FINAL SAMPLING AND ANALYSIS PLAN

Oakland Bay Sediment Characterization Study, Mason County, Washington

Prepared for

Washington Department of Ecology
Toxics Cleanup Program
Southwest Regional Office

September 2008

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Prepared for

Washington Department of Ecology
Toxics Cleanup Program
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Abbreviations and Acronyms

CFR	Code of Federal Regulations
cm	centimeter
COC	chain-of-custody
COPC	Constituents of Potential Concern
CRI	color rendering index
CSL	cleanup screening level
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DGPS	Differential Global Positioning System
DMMP	Dredged Material Management Program
dpm	disintegrations per minute
DQO	data quality objective
EDD	electronic data deliverable
E & E	Ecology and Environment, Inc.
Ecology	Washington State Department of Ecology
ft	feet (foot)
g	gram
GC/MS	gas chromatography/mass spectroscopy
HCID	hydrocarbon identification
Herrera	Herrera Environmental Consultants, Inc.
HPAH	high molecular weight polycyclic aromatic hydrocarbons
HRGS	Human reporter gene system
in	inch
kg	kilogram
L	liter
LCS	laboratory control sample
LPAH	low molecular weight polycyclic aromatic hydrocarbon
m	meter
MDL	method detection limit
µg	microgram
mg	milligram
MLLW	mean lower low water
MSDS	material safety data sheet
MSMP	Marine Sediment Monitoring Program
MS/MSD	matrix spike / matrix spike duplicate
NAD 83	North American Datum of 1983
nm	nanometer
NWTPH	northwest total petroleum hydrocarbon
OC	organic carbon
oz	ounce
PAH	polycyclic aromatic hydrocarbon

PARCC	precision, accuracy, representativeness, completeness, comparability
PCB	polychlorinated biphenyl
PCP	pentachlorophenol
PE	performance evaluation
ppb	parts per billion
PPE	personal protective equipment
ppt	parts per trillion
PQL	practical quantitation limit
PSDDA	Puget Sound Dredged Disposal Analysis
PSEP	Puget Sound Estuary Program
QA/QC	quality assurance / quality control
RI	Remedial Investigation
RL	reporting limit
RPD	relative percent difference
SAP	Sampling and Analysis Plan
SBP	Sub-Bottom Profiler
SIR	Sediment Investigation Report
SMS	Sediment Management Standards
SOPs	standard operating procedures
SQS	Sediment Quality Standard
SSAPA	Sediment Sampling and Analysis Plan Appendix
ft^2	square feet (foot)
m^2	square meter
SVOC	semi-volatile organic compound
TBT	tributyltin
TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
TDL	target detection limit
TEF	toxic equivalent factor
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TVS	total volatile solids
USEPA	U.S. Environmental Protection Agency
UV	ultraviolet
WAAS	Wide Area Augmentation System
WAC	Washington Administrative Code
WDOH	Washington Department of Health
WHO	World Health Organization
WWTP	wastewater treatment plant

1.0 Introduction

Oakland Bay is one of seven bays identified as a priority for environmental cleanup by the Washington State Department of Ecology (Ecology) as part of the Toxics Cleanup Program's Puget Sound Initiative. Ecology has identified Oakland Bay for focused sediment investigation related to source control, sediment cleanup and restoration. Ecology initiated this sediment investigation because previous environmental investigations throughout the bay, including the Shelton Harbor area, have documented contamination from historical and current industrial and commercial activities around the bay. Previous sediment quality investigations indicated that contaminant concentrations exceeded Chapter 173-204 Washington Administrative Code (WAC) Sediment Management Standards (SMS). Ecology is directing a sediment characterization investigation and a geophysical survey of the bay that will include assessment of potential contamination across the entire bay and assessment of the marine sediment environment associated with terrestrial and aquatic contaminant sources. Herrera Environmental Consultants, Inc. (Herrera) developed this Sampling and Analysis Plan (SAP) as a subcontractor to Ecology and Environment, Inc. (E & E) under Ecology's contract number C0700036 for the purpose of characterizing marine sediment throughout Oakland Bay to support the prioritization of cleanup and restoration actions under the Puget Sound Initiative.

In 2007, the Puget Sound Partnership was established to oversee and coordinate the Puget Sound Initiative into the future. The following objectives for a Puget Sound 2020 Action Agenda were then developed:

- Protect existing habitat and prevent further losses
- Restore habitat functions and values
- Significantly reduce toxics entering Puget Sound fresh and marine waters
- Significantly reduce nutrients and pathogens entering Puget Sound fresh and marine waters
- Improve water quality and habitat by managing storm water runoff
- Provide water for people, fish and wildlife, and the environment
- Protect ecosystem biodiversity and recover imperiled species
- Build and sustain the capacity for action.

To address elements of the first three objectives listed above, efforts will focus on cleaning up toxic sites and preventing new ones. A leading source of pollution to the Sound is contaminated sites around its shorelines. Ecology's Toxics Cleanup Program is in the process of identifying contaminated sites within one-half mile of the Sound and has targeted efforts to clean up and restore contaminated sites within seven priority bays, including Oakland Bay. The baywide

approach, rather than a site-specific approach, has been developed to prioritize cleanup of numerous sites within a geographic area.

The Toxics Cleanup Program relies on the MTCA regulations (Chapter 173-304 WAC) that set strict cleanup standards to ensure that the quality of cleanup and protection of human health and the environment are not compromised. The regulations establish protocols for determining whether to formally establish a site of concern based on a series of assessments performed either by Ecology or potentially liable parties. The Sediment Management Standards (SMS) are a set of regulations (Chapter 173-204 WAC) established, in part under the authority of MTCA, to reduce adverse effects on biological resources and significant health threats to humans from surface sediment contamination. This is accomplished by establishing sediment quality standards, applying the standards as the basis for management and reduction of pollutant discharges, and providing a management and decision process for the cleanup of contaminated sediments (173-204-100 WAC).

Within the context of the programs and regulations cited above, the overall goals for the Puget Sound Initiative baywide studies include:

- Determine boundaries where SMS criteria are exceeded
- Allow relative prioritization of areas for cleanup
- Provide sufficient physical, chemical, and biological data to identify a range of remedial alternatives that can be considered.

This study focuses on marine sediment characterization across Oakland Bay, with an emphasis on locations associated with specific upland inputs to the Bay, with locations associated with wood deposition, and with the distribution of contaminants moving across the bay from Shelton Harbor, as well as an overall assessment of bay. This plan describes the objectives and procedures for data collection efforts to characterize the sediment quality of Oakland Bay. The results of the sediment characterization will be used to assist Ecology in determining whether source control, cleanup, or further characterization or analysis is warranted to minimize actual or potential adverse impacts to people and/or the biotic community. This plan includes the following primary sections:

- Introduction
- Site Background and Objectives
- Organization and Schedule
- Study Design
- Quality Assurance / Quality Control
- Field Procedures
- Laboratory Analytical Methods
- Data Analysis and Reporting.

The SAP addresses the major components of Ecology's *Sediment Sampling and Analysis Appendix, Guidance on the Development of Sediment Sampling and Analysis Plans Meeting the Requirements of the Sediment Management Standards* (Chapter 173-204) (2008) and Ecology's *Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies* (2004a), and meets the requirements of Puget Sound Estuary Program (PSEP) guidelines (1996).

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2.0 Site Background and Objectives

Oakland Bay is a shallow estuary located in South Puget Sound, with the City of Shelton and its industrial waterfront and harbor located at the southwest corner of the bay (Figures 2-1 and 2-2). Water depth of the bay generally ranges between 10 and 35 ft, with shallow and broad intertidal zones exposed during low tides at the north end of the bay and in Shelton Harbor. Due to the restrictive nature of Hammersley Inlet, a long narrow waterway linking the bay to the Puget Sound Basin, the water in Oakland Bay has high refluxing, low flushing, and high retention rates (Ecology 2004b). Eight major freshwater creeks discharge into the bay: Deer, Cranberry, Malaney, Uncle John, Campbell, Johns, Shelton, and Goldsborough. The waters of Shelton Harbor and the northern portions of Oakland Bay are currently listed as impaired by the State of Washington under Section 303(d) of the Clean Water Act because of fecal coliform bacteria levels (Ecology 2004c).

The Shelton waterfront and harbor have been historically and are currently used by a number of timber and wood product manufacturing industries, including saw mills and plywood manufacturing, pulp and paper production, and insulation board and fiber board manufacturing. Over the years, process chemicals and wastewater from wood-product manufacturing processes have either been discharged through onsite industrial stormwater systems or were released due to accidental spills and leaks to the harbor, to Shelton and Goldsborough Creeks, or across upland portions of the waterfront. Discharges and spills of process chemicals and wastewater have included:

- Release of sulfite waste liquor generated from the former Rayonier pulp mill during outgoing tides from the mid-1920s through the early 1930s. It was believed that the release of the liquor to the bay may have been an important factor in declining commercial oyster production in Oakland Bay by the mid-1940s. Anecdotal evidence indicates that this waste material, at times, had been seen floating on the water surface in the northern portion of Oakland Bay (Ragan 2008). Tidal flushing into northern Oakland Bay occurs during seasonal cycles of the Bay.

- Release of air emission particulates from wood-fired power plants and associated emission stacks operated without air emissions control from Simpson and Rayonier mills along the south shore of Shelton Harbor between the mid-1920s and the late 1950s. Although power plants for the Rayonier pulp mill and burn plant were shut down by 1957, Simpson's main power plant and its associated stacks continued operating without emission control until 1976, when baghouses were installed.

- Residues from both baghouses were mixed into slurries and discharged to both the former wastewater treatment plant (WWTP) on Pine Street (1976 to 1979) and to the existing plant at Eagle Point (1979 to 1984). WWTP effluent was discharged at two locations immediately beyond the harbor

limits. Solids that settled out at each WWTP were disposed of at two public landfills (the Shelton "C Street" Landfill and the Mason County Landfill) and at the Dayton wood waste landfill owned by Simpson. After 1984, all residues generated at the Simpson plant were disposed of at their Dayton wood waste landfill.

- Various chemicals used at a former ITT Rayonier Research Laboratory specializing in cellulose chemistry and silvichemicals produced from wood pulp were discharged to the harbor through the laboratory's industrial stormwater discharge system from the mid-1930s to the mid-1990s.

- A wood preservative dip tank (location unknown) was referred to in a 1981 Ecology file. A letter stated that approximately 9,400 gallons of dilute Permatox 200 wood preservative was removed and disposed of by spraying it across the Simpson Dayton dry log sort yard. According to a material safety data sheet (MSDS), the preservative contained chlorinated phenols and pentachlorophenol (PCP).

- Residual Bunker C fuel oil releases to soil and groundwater from leaking aboveground storage tanks previously located between Sawmill #3 and Goldsborough Creek were identified in 1991. Limited removal of contaminated soil was conducted; however, residual contamination was left in place along Goldsborough Creek, the railroad tracks, and a metal frame tower.

- Numerous spill incidents reportedly occurred between 1980 and 2004. Most of the reported spills were petroleum products, including hydraulic oil, soluble or biodegradable lube oil, gear oil, and diesel. Other reported spills included polychlorinated biphenyl (PCB)-contaminated oil next to the railroad roundhouse in 1984; resin and veneer wastewater discharged to Shelton Creek in 1987 and 1988; and waste oil contaminated with PCBs adjacent to the plywood plant near Shelton Creek in 1990.

Numerous pilings have been installed in the harbor since the mid-1920s to support over-water railroad spurs used for unloading logs from trains directly into the water, for stabilizing log rafts, and for shoreline bulkheads.

Barges loaded with wood chips used by the pulp mill for processing into pulp, have historically moored in the harbor adjacent to the pulp mill. Logs used in lumber, plywood, and fiber board manufacturing were rafted and stored in the water prior to processing at sawmills and plywood plants from the late 1800s through the late 1960s. By the early 1970s, Simpson shifted its log handling practices from over-water log storage operations to a dry log sort yard located 3 miles west and inland from Shelton. Some log rafting activities have continued in the harbor since the

Figure 2-1. Vicinity map of Oakland Bay in Mason County, Washington.

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Figure 2-2. Site map of Shelton Harbor, Shelton, Washington.

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mid-1970s, including the Simpson log truck unloading facility at the north end of the harbor next to the vessel haul-out and marine railway facility, and along the south shore of the harbor adjacent to the Manke log sorting yard. Wood waste is a concern because it can impact aquatic life and sediment quality. Excessive wood waste can lead to anaerobic sediment conditions, leach compounds toxic to aquatic life (e.g., phenols, benzoic acid, and benzyl alcohol), and may not provide an appropriate substrate for benthic organisms.

From the early 1900s to late 2005, a bulk fuel storage marine facility operated at the north end of Shelton Harbor (also known as the former Evergreen Fuel site; Figure 2-2). In addition to Evergreen Fuel, three bulk fuel storage marine facilities operated about a half mile northeast of Shelton along the west shore of Oakland Bay (Union Oil, Shell, and ARCO) from the early 1930s to the mid-1980s. No site assessments have been conducted to determine whether petroleum releases have occurred at any of the three bulk fuel facilities.

Tributyltins (TBT), used as an anti-fouling agent on boat bottoms, have been found in sediments collected adjacent to the former Simpson marine railway. The presence of TBT in sediment is likely due to historical and current activities, such as sandblasting, cleaning, and painting of log boom boat bottoms and other boats, conducted in the vicinity of the Shelton Marina.

