detail in the SAP (Herrera 2019). Table 3-3 includes the list of organisms used in each of the toxicity tests and each primary test endpoint.

Table 3-3. Biological Tests for the LOTT NPDES Outfall Sediment Characterization.

Biological Test	Test Species	Primary Endpoint(s)
Amphipod Mortality (10-Day)	*Eohaustorius estuarius*	Mortality
Benthic Larval Development	*Mytilus galloprovincialis*	Survivorship
Juvenile Polychaete Survival and Growth (20-Day)	*Neanthes arenaceodentata*	Growth Rate

3.5. Quality Assurance and Quality Control

A QA1 data validation was performed on the chemistry data. The QA1 data validation checklist is presented in Appendix C. The laboratory flagged reported data detected above the method detection limit (MDL), but below the reporting limit (RL), as estimated (J). All data were acceptable as reported by the laboratory, with the following exceptions:

- Due to matrix spike recoveries outside of control criteria, the TOC and sulfides results for Sample LSED-01 were flagged as estimated (J).

Estimated values were used in the data analysis.

3.6. Deviations from the SAP

Sampling and laboratory analysis of chemistry parameters did not deviate from the SAP. Laboratory analysis of biological toxicity tests did not deviate from the SAP, with the following exception:

> The species identified in the SAP for benthic larval development, *Dendraster excentricus*, was no longer spawning at the time that the testing was scheduled. Therefore, the larval development test was conducted with mussel species, *Mytilus galloprovincialis*, which is the preferred species for testing.

4. RESULTS

Validated test results of the LOTT NPDES sediment characterization study are summarized in this section. Conventional and chemical concentrations, and bioassay results are summarized below. All conventional, chemical, and bioassay data have undergone a Quality Assurance Level 1 (QA1) data validation (see Section 3.5).

For marine sediments, SMS SQS and SIZmax chemical criteria are based on either dry weight concentrations or organic carbon-normalized concentrations. Concentrations of nonpolar organic compounds based on dry weight are normalized by the amount of organic carbon present in the sample. However, as recommended in SCUM II (Ecology 2017b), if the total organic carbon content of the sediment is relatively low (less than 0.5 percent) or high (greater than 3.5 percent), results should be compared to apparent effects thresholds (AETs) based on dry weight (Michelsen 1992). SMS SQS, SIZmax, and AET criteria are presented in Appendix A Tables A-1 and A-2.

Sediment sample records and data tables are presented in Appendix A. In the data tables (Tables A-1 and A-2), values exceeding SQS (or AET where applicable) chemical criteria are highlighted in gray. The reporting limits for 1,2,4-trichlorobenzene and hexachlorobenzene exceeded SQS chemical criteria in some samples. Therefore, as described in the SAP, the method detection limit (MDL) for these two compounds was used to compare to SMS criteria. Chemistry and bioassay laboratory reports (including chain of custody forms) are presented in Appendix B. The QA1 data validation checklist is provided in Appendix C.

Several chemical groups are represented by a total concentration, including low molecular weight polycyclic aromatic hydrocarbons (LPAHs), high molecular weight polycyclic aromatic hydrocarbons (HPAHs), and polychlorinated biphenyls (PCBs). Total concentrations are calculated by summing detected results. If all results are non-detect, then the maximum reporting limit (RL) of any one constituent is used as the RL for the associated total.

Results are summarized separately for physical description (Section 4.1), SMS chemical parameters (Section 4.2), and bioassay testing (Section 4.3).

4.1. PHYSICAL DESCRIPTION

The material observed in the surface sediment samples collected from Stations 1 through 5, 7, and 8 consisted of a gray to dark gray silty sand or fine sand. Stations 1 through 5 had a dark brown surface layer. The material observed in the surface sediment sample from Station 6 consisted of a dark gray sandy gravel or gravelly sand. Sulfur odors were noted at all stations with the exception of Station 8. Shells and shell fragments were observed at all stations.

4.2. CHEMICAL PARAMETERS

4.2.1. Conventionals

4.2.1.1. North Outfall

Total fines ranged from 22.4 percent to 58.4 percent at stations sampled near the North outfall (LSED-1 through LSED-5). Total fines at the stations farthest from the outfall (42.6 and 58.4 percent LSED-1 and LSED-5, respectively) were approximately two times the total fines found nearest the outfall (ranging from 22.4 to 26.0 percent at Stations LSED-2 through LSED-4). TVS ranged from 3.7 to 8.8 percent and was highest furthest from the outfall. TOC ranged from 1.1 to 2.5 percent, which is within the acceptable range of 0.5 to 3.2 percent for OC normalized criteria. Total sulfides ranged from 366 to 1,570 mg/kg and was highest furthest from the outfall. Ammonia ranged from 11 to 16 mg/kg and was highest at the outfall and south of the outfall.

4.2.1.2. Fiddlehead Outfall

Concentrations of conventional parameters were lower at the outfall (LSED-6) than 150 feet from the outfall (LSED-7 and LSED-8). Total fines ranged from 19.4 percent to 74.3 percent at the Fiddlehead outfall stations. Total fines was significantly less at the outfall station (19.4 percent at LSED-6) than 150 feet from the outfall (58.0 percent at LSED-7 and 74.3 percent at LSED-8). TVS ranged from 7.2 percent at the outfall to 14.2 percent at LSED-8. TOC ranged from 2.2 percent at the outfall to 4.7 percent at LSED-7 and 4.1 percent at LSED-8 (exceeding the acceptable range of 0.5 to 3.2 percent for OC normalized criteria). Total sulfides ranged from 881 mg/kg at the outfall to 2,310 mg/kg at LSED-7. Ammonia ranged from 14.2 mg/kg at the outfall to 32.5 mg/kg at LSED-8.