Shelton Harbor has also received discharges from the city's former and existing WWTP outfalls; septic systems; timber industries, commercial businesses, and residential communities; and non-point source runoff from stormwater since the early 1900s. The harbor also receives direct surface water discharge from two freshwater creeks, Shelton and Goldsborough Creeks, both of which flow through and have received industrial stormwater runoff from the Simpson waterfront plant since the early 1940s.

Other sites identified as potential sources of contamination located at a distance from Shelton Harbor and near Oakland Bay or adjacent to creeks that drain into the bay (see Figure 2-1) include:

- Two gasoline service stations operating since the early 1970s, including one station located along SR 3 adjacent to Johns Creek (Bayshore Union 76 gas station) and the other approximately 2,300 ft northeast of the Oakland Bay shoreline (Deer Creek store). Gasoline contamination in soil and groundwater was identified at the Deer Creek station.

- A concrete dip tank that previously contained wood preservatives for treating fence posts was identified at the Calvin J. Moran property adjacent to the bay. The concrete tank has reportedly overflowed during periods of heavy rainfall since last used in 1960.

Shellfish harvesting has historically been an important commercial and subsistence activity in Oakland Bay. Commercial shellfish harvesting became an important aquaculture industry starting in the late 1800s. Pollution associated with sulfite waste liquor discharged by the Rayonier pulp mill is believed to have led to declining commercial oyster production by the mid-

1940s. Re-populating with oysters and other shellfish in the northern portions of Oakland Bay, including Chapman Cove, and developing a second-generation of shellfish production began in the late 1960s.

Over the last 40 years, water quality impacts to Oakland Bay appear to have shifted from industrial effluent to non-point source pollution. Fecal coliform contamination has contributed to recent closures of shellfish harvesting in portions of the bay. Fecal coliform contamination is being investigated by other stakeholders and thus is not part of this investigation.

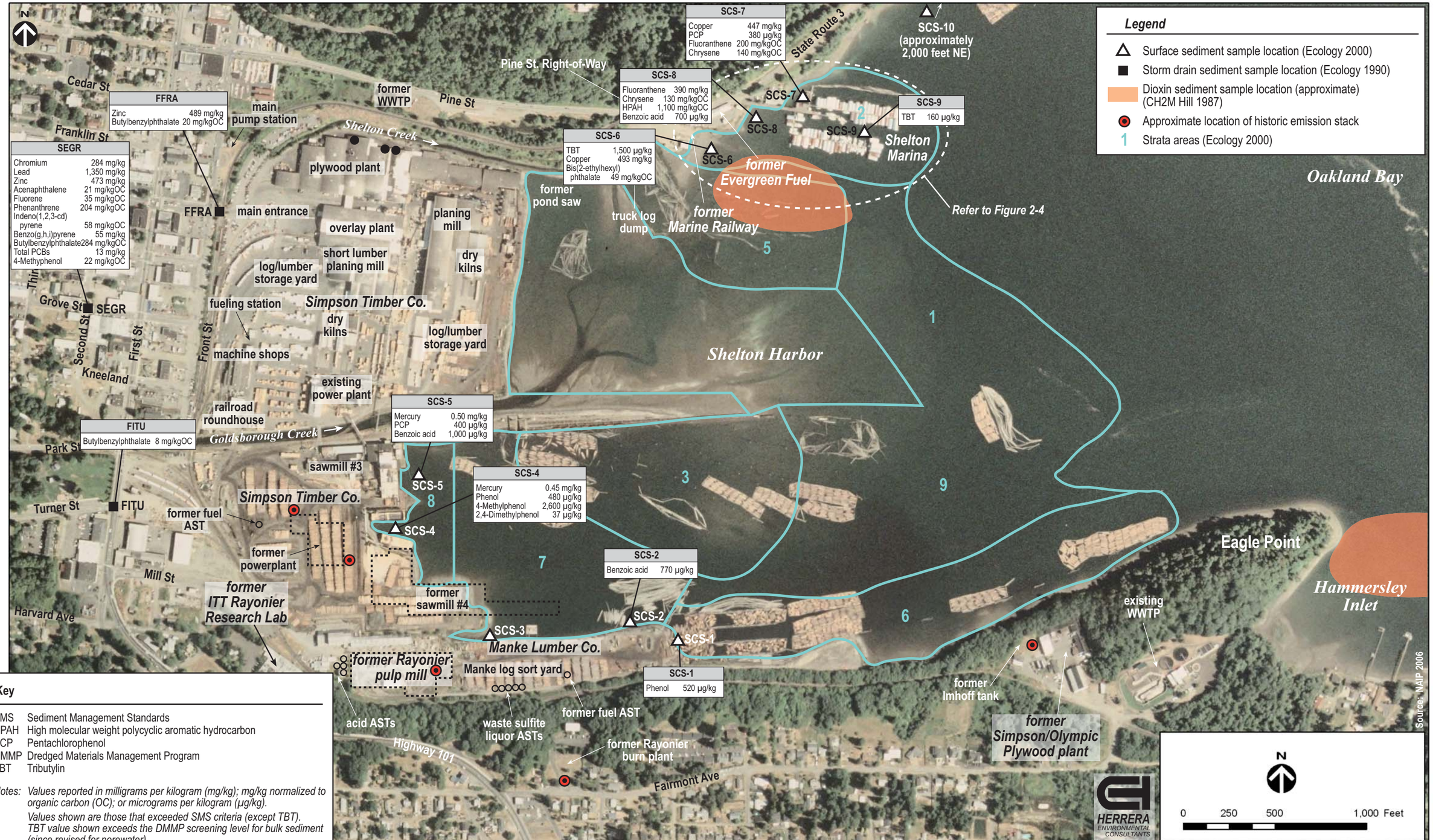
During early development of commercial shellfish industry in Oakland Bay, growers constructed 1-foot (ft) high concrete berms across tidelands, creating numerous shallow enclosures to retard ebbing tidewater. Plank floors covered over with gravel were placed in the base of many enclosures to provide a substrate for controlled shellfish growing conditions. These bermed structures reportedly still exist across most of the tidelands owned by Taylor Shellfish Company, including Chapman Cove and north and south of Bayshore Point (Ragan 2008). It is unknown whether these structures exist across other privately owned tidelands in Oakland Bay.

Current shellfish growing operations involve regular manipulation of sediment beds that includes significant addition of gravel from upland sources and reworking of the top 6 to 8 ft (Bloomfield 2008). Surface sediment in certain portions of the northern bay do not reflect natural depositional conditions.

Previous Investigations

The following sections summarize previous environmental investigations that have been conducted in Shelton Harbor, Oakland Bay, and Hammersley Inlet over the past 20 years. The studies are discussed by general study area (i.e., Shelton Harbor, and Oakland Bay/Hammersley Inlet), then in chronological order based on when the associated sampling activities occurred. Sampling locations from the previous investigations across Shelton Harbor are shown in Figure 2-3; at the Evergreen Fuel, Shelton Yacht Club and Marina, and former Simpson marine railway within Shelton Harbor in Figure 2-4; and in Oakland Bay and Hammersley Inlet in Figure 2-5.

Sediment data generated from these investigations have been evaluated according to the SMS, as will the data generated by the current Oakland Bay Sediment Characterization Study. The SMS 1) establish standards for the quality of surface sediments, 2) establish a process for applying these standards as the basis for management and reduction of pollutant discharges, and 3) provide a management and decision process for the cleanup of contaminated sediments. Sediment chemistry is evaluated based on threshold criteria that determine the need for further evaluation. Sediment quality standard (SQS) criteria correspond to sediment quality that will result in no acute or chronic adverse effects on biological resources and no significant health risk to humans. If any SQS criteria are exceeded, biological testing (bioassay) may be used to confirm that adverse biological effects can be measured in test organisms in site sediments.



Key

SMS	Sediment Management Standards
HPAH	High molecular weight polycyclic aromatic hydrocarbon
PCP	Pentachlorophenol
DMMP	Dredged Materials Management Program
TBT	Tributylin

Notes: *Values reported in milligrams per kilogram (mg/kg); mg/kg normalized to organic carbon (OC); or micrograms per kilogram (µg/kg).*
Values shown are those that exceeded SMS criteria (except TBT).
TBT value shown exceeds the DMMP screening level for bulk sediment (since revised for porewater).
No COPCs above SMS criteria were detected at SCS-3 and SCS-10.

Figure 2-3. Previous investigation sample locations in Shelton Harbor, Shelton, Washington.

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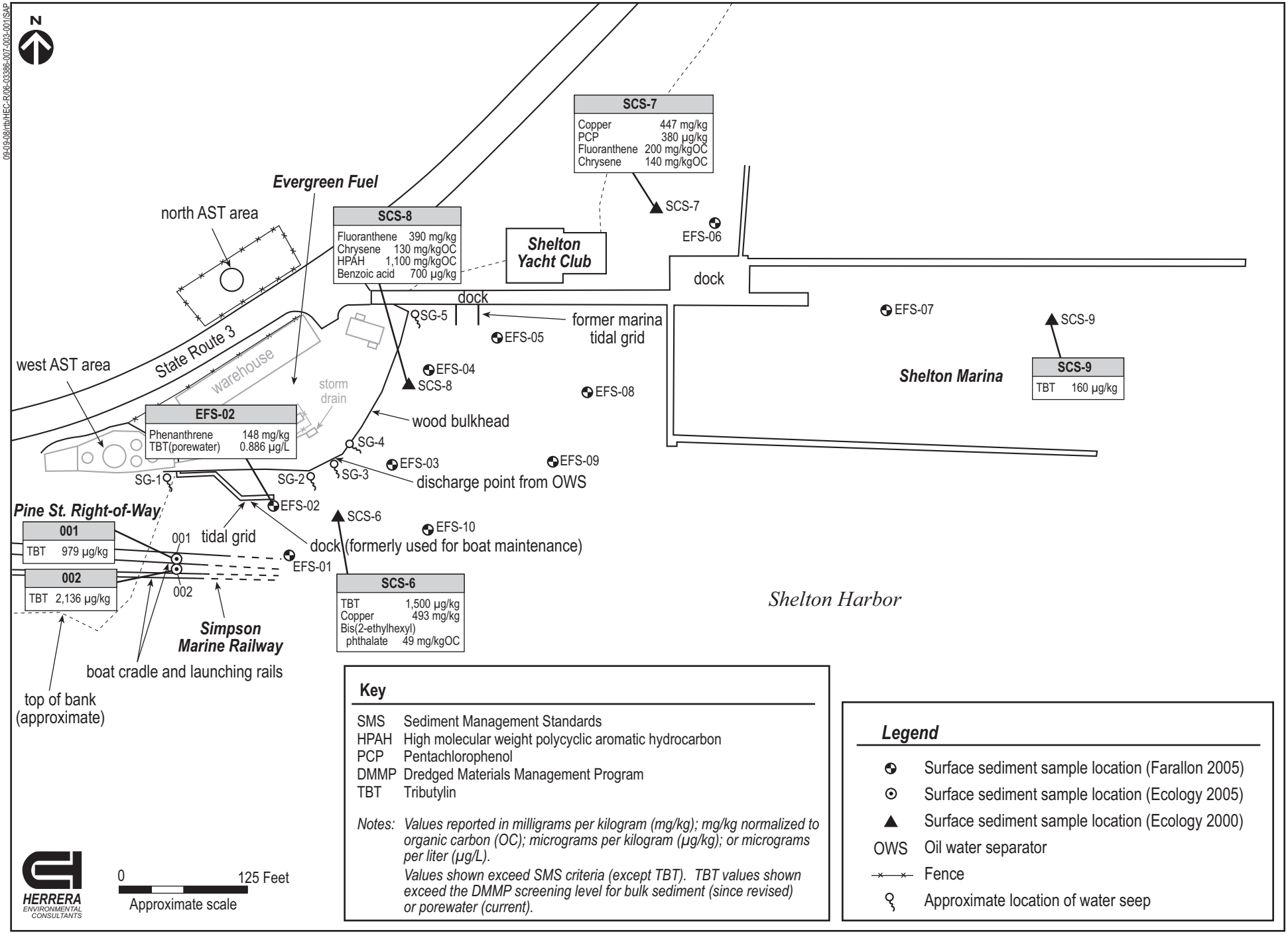

Figure 2-4. Previous investigation sample locations, former Evergreen Fuel site, Shelton Yacht Club and Marina, and former marine railway, Shelton, Washington.

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Figure 2-5 Previous investigation sample locations in Oakland Bay and Hammersley Inlet.

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Biological testing can also be performed concurrently with, prior to, or instead of sediment chemistry analyses, particularly when other toxic, radioactive, biological or deleterious substances are present. Cleanup screening level (CSL) criteria establish minor adverse effects as the level above which station clusters of potential concern are defined, and at or below which station clusters of low concern are defined. CSL criteria are used to direct sediment cleanup and aid in sediment management decision making.

2.1.1 Shelton Harbor

2.1.1.1 1984-1988 USEPA National Dioxin Study

Between 1984 and 1988, the USEPA conducted a National Dioxin Study to determine the extent of dioxin contamination in the United States and the associated risk to humans and the environment. Simpson volunteered to have their wood-fired power plant tested as part of this study (CH2M Hill 1987). The Simpson power plant was the only wood-fired boiler plant in the area operating at that time. Other wood-fired power plants and associated stacks that previously operated along the south shore of the harbor included the former Rayonier pulp and paper mill; the former Rayonier burn plant above the pulp mill, and the former Simpson/Olympic Plywood plant (Figure 2-3).

In 1986, composite sediment samples composed of five aliquots were collected both from an early former WWTP outfall next to the Evergreen Fuel site and from the existing WWTP outfall east of Eagle Point (Figure 2-3). Samples contained none of the more toxic tetra- through hexa-substituted isomers of chlorinated dioxins or furans, although total dioxins and furans were present and quantified at sub-part per billion levels (CH2M HILL 1987).

2.1.1.2 1989 City of Shelton Storm Drain Sediment Study

A storm drain sediment study was conducted to establish a stormwater priority pollutant concentration baseline in 1989 (Ecology 1990). Fine-grained sediment was collected at six locations in the city. Samples were analyzed for total organic carbon (TOC), percent solids, grain size, semi-volatile organic compound (SVOCs) (USEPA method 8270), pesticides and PCBs (USEPA method 8080), and metals (USEPA method 200 series). Because storm drains were cleaned each summer, data reflected accumulations of less than 1 year.

Three of the six samples collected had contaminant concentrations above SMS SQS criteria. One of the three samples collected from a storm drain at the intersection of Second and Grove Streets (designated as SEGR) had SQS exceedances for chromium, lead, zinc, acenaphthene, fluorene, phenanthrene, indeno(1,2,3-cd)pyrene, benzo(g,h,i)perylene, butylbenzylphthalate, total PCBs, and 4-methylphenol. The two remaining storm drain samples, including one located at the intersection of Front Street and Railroad Avenue (designated as FFRA) and the other located just north of the intersection of First and Turner Streets (designated as FITU), had SQS exceedances of butylbenzylphthalate in both samples and zinc in FFRA only) (Figure 2-3).

2.1.1.3 2000 Ecology Reconnaissance Survey of Inner Shelton Harbor Sediments

The objectives of this screening survey of Shelton Harbor sediment focused on evaluating metals and organic contaminant levels near 10 potential sources and estimating the distribution of wood waste in subtidal sediments. Results of sediment screening samples collected at 10 locations near discharge points identified along the Shelton waterfront indicated the following (Figure 2-3; SCS-1 through SCS-10):

- Three surface sediment samples addressing potential contaminant source inputs to the harbor were collected adjacent to Manke log sorting yard and former Rayonier pulp mill along the south shore (SCS-1 through SCS-3). A CSL exceedance for benzoic acid and a SQS exceedance for phenol were identified in two of the three samples; both constituents may be associated with wood waste. No SMS exceedances were identified at SCS-3.

- Two sediment samples addressing potential contaminant source inputs to the harbor were collected adjacent to Simpson operations south of Goldsborough Creek (SCS-4 and SCS-5). CSL exceedances for benzoic acid, phenol, 4-methylphenol, and 2,4-dimethylphenol were identified, all of which may be associated with wood waste. Both samples exhibited mercury levels exceeding the SQS criterion; phenol exceeded the SQS at SCS-4; PCP exceeded the SQS criterion at SCS-5.

- Four surface sediment samples were collected in the vicinity of the Evergreen Fuel/former Simpson marine railway/Shelton Marina area (SCS-6 through SCS-9). Results indicated copper exceeded the CSL criterion at SCS-6 and SCS-7 and benzoic acid exceeded the CSL criterion east of Evergreen Fuel (SCS-8). Other SQS exceedances were identified for bis(2-ethyl hexyl)phthalate, fluoranthene, chrysene, PCP, and high molecular weight polycyclic aromatic hydrocarbons (HPAH). Butyltin concentrations were generally low, except for one sample collected near the base of the launching rails at the vessel haul-out area (SCS-6). Individual concentrations of mono-(1,300 µg/kg), di-(4,100 µg/kg), and tri-(1,500 µg/kg) butyltin chloride all exceeded the PSDDA interim screening level of 73 µgTBT(ion)/kg for butyltin in sediments. Elevated butyltin levels (160 ug/kg) were also found at SCS-9 within the Shelton Marina.

- No SMS exceedances were identified at SCS-10, located approximately 2,000 ft northeast of the harbor.

The harbor was divided into nine strata (Figure 2-3) from which 37 composite surface sediment samples were collected and evaluated for the presence of wood waste. Strata were defined based on log handling practices (e.g., rafting, storing, dumping) and water depth. Results indicated that

mean wood content in the nine strata ranged from 5.1 to 18.5 percent on a weight basis. Wood waste was most predominant across the southern half of the harbor, with the highest concentrations near the Simpson and Manke property shorelines. Chemicals associated with wood waste that exceeded SMS were found in four samples from the south harbor and one sample near the marina; and included benzoic acid, phenol, 2,4-dimethylphenol and 4-methylphenol.

2.1.1.4 2005 Remedial Investigation of the Evergreen Fuel Site

Sampling was performed in both upland and sediment areas across the former Evergreen Fuel Site; sampling location map is provided in Figure 2-4 (Farallon 2005). Ten surface sediment samples were collected for chemical analysis from the following locations:

- EFS-01 – Within the intertidal zone near the base of the launching rails of the former Simpson marine railway facility
- EFS-02 – East of the Pine Street right-of-way, within the intertidal zone near a former tidal boat grid and vessel haul-out area
- EFS-03 – Within the intertidal zone near an oil/water separator discharge pipe
- EFS-04 – Within the intertidal zone east of the Evergreen Fuel office and warehouse
- EFS-05 – Within the intertidal zone in the vicinity of the marina's remnant tidal boat grid
- EFS-06 – Within the intertidal zone north of the marina dock
- EFS-07 – In the subtidal zone within the marina to characterize former fuel loading
- EFS-08 and EFS-09 – Approximately 200 ft east and offshore the Evergreen Fuel site within the marina
- EFS-10 – Approximately 130 ft east and offshore from the Pine Street right-of-way near Ecology (2000) sediment sample location SCS-6.

Results of these sediment samples indicated the following:

- Phenanthrene concentration exceeded the SQS criterion at EFS-02 collected within the Pine Street right-of-way.

- Concentrations of diesel- and/or lube oil-range hydrocarbons were detected in nine of the 10 sediment samples collected (no hydrocarbons were detected in EFS-09). Further evaluation of chromatograms from each of the nine samples indicated that apparent total petroleum hydrocarbon (TPH) concentrations consisted entirely of polycyclic aromatic hydrocarbons (PAHs) that elute as TPH in the analyses (Farallon 2005). The PAH concentrations in all nine sediment samples (with the exception of phenanthrene in EFS-02) were below SMS criteria; the PAHs in these samples were interpreted by Ecology as likely associated with residual creosote from nearby treated timbers of the bulkheads and docks.

- No PCBs were detected above practical quantitation limits (PQLs) in either soil or groundwater samples collected during the RI from the upland portion of the site. However, total PCBs were detected in all ten sediment samples ranging from 0.84 to 4.77 mg/kg organic carbon (OC); all concentrations were below SMS criteria.

- TBT in interstitial water was detected in two of the sediment samples: 0.888 µg/L at EFS-02 and 0.0326 µg/L at EFS-03. The Puget Sound Dredge Disposal Analysis Porewater Screening Level of 0.15 µg/L was used as a screening level of concern for the site; therefore, EFS-02 did fail the screening level for TBT.

- Two samples (EFS-08 and EFS-09) exceeded SQS criterion for silver because the laboratory reporting limit was slightly above the criterion. However, silver was not detected at the method detection limit of 0.114 mg/kg, well below the SQS criterion of 6.1 mg/kg. All ten samples exhibited concentrations of arsenic, chromium, copper, lead, mercury, and zinc below their respective SMS criteria. Concentrations of cadmium below the SMS criterion were detected in nine of the ten samples (no cadmium was detected in EFS-01).

Ecology determined that photo-activated PAH compounds were present in sediment at three locations at concentrations warranting bioassay testing. In January 2005, Ecology conducted bioassay tests on sediment sample EFS-03 (split sample) using both the standard method and the ultraviolet (UV) exposure method (Ecology 2008). The guidance for the UV exposure method cites several studies that suggest that photo-activation of certain PAH compounds can result in increased toxicity to organisms. Results indicated no substantial differences between the standard method and the UV exposure method in the 10-day and 20-day tests. In the 48-hour test, the mean individual growth rate for mussels using the UV method was substantially lower than that of the standard method. No further documentation regarding the bioassay data was found in the site file.

In addition to sediment samples, water samples at five seep locations in the intertidal area of the Evergreen Fuel site were sampled (Figure 2-4; SG-1 through SG-5). Based on specific

conductance and other geochemical measures taken at three of the seeps, it appeared that fresh water (groundwater) was discharging at seep SG-1 and salt water (marine water) was discharging at SG-2 and SG-4 (Mercuri 2005). No COPCs associated with the Evergreen Fuel site investigation were found at concentrations above regulatory cleanup criteria in samples SG-3 through SG-5. Results for samples SG-1 and SG-2 indicated the following:

- Reddish-brown stained soil was observed above the mean higher high water line near the discharge point for seep location SG-1, southeast and adjacent to the west AST area. Ecology expressed concern that the stained soil may be associated with petroleum product.

- The seep sample collected at SG-2 near the bulkhead indicated the presence of PAHs that may be attributed to contact with creosote-treated pilings.

2.1.1.5 2005 Ecology Initial Investigation of the Simpson Marine Railway

Ecology conducted further investigation of the marine railway to follow-up on TBT found in sediment in the Evergreen Fuel Remedial Investigation (Ecology 2005). Two surface sediment samples were collected and analyzed for the presence of TBT, metals, total organic carbon (TOC), SVOCs, and diesel- and lube oil-range hydrocarbons (001 and 002, Figure 2-4). Both samples contained mono- (180 and 580 µg/kg), di- (510 and 1,800 µg/kg), and tri- (1,100 and 2,400 µg/kg) butyltin chloride. To compare tributyltin chloride results to the PSDDA screening level, the chloride results were multiplied by 0.89 (Michelsen et al. 1996), resulting in 979 and 2,136 µg/kg as TBT for the two samples; both exceeding the PSDDA screening level of 73 µg/kg. No information was available concerning other analytes of concern.

2.1.2 Oakland Bay and Hammersley Inlet

2.1.2.1 1989-1999 Sediment Studies in Oakland Bay

Three sediment quality studies conducted in Oakland Bay were identified in the Ecology Environmental Information Management (EIM) database. The locations of sediment samples collected from these studies are shown in Figure 2-5; the name of the study conducted and samples collected in Oakland Bay include the following:

- 1997-1999 PSAMPNOAA (Puget Sound Assessment and Monitoring Program and the NOAA National Status and Trends Program) – Six sediment samples were collected in Oakland Bay near Shelton Harbor. The samples include PSAMP/NOAA-227, PSAMP/NOAA-228, PSAMP/NOAA-229, PSAMP/NOAA-230, PSAMP/NOAA-231, and PSAMP/NOAA-232.

- 1989-1995 PSAMP HP (Puget Sound Assessment and Monitoring Program's historical sediment monitoring) – This program was part of the

Puget Sound Ambient Monitoring Program; the sediment component of this program was implemented in 1989 by Ecology. Four sediment samples were collected in Oakland Bay as part of this study, including two samples collected outside of Shelton Harbor and one sample near Chapman Cove (same area was sampled twice). The samples include PSAMP HP-50 (in 1989), PSAMP HP-70 (in 1992), and PSAMP HP-101R (in 1990 and 1993).

- 1992 DNRREC92 (Washington DNR Aquatic Lands Sediment Quality Reconnaissance) – Two sediment samples were collected in Shelton Harbor, including DNREC92SHLT01XX and DNREC92SHLT02XX.

Analyses conducted on the sediment samples collected in the three studies included grain size, TOC, SVOCs, metals, PCBs, and pesticides (DNR samples were not analyzed for PCBs or pesticides). No samples exceeded SMS criteria.

In addition to chemical and physical analyses, bioassay toxicity testing was conducted on sediment samples collected during the joint 1997-1999 Ecology/NOAA survey (1997-1999 PSAMPNOAA Programs). The six samples listed in the first bullet above were tested using the following bioassay test methods:

- Amphipod survival in solid-phase sediments
- Sea urchin fertilization success in pore waters
- Microbial bioluminescence activity in organic solvent extracts (Microtox™)
- Cytochrome P450 HRGS (human reporter gene system) induction in organic solvent extracts.

The results indicated significant cytochrome P450 HRGS responses in all six samples collected in Oakland Bay near Shelton Harbor (Long et al. 2003). No toxicity was observed on these samples tested by the three remaining bioassay tests.

Benthic faunal index summaries for all six samples showed reduced total abundance and/or species richness (lower quartile <= 25%). Three stations in Shelton Harbor showed intermediate/degraded sediments based on chemistry, toxicity and benthic fauna.

2.1.2.2 2004/2005 Fecal Coliform Bacteria TMDL Studies

Several agencies have collected fecal coliform data in the Oakland Bay/Hammersley Inlet watershed over the years including the Washington Department of Health (WDOH), the Squaxin Island Tribe, Mason County, and Ecology. In the late 1980s, during extensive reconstruction of Shelton's sewer systems, fecal pollution significantly dropped. In response, WDOH upgraded

portions of Oakland Bay from Restricted to Conditionally Approved, allowing shellfish harvesting to take place except during predictable pollution events, such as following significant rainfall (current shellfish harvest restricted areas are depicted on Figure 2-1). Fecal coliform pollution in Oakland Bay has increased slightly in recent years (WDOH 2007).