4.2.2. SMS Chemical Parameters

All results for chemical parameters are compared to SMS SQS and SIZmax criteria in Appendix A. Table A-1 presents dry weight results for all parameters. Table A-2 presents OC normalized results for nonpolar organic compounds (PAHs, chlorinated benzenes, phthalates, miscellaneous organic compounds, and PCBs). The high TOC concentrations for LSED-7 and LSED-8 (greater than 3.5 percent) require comparison of nonpolar organic compound results to dry weight AETs (Table A-1) rather than OC normalized SMS criteria (Table A-2).

4.2.2.1. Metals

Metals were detected above the RLs in all samples at low concentrations. All metals concentrations were well below the SQS criteria.

4.2.2.2. Semivolatile Organic Compounds

SVOCs were detected in all samples. The most common SVOCs detected were:

- PAHs (detected in all samples)
- 1-4-diclorobenzene (detected in LSED-3 through LSED-6)
- butyl benzyl phthalate (detected in all samples except LSED-2)
- bis(2-ethylhexyl) phthalate (detected in all samples except LSED-1, LSED-2, and LSED-3)
- dibenzofuran (detected in all samples except LSED-1 and LSED-2)
- phenol (detected in all samples except LSED-1)
- 4-methylphenol (detected in all samples)
- benzoic acid (detected in all samples except LSED-2, LSED-3, and LSED-4).

All SVOC results were less than SMS SQS criteria except for butyl benzyl phthalate detected at 288 µg/kg (versus the SQS criterion of 63 µg/kg) for Station LSED-7 located 150 feet from the Fiddlehead outfall (see Figure 3-2).

4.2.2.3. PCBs

Low levels of total PCBs were detected in all samples. The OC normalized concentrations for Stations LSED-1 through LSED-6 ranged from 0.5 to 1.0 mg/kg OC, and were well below the SQS criterion of 12 mg/kg OC. The dry weight concentrations for Fiddlehead outfall Stations LSED-7 (25.8 µg/kg) and LSED-8 (31.3 µg/kg) were well below the SQS criterion of 130 µg/kg.

4.2.3. Historical Comparison

At the North outfall, no exceedances of SQS or SIZmax criteria were observed at stations sampled in 1996 or 2019.

At the Fiddlehead outfall, sediment sampled in 1996 from the outfall exceeded the SQS criterion (63 µg/kg) for butyl benzyl phthalate (290 µg/kg), and exceeded SIZmax criteria (1,900 µg/kg and 670 µg/kg, respectively) for bis(2-ethylhexyl)phthalate (31,000 µg/kg) and 4-methylphenol (16,000 µg/kg). In 2019, only one exceedance of the SQS criterion for butyl benzyl phthalate (63 µg/kg) was observed in sediment collected 150 feet from the outfall (288 µg/kg).

4.3. BIOLOGICAL TOXICITY

The SMS biological effects criteria are presented above in Table 2-2. Biological test results are presented in Table 4-1. As shown in Table 4-1, Sample LSED-7 passed all SQS and SIZmax criteria for all three toxicity tests. The bioassay laboratory report is provided in Appendix C.

4.3.1. Amphipod Mortality

Station LSED-7 passed SMS amphipod mortality criteria with a mortality rate of 8 percent relative to the reference sediment sample (CAR 47).

4.3.2. Benthic Larval Development

Station LSED-7 passed SMS larval development criteria with a mean normal survivorship of 103 percent of the reference sediment sample (CAR 47).

4.3.3. Juvenile Polychaete Growth

Station LSED-7 passed SMS juvenile polychaete growth criteria with a mean individual growth rate of 113 percent of the reference sediment sample (CAR 47).

Table 4-1. Biological Toxicity Test Results Compared to SMS Criteria for the LOTT NPDES Outfall Sediment Characterization Study.

Test	Measure	SQS	SIZmax	Sample LSED-7
Amphipod Mortality	Significantly higher than reference	Yes	Yes	No
	Mortality percent relative to reference	>25%	>30%	8%
Larval Development	Significantly lower than reference	Yes	Yes	No
	Mean normal survivorship percent of reference	<85%	<70%	103%
Juvenile Polychaete Growth	Significantly lower than reference	Yes	Yes	No
	Mean individual growth rate percent of reference	<70%	<50%	113%

5. CONCLUSIONS

A total of eight surface sediment samples were collected in September 2019 in compliance with NPDES permit No. WA0037061 for LOTT Clean Water Alliance and the Ecology-approved SAP. Five samples were collected up to 450 feet from the primary North outfall and three samples were collected up to 150 feet from the emergency Fiddlehead outfall. All samples were analyzed for conventional parameters, metals, SVOCs, and PCBs and compared to SMS criteria, yielding the following conclusions:

- Metals – Did not exceed any SMS criteria at any station.
- SVOCs –Only the SQS criterion for butyl benzyl phthalate was exceeded at Station LSED-7 located 150 feet west of the Fiddlehead outfall.
- PCBs – Did not exceed any SMS criteria at any station.

In general, low chemical concentrations were found across the site that were well below SMS criteria. One exception is the elevated concentration of butyl benzyl phthalate at Station LSED-7, which is located 150 feet west of the Fiddlehead outfall and required biological toxicity testing. Sediment collected from Station LSED-7 passed all SQS biological toxicity criteria with a low amphipod mortality, high benthic larval development, and high juvenile polychaete growth relative to a reference sample.

The 2019 LOTT NPDES outfall sediment characterization study successfully evaluated surface sediment quality in the vicinity of the North and Fiddlehead outfalls. The chemical and biological test results clearly indicate there are no adverse sediment impacts to benthic organisms from the outfalls. The high quality results of this investigation establishes conditions with which future monitoring results can be compared.

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