In September 2004, the shorelines of Oakland Bay and Hammersley Inlet were surveyed for small drainages and/or discharge points in addition to the major tributaries that may contribute pollution to the marine water bodies (Figure 2-5). The 279 identified locations included storm water culverts, unnamed tributaries, and direct runoff points from agricultural activities (Ecology 2004c). In February 2005, out of the 142 drainage points sampled (those conveying water), only 10 had fecal coliform concentrations greater than the water quality standard of 100 colony forming units (cfu)/100 milliliters (ml). Two sites were located in the upper portion of Oakland Bay (one on the northwest shore and one near the mouth of Deer Creek), one site was located just south of Chapman Cove, and the remaining sites were located on the southern shoreline of Shelton Harbor and the southern shoreline of Hammersley Inlet (Ecology 2004c).

Because Oakland Bay is classified as a shellfish growing area, fecal coliform pollution continues to be investigated by several agencies.

2.2 Study Objectives

The scope of this study is limited geographically to the marine areas of Oakland Bay, including northeast Oakland Bay, Shelton Harbor, and the west end of Hammersley Inlet (i.e., to Miller Point).

The general objective of the study is to conduct a multi-faceted, tiered sediment characterization of Oakland Bay to define the baywide nature and extent of potential sediment contamination and wood waste. Water quality conditions, and specifically fecal coliform contamination, are not part of this investigation. The specific objectives of the sediment characterization include the following:

- In Shelton Harbor, conduct a sampling and analysis effort based on previous investigations and existing data gaps to further characterize and prioritize areas for potential cleanup. This will be conducted through:
  - Determination of contaminant concentration trends across the Harbor
  - Sampling near known and suspected sources of contaminants
  - Evaluation of the distribution of wood waste through cores and chemical analysis

  - Determination of the biological effects through toxicity testing in surface sample locations.

- In Oakland Bay, conduct a sampling and analysis effort to assess presence of contaminants and wood waste. Chemical analysis of sediments, wood waste characterization through coring and chemical analysis, and toxicity testing to evaluate biological effects will be performed.

- Evaluate potential for transport of contaminated sediments and wood waste out of Shelton Harbor into and across Oakland Bay and Hammersley Inlet.

- Conduct a geophysical survey to determine the distribution of wood waste across Shelton Harbor and Oakland Bay for mapping and determining volume estimates (core samples will be used to compare visual evidence of wood waste presence to that indicated by the broader geophysical survey).

- Characterize horizontal and vertical extent of contamination in sediment across Shelton Harbor for effects from known and suspected sources, and characterize potential transport into Oakland Bay. Characterize Oakland Bay sediment for effects from tidal flushing, creek inputs, and potential near-shore use of hazardous substances.

- Characterize wood waste using chemical and toxicity testing. In Shelton Harbor, sample locations are associated with a range of wood waste and quantities. In Oakland Bay, sample locations are associated with areas of known rafting and wood waste accumulations.

- Estimate sedimentation rates in Oakland Bay and Shelton Harbor using radioisotope dating and geophysical survey data.

- Conduct bioassays to determine extent of acute and chronic toxicity of sediment at all surface locations in Shelton Harbor and Oakland Bay.

- Conduct a screening-level "fingerprinting" evaluation of TPH, PAHs, and dioxin/furan sediment data to provide a preliminary indication of the usefulness of the analytical data to differentiate between sources of contaminants.

- Provide chemical and toxicity testing comparisons through analysis of sediments from a reference location.

Data generated from site characterization efforts can be used in the future to complete human health and ecological risk assessments; Ecology will determine the need for risk assessments after the sediment and bioassay data have been evaluated. Collection and analysis of tissue samples may be conducted at a later time based on evaluation of data collected during this study.

3.0 Organization and Schedule

Herrera, as a subconsultant to E & E, will manage technical work conducted for the project, including background information gathering, plan preparation, field coordination and sampling, reporting, and performing a geophysical survey. In addition, the expertise of Teresa Michelsen of Avocet Consulting will be utilized for study design and data evaluation support, and for senior review of key deliverables.

Key staff to be assigned to this work assignment includes:

- Andy Hafferty (E & E), Principal in Charge, Senior Chemist and Oceanographer
- Peter Jowise (Herrera), Project Manager
- Gina Catarra (Herrera), Assistant Project Manager and Field Team Leader
- Rob Zisette (Herrera), QC Manager
- Teresa Michelsen Ph.D. (Avocet Consulting), Study Design/Data Evaluation Advisor
- Jennifer Goldsmith (Herrera), Fluvial Geomorphologist
- Jeff Parsons Ph.D. (Herrera), Coastal Geomorphologist.

In addition to the key staff identified above, the project team will include staff level scientists from E & E and Herrera for SAP development, field work implementation, laboratory coordination, and report production.

E & E solicited competitive bids for laboratory analytical services and for independent validation of laboratory data and database development for the Port Angeles Harbor Sediment Study, and given the high degree of nearly identical activities anticipated in the Oakland Bay Study, the same laboratories will be utilized for the Oakland Bay Study. Herrera will subcontract the following laboratories to ensure a high level of data comparability for this work assignment:

- Axys Analytical Services, Ltd. for dioxin/furan analyses
- Test America for TPH, metals, pesticides, PCBs, and sediment core dating analyses
- Analytical Resources, Inc. for grain size, TOC, SVOCs, sulfide, ammonia, TBTs, total volatile solids (TVS) and wood resins analyses

- New Fields Northwest, LLC for bioassay tests
- Global Geophysics for marine geophysics survey
- Research Support Services (RSS) and Bio-Marine Enterprises for sampling vessels.

The major deliverables and associated deadlines for this work assignment are presented in Section 3-1.

3.1 Schedule and Deliverables

The major deliverables and associated deadlines for this work assignment are listed below.

Deliverable	Schedule Deadline
Final Existing Information and Data Gaps Memorandum	April 22, 2008
Public Review Draft SAP/HSP/RA Work Plan	May 8, 2008
Geophysical Study	June, 2008
Public Comment Period	June 2 – August 11, 2008
Public Meeting	June 16, 2008
Stakeholder Meeting	July 29, 2008
Technical Meeting	August 6, 2008
Stakeholder Meeting	August 11, 2008
Ecology technical memo about SAP changes to stakeholders	August 18, 2008
Final SAP Work Plan and Responsiveness Summary	September 25, 2008
Commence Field Work	September 29, 2008
Progress reports to stakeholders (via attendance at Clean Water District Advisory Meetings) and email)	October 2008 to June 2009
** Presentation to stakeholders of preliminary study results	by May 2009
** Public Review Draft Sediment Investigation Report (SIR) for 30 day comment period (7 to 10 days after presenting to stakeholders)	July 2009
** Final SIR	September2009

** Dates are approximate

4.0 Study Design

This section describes the study design for each data type to be collected for the Oakland Bay Sediment Characterization Study. The study follows methods and guidance developed under State sediment management programs (Sediment Management Standards (173-204 WAC) and Sediment Sampling and Analysis Plan Appendix (Ecology 2008), Puget Sound Estuary Program and the Dredge Materials Management Program), input from citizens and stakeholders, and from public meetings. A summary of sampling areas within Oakland Bay is presented in Table 4-1.

Table 4-1. Summary description of sampling areas.

Areas of Concern	Location	Potential Sources of Interest
Oakland Bay	Northeast and central Oakland Bay	Six creeks, three bulk fuel facilities, two gas stations, a wood preservative site, log rafts
Shelton Harbor	West of Oakland Bay and Hammersley Inlet	Two creeks, numerous stormwater and industrial waste pipe discharges, overland flow from industrial operations, fuel spills, groundwater, historic wood treating, log rafting, wood chip loading
Hammersley Inlet	Southeast portion of Oakland Bay and Hammersley inlet to Miller Point	WWTP effluent discharges, log rafts, sediment redistribution from Shelton Harbor
Reference Samples	Carr Inlet	Reference sediment for toxicity testing

Sediment samples will be collected across Shelton Harbor, Oakland Bay, and Hammersley Inlet to identify the presence of contaminants of potential concern (COPCs), to estimate the abundance of wood waste, and to evaluate sedimentation rates. Samples will be collected from stations associated with historical discharges to the marine environment along the shorelines and from areas across each water body where either wood waste has been directly deposited, where aerial deposition has or is likely to have occurred, or contaminants may have been redistributed by fluvial forces. Some sampling locations are referred to as sediment sample locations and others are described as wood waste sample locations. The distinction has been made to identify specific locations either known or suspected to have been impacted by the release of wood waste into the native sediment; these locations are the wood waste sampling stations. Sediment sampling locations are in areas where the sediment is not expected to have been significantly impacted by wood waste. Samples will be collected from the sediment surface (0 to 10 cm) and from 4-ft (sediment locations) or 12-ft (wood waste locations) cores. Core depths will be impacted by sediment composition and the degree to which sample collection equipment can penetrate the wood waste or sediment.

Industrial COPCs include SVOCs, organochlorine pesticides, PCBs as Aroclors, heavy metals, dioxins/furans, petroleum hydrocarbons, and TBTs. TOC and grain size analyses will be conducted to supplement the COPC data. Wood waste COPCs include sulfide, ammonia, and fatty acid resins; the wood waste component will be determined through analysis of total volatile solids on a percentage basis. Wood waste “sediments” are expected to be composed of wood

waste materials mixed with sediment. Field personnel will remove larger, obvious wood waste materials (e.g., large pieces of bark or solid wood chips) from each sample prior to submitting aliquots for analysis. No attempt will be made to remove wood waste fines from the samples. A visual estimate of gross wood content encountered in the field will be made during sampling and recorded in notebooks. A summary of total sample numbers and analyses required is provided in Section 6.0.

The Summary of Existing Conditions and Data Gaps report (Herrera 2008) identified seven major issues of concern that will be addressed in this SAP, including:

- The spatial extent and contaminant concentration of wood waste debris associated with pulp, paper, and lumber mill activities, including log rafting.
- Petroleum contamination in areas associated with petroleum-based industry, machinery and vehicles associated with timber processing, boating, and stormwater runoff from roads.
- COPC concentrations in sediment near industrial discharge points along the Shelton Harbor shoreline.
- COPC concentrations in sediment near creek discharge points.
- TBT contamination in sediment and biota near the marina and marine railway.
- SVOC concentrations associated with dense areas of intact, degrading, and/or submerged creosote pilings.
- Sediment contaminant concentrations where significant intertidal and shallow subtidal beaches are present, and where contact with or consumption of bivalves by biota and human populations is increased.

To address these data gaps, first geophysical surveys will be conducted across Oakland Bay, Shelton Harbor, and Hammersley Inlet and then sediment and wood waste sediment samples will be collected.

4.1 Geophysical Surveys

Two different, but complementary, data-collection methods will be used to provide information to meet the diverse objectives of the Oakland Bay study. The geophysical study will provide additional information regarding sedimentation within Oakland Bay.

4.1.1 Geophysical Mapping

Shallow acoustic tomography (imaging) of the seabed will be performed across each of the primary geomorphic units throughout greater Oakland Bay, including the Goldsborough Creek delta, Shelton Creek delta, Deer Creek delta, Campbell Creek delta (Chapman Cove) and the main basins of Oakland Bay, Shelton Harbor, and Hammersley Inlet (Figure 4-1). Acoustic imaging will used to estimate the changes in the composition of the uppermost layers of the seabed. The onset of development in the area (i.e., deforestation and other changes to the local hydrology) had a strong impact on sedimentation and thus produced changes in the composition of the seabed. It is expected that these changes will record the amount of sediment deposited since the onset of development 150 years ago. In conjunction with core-dating mentioned below and known geologic markers determined from the background analysis (e.g., the timing of the stabilization of the modern sea level), it is possible that a sediment budget may be formulated for the various depositional areas. This information will provide a detailed picture of the geomorphic processes active in greater Oakland Bay.

The strength of the reflections observed in the acoustic imaging also will provide an estimate of the absolute composition of the seabed. The presence of different types of wood waste (bark, sawdust) has a strong impact on the reflectivity of the uppermost portion of the seabed, such that acoustic energy is either attenuated or reflected. The reflectivity measurements will then be correlated to the observations made of the sediment cores and used to extrapolate the core observations throughout the Bay.

Electrical resistivity mapping of marine sediments is also capable of resolving wood waste horizons and estimating wood waste thicknesses. Resistivity mapping in areas of known wood waste (inner Shelton Harbor) will help identify the thickness of wood waste, as well as its interaction with ongoing sedimentological processes (Figure 4-1). The survey will be performed along several lines oriented north-to-south across the inner harbor; the exact locations will be determined in the field to provide adequate coverage and ability of the technique to resolve the presence of wood waste.

Finally, side-scan sonar will be used to identify anomalous large material lying on the seabed. It is expected that large logs and other refuse/debris will be observed in the side-scan data.

4.1.2 Sediment Core Dating

The goal of the sediment core dating (radioisotopic sediment survey) is to determine the historical patterns (within the last 100 years) of sedimentation and accumulation in Oakland Bay and Shelton Harbor. Although studies have been performed on the circulation of Oakland Bay, this work was not specifically targeted to understand the dynamics of the sediment transport, in particular the mobility of contaminated sediment and wood waste. The lead-210 results should enable a sediment budget of the Bay, which would determine the extent of removal of contamination from erosion and the areas ultimately most affected by the accumulation of contaminated sediment and wood waste.

Sediment cores will be collected from three stations. One station will be located along the edge of the alluvial fan associated with north Oakland Bay sedimentation, one station will be located between the two Oakland Bay data points, OB-3 and OB-5 toward the center of the bay (Figure 4-2), and one station will be located in Shelton Harbor along the edge of the alluvial fan created by Goldsborough and Shelton Creeks (Figure 4-3). Cores will be divided into 2 centimeter (cm) intervals and only every third interval will be analyzed for lead-210. It is anticipated that each core will have 20 intervals analyzed for lead-210 and two intervals analyzed for cesium-137.

Lead-210 measurements are routinely employed to date recent marine sediments. The technique works by examining the change in the relative presence of lead-210. Lead-210 ceases to be reformed once it is buried. The remaining lead-210 decays at a known rate. Therefore by measuring the amount of lead-210 in sediment it can be determined how long it has been since that particular sediment was buried. Sedimentation rate can be estimated by examining the trend in the reduction of lead-210 with depth below the seabed.

4.2 Oakland Bay

The study consists of a non-random design that utilizes a tiered analysis approach to spatially characterize sediment conditions across the bay. Sampling stations were identified at locations chosen to help assess the presence of chemical contaminants and wood waste, to identify potential sources of hazardous substances, and to evaluate contaminant transport and sediment depositional rates. Sampling station locations were selected based on guidance for initial investigation of sediment contamination in the *Sediment Sampling and Analysis Plan Appendix* (Ecology 2008) and review of previous studies in Oakland Bay (Herrera 2008). Sampling locations within Oakland Bay are presented on Figure 4-2.

Sediment chemistry analyses, wood waste sediment chemistry analyses, and bioassay toxicity analyses will be completed concurrently. A surface (0-10 cm) sediment sample will be collected at each sediment sampling station and submitted for analyses. In addition, a 4-ft core will be collected at each sediment sampling station. A surface (0-10 cm) wood waste sediment sample will be collected at each wood waste station. A subsurface core will be advanced a minimum of 4 ft or to the bottom of the wood waste encountered (to a maximum depth of 12 ft) at each wood waste station. Core samples will be collected by sectioning each core into 1-ft intervals (for example; 0-1 ft, 1-2 ft, and so on to the maximum depth of the core) and containerizing sediment from each interval. Each surface and core sample will be visually evaluated for gross wood content to allow estimates of wood waste thickness, type (bark, chips, sawdust), and abundance.

The analyses to be conducted on individual samples are based on *Sediment Sampling and Analysis Plan Appendix* (Ecology 2008) guidance and review of previous studies (Herrera 2008).

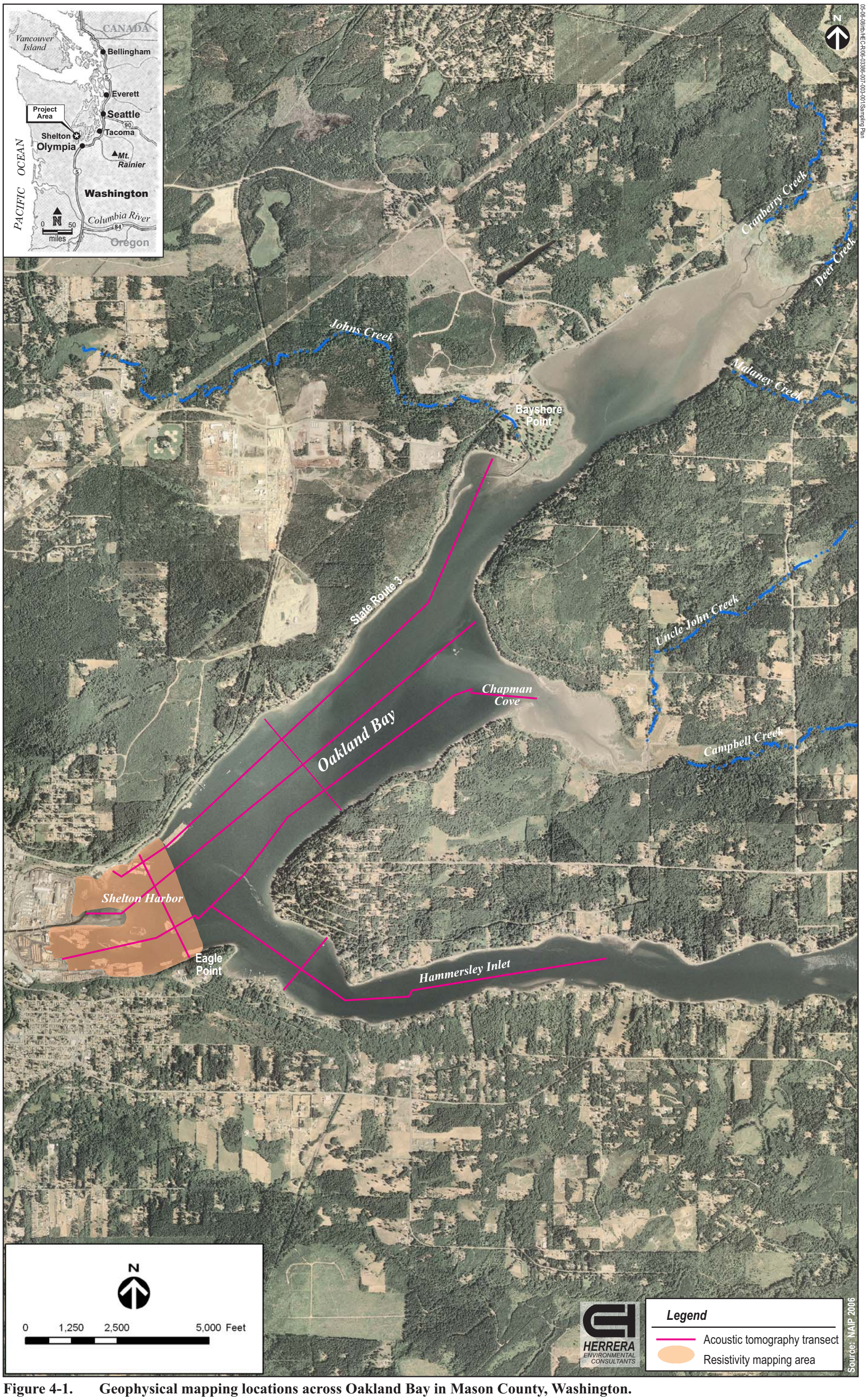

Figure 4-1. Geophysical mapping locations across Oakland Bay in Mason County, Washington.

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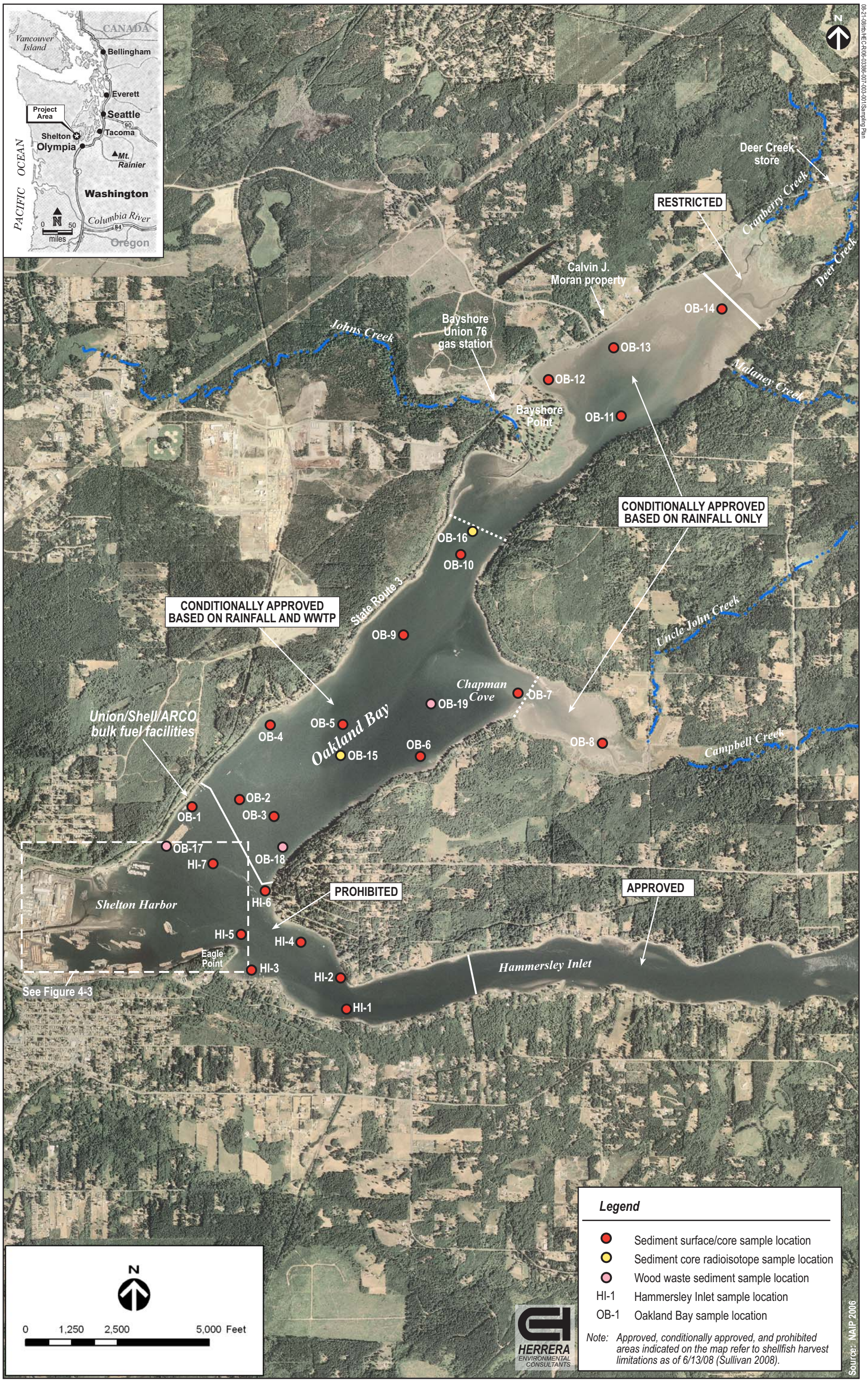

Figure 4-2. Sediment and wood waste sample locations (to be collected) in Oakland Bay and Hammersley Inlet in Mason County, Washington.

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Figure 4-3. Sediment and wood waste sample locations (to be collected) in Shelton Harbor, Shelton, Washington.

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4.2.1 Sediment

Sampling stations have been established in general transects across the bay, at locations to characterize bay boundaries, and at locations to represent depositional sediments. Samples from all of these locations will be analyzed for the broad spectrum of industrial discharge COPCs. Surface samples will also be analyzed for dioxins/furans and bioassay toxicity.

4.2.1.1 Surface Sediment Samples

Representative surface sediment (0 to 10 cm) samples will be collected at 14 locations within Oakland Bay (Figure 4-2). An aliquot from each location will be homogenized and submitted for chemical and bioassay analysis. Sample aliquots for ammonia and sulfide will be collected prior to sample homogenization to minimize losses due to volatilization. Refer to Section 6 for recommended holding times for analyses. As shown in Tables 4-2 and 4-3, samples from all locations will be analyzed for the broad spectrum of industrial discharge COPCs. Surface sediment samples will also be analyzed for dioxins/furans and bioassay toxicity. A few samples near potential on-shore petroleum sources will be analyzed for TPH. The chemical analyte list, analytical methods, target detection limits (TDLs), and comparative criteria are discussed in Section 7.1.

4.2.1.2 Subsurface Sediment Cores

Sediment cores will be collected to determine the vertical extent of potential contamination. Core sampling locations will be co-located at the 14 surface sediment locations (Figure 4-2). Cores will be advanced to 4+ ft below the surface using a Vibracore sampler. If significant wood waste is encountered, based on visual observations, cores will be advanced to to the bottom of the wood waste, to a maximum of 12 ft. Cores will be archived as sample aliquots in 1-ft increments beginning at the sediment surface and may be submitted for chemical analysis at a later time. The 1-2 ft segment from each core will be divided into multiple aliquots. Each other 1-ft increment will be homogenized and archived (identified in Table 4-3).

Sample aliquots for ammonia and sulfide will be collected from the 1-2 ft increment prior to sample homogenization. The remaining 1-2 ft core sample material will be homogenized and sample aliquots for grain size and TOC will then be collected. Because archiving (freezing and deferring analyses until a later date) of sediments may affect results for some analyses (total sulfides, ammonia, total organic carbon, and grain size), 1-2 ft increment samples will be initially analyzed for these parameters only. The remaining material will be placed in the applicable sample containers as if they were to be analyzed immediately (these samples are marked with a "P" in Table 4-3 to indicate that they are ready for potential additional analyses). As with the archived samples, these containerized samples will be stored frozen. Each other 1-ft increment will be homogenized and placed in large sample jars for archiving. Core collection and evaluation will also include a physical description of the stratigraphy. The chemical analyte list, analytical methods, target detection limits, and comparative criteria are discussed in Section 7.1.

Table 4-2. Rationale for samples to be collected from Oakland Bay.

Sample ID [a]	Description [b]	Sample Justification
OB-01-SS-00	Surface	Former bulk fuel storage along shoreline. Analyze for COPCs (SVOCs, pesticides, PCB, TPH, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
OB-01-SC-12	Subsurface	Former bulk fuel storage along shoreline. Analyze for COPCs (SVOCs, pesticides, PCB, and metals). Samples analyzed based on surface sample sediment results.
OB-02-SS-00	Surface	Characterization of lower-Oakland Bay. COPCs (SVOCs, pesticides, PCB, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
OB-02-SC-12	Subsurface	Characterization of lower-Oakland Bay. COPCs (SVOCs, pesticides, PCB, and metals). Samples analyzed based on surface sample sediment results.
OB-03-SS-00	Surface	Characterization of lower-Oakland Bay. COPCs (SVOCs, pesticides, PCB, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
OB-03-SC-12	Subsurface	Characterization of lower-Oakland Bay. COPCs (SVOCs, pesticides, PCB, and metals). Samples analyzed based on surface sample sediment results.
OB-04-SS-00	Surface	Characterization of mid-Oakland Bay. COPCs (SVOCs, pesticides, PCB, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
OB-04-SC-12	Subsurface	Characterization of mid-Oakland Bay. COPCs (SVOCs, pesticides, PCB, and metals). Samples analyzed based on surface sample sediment results.
OB-05-SS-00	Surface	Characterization of mid-Oakland Bay. COPCs (SVOCs, pesticides, PCB, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
OB-05-SC-12	Subsurface	Characterization of mid-Oakland Bay. COPCs (SVOCs, pesticides, PCB, and metals). Samples analyzed based on surface sample sediment results.
OB-06-SS-00	Surface	Characterization of mid-Oakland Bay. COPCs (SVOCs, pesticides, PCB, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
OB-06-SC-12	Subsurface	Characterization of mid-Oakland Bay. COPCs (SVOCs, pesticides, PCB, and metals). Samples analyzed based on surface sample sediment results.
OB-07-SS-00	Surface	Chapman Cove – potential point source to Oakland Bay. Analyze for COPCs (SVOCs, pesticides, PCB, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.

Table 4-2 (continued). Rationale for samples to be collected from Oakland Bay.

Sample ID [a]	Description [b]	Sample Justification
OB-07-SC-12	Subsurface	Chapman Cove – potential point source to Oakland Bay. Analyze for COPCs (SVOCs, pesticides, PCB, and metals). Samples analyzed based on surface sample sediment results.
OB-08-SS-00	Surface	Uncle John and Campbell Creeks – potential point source to Oakland Bay. Analyze for COPCs (SVOCs, pesticides, PCB, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
OB-08-SC-12	Subsurface	Uncle John and Campbell Creeks – potential point source to Oakland Bay. Analyze for COPCs (SVOCs, pesticides, PCB, and metals). Samples analyzed based on surface sample sediment results.
OB-09-SS-00	Surface	Characterization of upper mid-Oakland Bay. COPCs (SVOCs, pesticides, PCB, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
OB-09-SC-12	Subsurface	Characterization of upper mid-Oakland Bay. COPCs (SVOCs, pesticides, PCB, and metals). Samples analyzed based on surface sample sediment results.
OB-10-SS-00	Surface	Characterization of upper mid-Oakland Bay . COPCs (SVOCs, pesticides, PCB, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
OB-10-SC-12	Subsurface	Characterization of upper mid-Oakland Bay. COPCs (SVOCs, pesticides, PCB, and metals). Samples analyzed based on surface sample sediment results.
OB-11-SS-00	Surface	Characterization of upper-Oakland Bay (topographic low). COPCs (SVOCs, pesticides, PCB, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
OB-11-SC-12	Subsurface	Characterization of upper-Oakland Bay (topographic low). COPCs (SVOCs, pesticides, PCB, and metals). Samples analyzed based on surface sample sediment results.
OB-12-SS-00	Surface	Characterization of upper-Oakland Bay (public access). COPCs (SVOCs, pesticides, PCB, TPH, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
OB-12-SC-12	Subsurface	Characterization of upper-Oakland Bay (public access). COPCs (SVOCs, pesticides, PCB, and metals). Samples analyzed based on surface sample sediment results.
OB-13-SS-00	Surface	Concrete tank with wood preservative along shoreline – potential point source to Oakland Bay. Analyze for COPCs (SVOCs, pesticides, PCB, TPH, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
OB-13-SC-12	Subsurface	Concrete tank with wood preservative along shoreline – potential point source to Oakland Bay. Analyze for COPCs (SVOCs, pesticides, PCB, and metals). Samples analyzed based on surface sample sediment results.

Table 4-2 (continued). Rationale for samples to be collected from Oakland Bay.

Sample ID [a]	Description [b]	Sample Justification
OB-14-SS-00	Surface	Deer Creek and Cranberry Creek – potential point source to Oakland Bay. Analyze for COPCs (SVOCs, pesticides, PCB, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
OB-14-SC-12	Subsurface	Deer Creek and Cranberry Creek – potential point source to Oakland Bay. Analyze for COPCs (SVOCs, pesticides, PCB, and metals). Samples analyzed based on surface sample sediment results.
OB-15-RI-04	Sediment Core	Sediment core dating. Collect from deepest area in central portion of Oakland Bay.
OB-16-RI-04	Sediment Core	Sediment core dating. Collect along edge of Johns Creek alluvial fan.
OB-17-WS-00	Wood Waste	Historic log rafting area north of Shelton Harbor. COPCs (SVOCs, wood resin, pesticides, PCBs, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
OB-17-WC-12	Wood Waste	Historic log rafting area north of Shelton Harbor. COPCs (SVOCs, wood resin, pesticides, PCBs, and metals).
OB-18-WS-00	Wood Waste	Historic log rafting area north of Munson Point. COPCs (SVOCs, wood resin, pesticides, PCBs, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
OB-18-WC-12	Wood Waste	Historic log rafting area north of Munson Point. COPCs (SVOCs, wood resin, pesticides, PCBs, and metals).
OB-19-WS-00	Wood Waste	Historic log rafting area near Chapman Cove. COPCs (SVOCs, wood resin, pesticides, PCBs, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms
OB-19-WC-12	Wood Waste	Historic log rafting area near Chapman Cove. COPCs (SVOCs, wood resin, pesticides, PCBs, and metals).

[a] Example of sample ID: OB-15-RI-04 = Oakland Bay, Station 15, Radioisotope, 0-4 ft interval. Additional identifiers: SC = sediment core; SS = surface sediment; WC = wood waste sediment core; WS = wood waste surface sediment. See Section 6.1.1.
[b] Description of matrix: surface or subsurface sediment, or wood waste sediment.

Table 4-3. Summary of samples to be collected from Oakland Bay.

Sample ID [a]	Description	TOC/ GS	SVOC	Resin	Pest	PCB [b]	Dioxin/ Furan	TPH	TBT	Metal	S2 NH3	TVS	Pb210	Cs137	Bioassay
OB-01-SS-00	Surface	X	X		X	X	X	X		X	X				X
OB-01-SC-12	Subsurface	X	P		P	P				P	X				
OB-02-SS-00	Surface	X	X		X	X	X			X	X				X
OB-02-SC-12	Subsurface	X	P		P	P				P	X				
OB-03-SS-00	Surface	X	X		X	X	X			X	X				X
OB-03-SC-12	Subsurface	X	P		P	P				P	X				
OB-04-SS-00	Surface	X	X		X	X	X			X	X				X
OB-04-SC-12	Subsurface	X	P		P	P				P	X				
OB-05-SS-00	Surface	X	X		X	X	X			X	X				X
OB-05-SC-12	Subsurface	X	P		P	P				P	X				
OB-06-SS-00	Surface	X	X		X	X	X			X	X				X
OB-06-SC-12	Subsurface	X	P		P	P				P	X				
OB-07-SS-00	Surface	X	X		X	X	X			X	X				X
OB-07-SC-12	Subsurface	X	P		P	P				P	X				
OB-08-SS-00	Surface	X	X		X	X	X			X	X				X
OB-08-SC-12	Subsurface	X	P		P	P				P	X				
OB-09-SS-00	Surface	X	X		X	X	X			X	X				X
OB-09-SC-12	Subsurface	X	P		P	P				P	X				
OB-10-SS-00	Surface	X	X		X	X	X			X	X				X
OB-10-SC-12	Subsurface	X	P		P	P				P	X				
OB-11-SS-00	Surface	X	X		X	X	X			X	X				X
OB-11-SC-12	Subsurface	X	P		P	P				P	X				
OB-12-SS-00	Surface	X	X		X	X	X	X		X	X				X
OB-12-SC-12	Subsurface	X	P		P	P				P	X				
OB-13-SS-00	Surface	X	X		X	X	X	X		X	X				X

Table 4-3 (continued). Summary of samples to be collected from Oakland Bay.

Sample ID [a]	Description	TOC/ GS	SVOC	Resin	Pest	PCB [b]	Dioxin/ Furan	TPH	TBT	Metal	S2 NH3	TVS	Pb210	Cs137	Bioassay
OB-13-SC-12	Subsurface	X	P		P	P				P	X				
OB-14-SS-00	Surface	X	X		X	X	X			X	X				X
OB-14-SC-12	Subsurface	X	P		P	P				P	X				
OB-15-RI-04	Sediment Core												X	X	
OB-16-RI-04	Sediment Core												X	X	
OB-17-WS-00	Wood Waste	X	X	X	X	X	X			X	X	X			X
OB-17-WC-12	Wood Waste	X	X	X	X	X				X	X	X			
OB-18-WS-00	Wood Waste	X	X	X	X	X	X			X	X	X			X
OB-18-WC-12	Wood Waste	X	X	X	X	X				X	X	X			
OB-19-WS-00	Wood Waste	X	X	X	X	X	X			X	X	X			X
OB-19-WC-12	Wood Waste	X	X	X	X	X				X	X	X			
Archived Samples															
OB-01-SC-01	Subsurface														
OB-01-SC-23	Subsurface														
OB-01-SC-34	Subsurface														
OB-02-SC-01	Subsurface														
OB-02-SC-23	Subsurface														
OB-02-SC-34	Subsurface														
OB-03-SC-01	Subsurface														
OB-03-SC-23	Subsurface														
OB-03-SC-34	Subsurface														
OB-04-SC-01	Subsurface														
OB-04-SC-23	Subsurface														
OB-04-SC-34	Subsurface														
OB-05-SC-01	Subsurface														

Table 4-3 (continued). Summary of samples to be collected from Oakland Bay.

Sample ID [a]	Description	TOC/ GS	SVOC	Resin	Pest	PCB [b]	Dioxin/ Furan	TPH	TBT	Metal	S2 NH3	TVS	Pb210	Cs137	Bioassay
OB-05-SC-23	Subsurface														
OB-05-SC-34	Subsurface														
OB-06-SC-01	Subsurface														
OB-06-SC-23	Subsurface														
OB-06-SC-34	Subsurface														
OB-07-SC-01	Subsurface														
OB-07-SC-23	Subsurface														
OB-07-SC-34	Subsurface														
OB-08-SC-01	Subsurface														
OB-08-SC-23	Subsurface														
OB-08-SC-34	Subsurface														
OB-09-SC-01	Subsurface														
OB-09-SC-23	Subsurface														
OB-09-SC-34	Subsurface														
OB-10-SC-01	Subsurface														
OB-10-SC-23	Subsurface														
OB-10-SC-34	Subsurface														
OB-11-SC-01	Subsurface														
OB-11-SC-23	Subsurface														
OB-11-SC-34	Subsurface														
OB-12-SC-01	Subsurface														
OB-12-SC-23	Subsurface														
OB-12-SC-34	Subsurface														
OB-13-SC-01	Subsurface														
OB-13-SC-23	Subsurface														

Table 4-3 (continued). Summary of samples to be collected from Oakland Bay.

Sample ID [a]	Description	TOC/ GS	SVOC	Resin	Pest	PCB [b]	Dioxin/ Furan	TPH	TBT	Metal	S2 NH3	TVS	Pb210	Cs137	Bioassay
OB-13-SC-34	Subsurface														
OB-14-SC-01	Subsurface														
OB-14-SC-23	Subsurface														
OB-14-SC-34	Subsurface														
OB-17-WC-01	Wood Waste														
OB-17-WC-23	Wood Waste														
OB-17-WC-34	Wood Waste														
OB-18-WC-01	Wood Waste														
OB-18-WC-23	Wood Waste														
OB-18-WC-34	Wood Waste														
OB-19-WC-01	Wood Waste														
OB-19-WC-23	Wood Waste														
OB-19-WC-34	Wood Waste														

[a] Example of sample ID: OB-15-RI-04 = Oakland Bay, Station 15, Radioisotope, 0-4 ft interval. Additional identifiers: SC = sediment core; SS = surface sediment; WC = wood waste sediment core; WS = wood waste surface sediment. See Section 6.1.1.
[b] PCBs analyzed as Aroclors for sediment and wood waste sediment samples.
Bioassay = Sediment Management Standards acute and chronic tests
Ce137 = Cesium-137
Dioxin/furan = 2,3,7,8-substituted isomers and congeners
Metals = Antimony, arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc
P = For sediment cores, 1-2 ft interval samples analyzed pending surface sample results.
Pb210 = Lead-210
PCB = Polychlorinated biphenyls
Resin = Wood waste indicator compounds, e.g., guaiacols and fatty acids
Pest = Chlorinated pesticides
SVOC = Semi-volatile organic compounds
TBT = Tributyltin
TOC = Total organic carbon
TPH = Total petroleum hydrocarbons as NWTPH-HCID (hydrocarbon identification)
TVS = Total volatile solids
X = Samples submitted for laboratory analysis.

Based on surface sediment analytical results, additional analysis of the 1-2 ft interval may be conducted on archived sediment core samples. The SMS provides criteria used to identify surface sediment that have no adverse acute or chronic effects on biological resources and no significant risk to humans, which will be used to help determine additional analyses. Specifically, surface sediment with SQS exceedances, bioassay toxicity, or exceedances of other criteria not having an SQS value (see Section 8.1) may trigger subsurface analysis. Additional analyses may be conducted on archived sediment core samples collected over other depth intervals based on this initial data.

4.2.2 Wood Waste

Historical wood rafting operations have been identified, along the shoreline north of the Shelton Marina (station OB-17), across Hammersley Inlet east of Shelton Harbor (station OB-18), and at Chapman Cove (station OB-19).

4.2.2.1 Surface Wood Waste Sediment Samples

Representative surface wood waste sediment (0 to 10 cm) samples will be collected at each of these three locations within Oakland Bay (Figure 4-2). Sediment from each location will be homogenized and submitted for chemical and bioassay analysis. Sample aliquots for ammonia and sulfide will be separated out prior to sample homogenization to minimize losses due to volatilization. Refer to Section 6 for recommended holding times for analyses. As shown in Tables 4-2 and 4-3, samples from all of these locations will be analyzed for the broad spectrum of industrial discharge COPCs. Surface wood waste sediment samples will also be analyzed for TVS and other wood waste indicators (resins and guaiacols), dioxins/furans, and bioassay toxicity. The chemical analyte list, analytical methods, TDLs, and comparative criteria are discussed in Section 7.1.

4.2.2.2 Subsurface Wood Waste Sediment Cores

Wood waste sediment cores will be collected to determine the vertical extent of potential contamination. Core sampling locations will be co-located at the three surface wood waste sediment stations (Figure 4-2). Cores will be advanced to 4+ ft below the surface using a Vibracore sampler. If significant wood waste is encountered, based on visual observations, cores will be advanced to to the bottom of the wood waste, to a maximum of 12 ft. Core samples will be collected by sectioning each core into 1-ft intervals and then containerizing sediment from each interval.

Sample aliquots for ammonia and sulfide will be separated from the 1-2 ft increment prior to sample homogenization. The remaining 1-2 ft core sample material will be homogenized and sample aliquots for all other analyses containerized. As shown in Tables 4-2 and 4-3, 1-2 ft interval samples from these locations will be analyzed for the broad spectrum of industrial discharge COPCs, TVS, and other wood waste indicators (resins and guaiacols). The chemical analyte list, analytical methods, TDLs, and comparative criteria are discussed in Section 7.1.

Each other 1-ft increment will be homogenized and placed in large sample jars for archiving and stored frozen (identified in Table 4-3). Core collection and evaluation will include a physical description of the stratigraphy.

The SMS provides criteria used to identify surface sediment that have no adverse acute or chronic effects on biological resources and no significant risk to humans, which will be used to help determine additional analyses. Specifically, surface sediment with SQS exceedances, bioassay toxicity, or exceedances of other criteria not having an SQS value (see Section 8.1) may trigger subsurface analysis. Additional analyses may be conducted on archived sediment core samples collected over other depth intervals based on this initial data.

4.2.3 Bioassays

Bioassays will be conducted to determine the extent of acute and chronic toxicity of sensitive test organisms to contaminants found in Oakland Bay sediments. The 14 surface sediment samples collected across Oakland Bay will be submitted for toxicity testing. In addition, surface wood waste sediment collected from the three wood waste sample locations will be submitted for toxicity testing. Toxicity tests to be conducted on Oakland Bay sediments include amphipod mortality, juvenile polychaete growth, bivalve larvae development, and Microtox® (porewater) bioluminescence. Details on toxicity testing methodology are provided in Section 7.2.

4.3 Shelton Harbor

The study consists of a non-random design that utilizes a tiered analysis approach to spatially characterize sediment conditions across the harbor. Sampling stations are placed at locations with potential and/or known point and non-point sources, to characterize current wood waste distribution, to evaluate movement/concentration trends of contaminants out from the Harbor, and to characterize deposition rates. Station locations were based on guidance for investigation of sediment contamination in the *Sediment Sampling and Analysis Plan Appendix* (Ecology 2008) and review of data from previous investigations in Shelton Harbor (Herrera 2008). Sampling locations within Shelton Harbor are presented on Figures 4-3 and 4-4.

Sediment chemistry analyses, wood waste sediment chemistry analyses, and bioassay toxicity analyses will be completed concurrently. A surface (0-10 cm) sediment sample will be collected at each sediment sampling station and submitted for analyses. In addition, a 4-ft core will be collected at each sediment sampling station. A surface (0-10 cm) wood waste sediment sample will be collected at each wood waste station. A subsurface core will be advanced a minimum of 4 ft or to the bottom of the wood waste encountered (to a maximum depth of 12 ft) at each wood waste station. Core samples will be collected by sectioning each core into 1-ft intervals (for example; 0-1 ft, 1-2 ft, and so on to the maximum depth of the core) and containerizing sediment from each interval. Each surface and core sample will be visually evaluated for gross wood content to allow estimates of wood waste thickness, type (bark, chips, sawdust), and abundance.

The analyses to be conducted on individual samples are based on *Sediment Sampling and Analysis Plan Appendix* (Ecology 2008) guidance and review of previous studies (Herrera 2008).

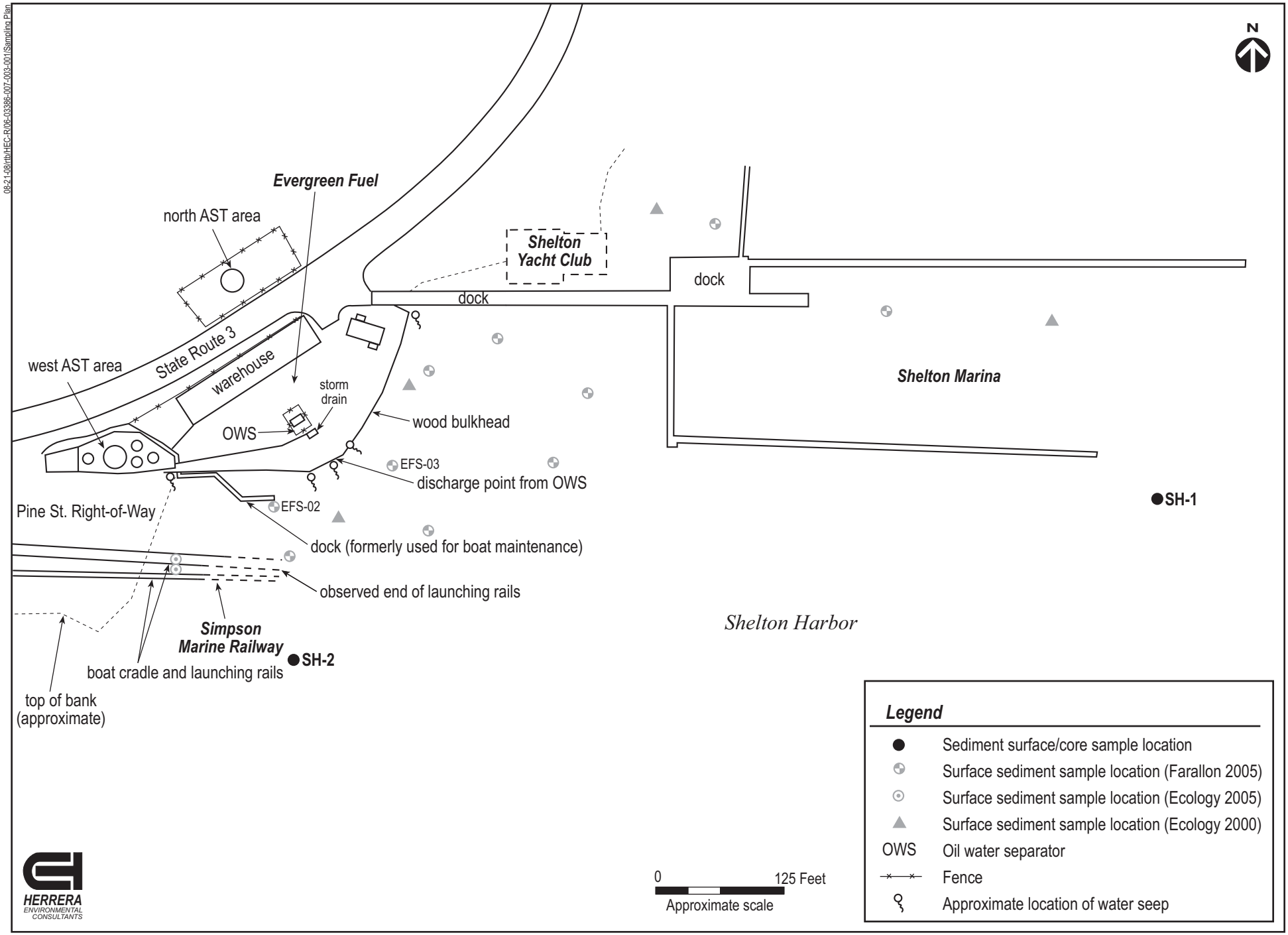

Figure 4-4. Sediment sample locations (to be collected) at the former Evergreen Fuel site, Shelton, Washington.

4.3.1 Sediment

The Data Gaps report identified 26 pipe discharge locations in and around Shelton Harbor that have conveyed stormwater or industrial waste into the harbor, with 15 locations situated along the harbor shoreline. This study will focus on seven shoreline discharge locations (stations, SH-4, SH-5, SH-6, SH-11, SH-12, SH-13, and SH-25) based on previous sampling performed and the clustering of mapped discharge points. Four sample stations (stations SH-3, SH-7, SH-8, and SH-9) will be used to address Goldsborough and Shelton Creek discharges into the north and central portions of the harbor. Four additional sample stations (SH10 and SH-14 to SH-16) will be used to characterize the harbor as it transitions to Hammersley Inlet and Oakland Bay.

4.3.1.1 Surface Sediment Samples

Representative surface sediment (0 to 10 cm) samples will be collected at 16 locations within Shelton Harbor (Figures 4-3 and 4-4). An aliquot from each location will be homogenized and submitted for chemical and bioassay analysis. Sample aliquots for ammonia and sulfide will be collected prior to sample homogenization to minimize losses due to volatilization. Refer to Section 6 for recommended holding times for analyses. As shown in Tables 4-4 and 4-5, samples from all locations will be analyzed for the broad spectrum of industrial discharge COPCs. Surface sediment samples will also be analyzed for dioxins/furans and bioassay toxicity. A few samples near potential on-shore petroleum sources will be analyzed for TPH. Samples in areas suspected to be impacted by boating and marina activities will be analyzed for tributyltin (TBT). The chemical analyte list, analytical methods, TDLs, and comparative criteria are discussed in Section 7.1.

4.3.1.2 Subsurface Sediment Cores

Sediment cores will be collected to determine the vertical extent of potential contamination. Core sampling locations will be co-located at the 16 surface sediment locations (Figures 4-3 and 4-4). Cores will be advanced to 4+ ft below the surface using a Vibracore sampler. If significant wood waste is encountered, based on visual observations, cores will be advanced to to the bottom of the wood waste, to a maximum of 12 ft. Cores will be archived as sample aliquots in 1-ft increments beginning at the sediment surface and may be submitted for chemical analysis at a later time.

Sample aliquots for ammonia and sulfide will be collected from the 1-2 ft increment prior to sample homogenization. The remaining sample material will be homogenized. Sample aliquots for all other analyses will then be collected. As shown in Tables 4-4 and 4-5, 1-2 ft interval samples from these locations will be analyzed for the broad spectrum of industrial discharge COPCs. The chemical analyte list, analytical methods, TDLs, and comparative criteria are discussed in Section 7.1.

All other 1-ft increments will be homogenized and placed in large sample jars for archiving and stored frozen. Table 4-5 identifies the archive samples. Core collection and evaluation will include a physical description of the stratigraphy.

Table 4-4. Rationale for samples to be collected in Shelton Harbor.

Sample ID [a]	Description [b]	Sample Justification
SH-01-SS-00	Surface	Located near Shelton Marina. COPCs (SVOCs, pesticides, PCB, TPH, metals, and dioxin/furans) and butyltins. Bioassay to assess sediment toxicity on benthic organisms.
SH-01-SC-12	Subsurface	Located near Shelton Marina. COPCs (SVOCs, pesticides, PCB, TPH, and metals) and butyltins.
SH-02-SS-00	Surface	Located near marine railway. COPCs (SVOCs, pesticides, PCB, TPH, metals, and dioxin/furans) and butyltins. Bioassay to assess sediment toxicity on benthic organisms.
SH-02-SC-12	Subsurface	Located near marine railway. COPCs (SVOCs, pesticides, PCB, TPH, and metals) and butyltins.
SH-03-SS-00	Surface	Shelton Creek – potential point source to Shelton Harbor. Analyze for COPCs (SVOCs, pesticides, PCB, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
SH-03-SC-12	Subsurface	Shelton Creek – potential point source to Shelton Harbor. Analyze for COPCs (SVOCs, pesticides, PCB, and metals).
SH-04-SS-00	Surface	Outfall location – pond saw, plywood plant. COPCs (SVOCs, pesticides, PCB, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
SH-04-SC-12	Subsurface	Outfall location– pond saw, plywood plant COPCs (SVOCs, pesticides, PCB, and metals).
SH-05-SS-00	Surface	Outfall location – east log storage yard. COPCs (SVOCs, pesticides, PCB, TPH, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
SH-05-SC-12	Subsurface	Outfall location – east log storage yard. COPCs (SVOCs, pesticides, PCB, and metals).
SH-06-SS-00	Surface	Outfall location – shops, boiler plant, overlay plant. COPCs (SVOCs, pesticides, PCB, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
SH-06-SC-12	Subsurface	Outfall location – shops, boiler plant, overlay plant. COPCs (SVOCs, pesticides, PCB, and metals).
SH-07-SS-00	Surface	Goldsborough Creek – potential point source to Shelton Harbor. COPCs (SVOCs, pesticides, PCB, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
SH-07-SC-12	Subsurface	Goldsborough Creek – potential point source to Shelton Harbor. COPCs (SVOCs, pesticides, PCB, and metals).
SH-08-SS-00	Surface	Goldsborough Creek – potential point source to Shelton Harbor. COPCs (SVOCs, pesticides, PCB, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
SH-08-SC-12	Subsurface	Goldsborough Creek – potential point source to Shelton Harbor. COPCs (SVOCs, pesticides, PCB, and metals).
SH-09-SS-00	Surface	Shelton and Goldsborough Creeks confluence in Shelton Harbor. COPCs (SVOCs, pesticides, PCB, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
SH-09-SC-12	Subsurface	Shelton and Goldsborough Creeks confluence in Shelton Harbor. COPCs (SVOCs, pesticides, PCB, and metals).
SH-10-SS-00	Surface	Mid-Shelton Harbor characterization. COPCs (SVOCs, pesticides, PCB, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.

Table 4-4 (continued). Rationale for samples to be collected in Shelton Harbor.

Sample ID [a]	Description [b]	Sample Justification
SH-10-SC-12	Subsurface	Mid-Shelton Harbor characterization. COPCs (SVOCs, pesticides, PCB, and metals).
SH-11-SS-00	Surface	Outfall location – City stormwater and proximity to reported wood treating area, and to pentachlorophenol exceedance from prior study. COPCs (SVOCs, pesticides, PCB, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
SH-11-SC-12	Subsurface	Outfall location. – City stormwater and proximity to reported wood treating area, and to pentachlorophenol exceedance from prior study. COPCs (SVOCs, pesticides, PCB, and metals).
SH-12-SS-00	Surface	Outfall location – sawmill stormwater. COPCs (SVOCs, pesticides, PCB, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
SH-12-SC-12	Subsurface	Outfall location – sawmill stormwater. COPCs (SVOCs, pesticides, PCB, and metals).
SH-13-SS-00	Surface	Outfall location – Rayonier laboratory. COPCs (SVOCs, pesticides, PCB, TPH, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
SH-13-SC-12	Subsurface	Outfall location – Rayonier laboratory. COPCs (SVOCs, pesticides, PCB, and metals).
SH-14-SS-00	Surface	Mid-Shelton Harbor characterization. COPCs (SVOCs, pesticides, PCB, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
SH-14-SC-12	Subsurface	Mid-Shelton Harbor characterization. COPCs (SVOCs, pesticides, PCB, and metals).
SH-15-SS-00	Surface	Outer-Shelton Harbor characterization. COPCs (SVOCs, pesticides, PCB, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
SH-15-SC-12	Subsurface	Outer-Shelton Harbor characterization. COPCs (SVOCs, pesticides, PCB, and metals).
SH-16-SS-00	Surface	Outer-Shelton Harbor characterization. COPCs (SVOCs, pesticides, PCB, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
SH-16-SC-12	Subsurface	Outer-Shelton Harbor characterization. COPCs (SVOCs, pesticides, PCB, and metals).
SH-17-RI-04	Sediment Core	Sediment core dating. Collect from Goldsborough Creek alluvial fan.
SH-18-WS-00	Wood Waste	Stratum 8. COPCs (SVOCs, wood resin, pesticides, PCBs, TPH, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
SH-18-WC-12	Wood Waste	Stratum 8. COPCs (SVOCs, wood resin, pesticides, PCBs, and metals).

Table 4-4 (continued). Rationale for samples to be collected in Shelton Harbor.

Sample ID [a]	Description [b]	Sample Justification
SH-19-WS-00	Wood Waste	Stratum 7. COPCs (SVOCs, wood resin, pesticides, PCBs, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
SH-19-WC-12	Wood Waste	Stratum 7. COPCs (SVOCs, wood resin, pesticides, PCBs, and metals).
SH-20-WS-00	Wood Waste	Stratum 7. COPCs (SVOCs, wood resin, pesticides, PCBs, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
SH-20-WC-12	Wood Waste	Stratum 7. COPCs (SVOCs, wood resin, pesticides, PCBs, and metals).
SH-21-WS-00	Wood Waste	Stratum 3. COPCs (SVOCs, wood resin, pesticides, PCBs, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
SH-21-WC-12	Wood Waste	Stratum 3. COPCs (SVOCs, wood resin, pesticides, PCBs, and metals).
SH-22-WS-00	Wood Waste	Stratum 3. COPCs (SVOCs, wood resin, pesticides, PCBs, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
SH-22-WC-12	Wood Waste	Stratum 3. COPCs (SVOCs, wood resin, pesticides, PCBs, and metals).
SH-23-WS-00	Wood Waste	Stratum 9. COPCs (SVOCs, wood resin, pesticides, PCBs, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
SH-23-WC-12	Wood Waste	Stratum 9. COPCs (SVOCs, wood resin, pesticides, PCBs, and metals).
SH-24-WS-00	Wood Waste	Stratum 6. COPCs (SVOCs, wood resin, pesticides, PCBs, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
SH-24-WC-12	Wood Waste	Stratum 6. COPCs (SVOCs, wood resin, pesticides, PCBs, and metals).
SH-25-WS-00	Wood Waste	Stratum 6. COPCs (SVOCs, wood resin, pesticides, PCBs, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
SH-25-WC-12	Wood Waste	Stratum 6. COPCs (SVOCs, wood resin, pesticides, PCBs, and metals).
SH-26-WS-00	Wood Waste	Stratum 4. COPCs (SVOCs, wood resin, pesticides, PCBs, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
SH-26-WC-12	Wood Waste	Stratum 4. COPCs (SVOCs, wood resin, pesticides, PCBs, and metals).

Table 4-4 (continued). Rationale for samples to be collected in Shelton Harbor.

Sample ID [a]	Description [b]	Sample Justification
SH-27-WS-00	Wood Waste	Stratum 5. COPCs (SVOCs, wood resin, pesticides, PCBs, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms
SH-27-WC-12	Wood Waste	Stratum 5. COPCs (SVOCs, wood resin, pesticides, PCBs, and metals).
SH-28-WS-00	Wood Waste	Stratum 1. COPCs (SVOCs, wood resin, pesticides, PCBs, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
SH-28-WC-12	Wood Waste	Stratum 1. COPCs (SVOCs, wood resin, pesticides, PCBs, and metals).
SH-29-WS-00	Wood Waste	Outer Shelton Harbor. COPCs (SVOCs, wood resin, pesticides, PCBs, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
SH-29-WC-12	Wood Waste	Outer Shelton Harbor. COPCs (SVOCs, wood resin, pesticides, PCBs, and metals).
SH-30-WS-00	Wood Waste	Stratum 2. COPCs (SVOCs, wood resin, pesticides, PCBs, metals, and dioxin/furans) and butyltins. Bioassay to assess sediment toxicity on benthic organisms.
SH-30-WC-12	Wood Waste	Stratum 2. COPCs (SVOCs, wood resin, pesticides, PCBs, and metals) and butyltins.

[a] Example of sample ID: SH-17-RI-04 = Shelton Harbor, Station 17, Radioisotope, 0-4 ft interval. Additional identifiers: SC = sediment core; SS = surface sediment; WC = wood waste sediment core; WS = wood waste surface sediment.
[b] Description of matrix: surface or subsurface sediment, or wood waste sediment.

Table 4-5. Summary of samples to be collected from Shelton Harbor.

Sample ID [a]	Description	TOC/GS	SVOC	Resin	Pest	PCB [b]	Dioxin/ Furan	TPH	TBT	Metal	S2/NH3	TVS	Pb210	Cs137	Bioassay
SH-01-SS-00	Surface	X	X		X	X	X	X	X	X	X				X
SH-01-SC-12	Subsurface	X	X		X	X		X	X	X	X				
SH-02-SS-00	Surface	X	X		X	X	X	X	X	X	X				X
SH-02-SC-12	Subsurface	X	X		X	X		X	X	X	X				
SH-03-SS-00	Surface	X	X		X	X	X			X	X				X
SH-03-SC-12	Subsurface	X	X		X	X				X	X				
SH-04-SS-00	Surface	X	X		X	X	X			X	X				X
SH-04-SC-12	Subsurface	X	X		X	X				X	X				
SH-05-SS-00	Surface	X	X		X	X	X	X		X	X				X
SH-05-SC-12	Subsurface	X	X		X	X				X	X				
SH-06-SS-00	Surface	X	X		X	X	X			X	X				X
SH-06-SC-12	Subsurface	X	X		X	X				X	X				
SH-07-SS-00	Surface	X	X		X	X	X			X	X				X
SH-07-SC-12	Subsurface	X	X		X	X				X	X				
SH-08-SS-00	Surface	X	X		X	X	X			X	X				X
SH-08-SC-12	Subsurface	X	X		X	X				X	X				
SH-09-SS-00	Surface	X	X		X	X	X			X	X				X
SH-09-SC-12	Subsurface	X	X		X	X				X	X				
SH-10-SS-00	Surface	X	X		X	X	X			X	X				X
SH-10-SC-12	Subsurface	X	X		X	X				X	X				
SH-11-SS-00	Surface	X	X		X	X	X			X	X				X
SH-11-SC-12	Subsurface	X	X		X	X				X	X				
SH-12-SS-00	Surface	X	X		X	X	X			X	X				X
SH-12-SC-12	Subsurface	X	X		X	X				X	X				

Table 4-5 (continued). Summary of samples to be collected from Shelton Harbor.

Sample ID [a]	Description	TOC/GS	SVOC	Resin	Pest	PCB [b]	Dioxin/ Furan	TPH	TBT	Metal	S2/NH3	TVS	Pb210	Cs137	Bioassay
SH-13-SS-00	Surface	X	X		X	X	X	X		X	X				X
SH-13-SC-12	Subsurface	X	X		X	X				X	X				
SH-14-SS-00	Surface	X	X		X	X	X			X	X				X
SH-14-SC-12	Subsurface	X	X		X	X				X	X				
SH-15-SS-00	Surface	X	X		X	X	X			X	X				X
SH-15-SC-12	Subsurface	X	X		X	X				X	X				
SH-16-SS-00	Surface	X	X		X	X	X			X	X				X
SH-16-SC-12	Subsurface	X	X		X	X				X	X				
SH-17-RI-04	Sediment Core												X	X	
SH-18-WS-00	Wood Waste	X	X	X	X	X	X	X		X	X	X			X
SH-18-WC-12	Wood Waste	X	X	X	X	X				X	X	X			
SH-19-WS-00	Wood Waste	X	X	X	X	X	X			X	X	X			X
SH-19-WC-12	Wood Waste	X	X	X	X	X				X	X	X			
SH-20-WS-00	Wood Waste	X	X	X	X	X	X			X	X	X			X
SH-20-WC-12	Wood Waste	X	X	X	X	X				X	X	X			
SH-21-WS-00	Wood Waste	X	X	X	X	X	X			X	X	X			X
SH-21-WC-12	Wood Waste	X	X	X	X	X				X	X	X			
SH-22-WS-00	Wood Waste	X	X	X	X	X	X			X	X	X			X
SH-22-WC-12	Wood Waste	X	X	X	X	X				X	X	X			
SH-23-WS-00	Wood Waste	X	X	X	X	X	X			X	X	X			X
SH-23-WC-12	Wood Waste	X	X	X	X	X				X	X	X			
SH-24-WS-00	Wood Waste	X	X	X	X	X	X			X	X	X			X
SH-24-WC-12	Wood Waste	X	X	X	X	X				X	X	X			
SH-25-WS-00	Wood Waste	X	X	X	X	X	X			X	X	X			X
SH-25-WC-12	Wood Waste	X	X	X	X	X				X	X	X			
SH-26-WS-00	Wood Waste	X	X	X	X	X	X			X	X	X			X

Table 4-5 (continued). Summary of samples to be collected from Shelton Harbor.

Sample ID [a]	Description	TOC/GS	SVOC	Resin	Pest	PCB [b]	Dioxin/ Furan	TPH	TBT	Metal	S2/NH3	TVS	Pb210	Cs137	Bioassay
SH-26-WC-12	Wood Waste	X	X	X	X	X				X	X	X			
SH-27-WS-00	Wood Waste	X	X	X	X	X	X			X	X	X			X
SH-27-WC-12	Wood Waste	X	X	X	X	X				X	X	X			
SH-28-WS-00	Wood Waste	X	X	X	X	X	X			X	X	X			X
SH-28-WC-12	Wood Waste	X	X	X	X	X				X	X	X			
SH-29-WS-00	Wood Waste	X	X	X	X	X	X			X	X	X			X
SH-29-WC-12	Wood Waste	X	X	X	X	X				X	X	X			
SH-30-WS-00	Wood Waste	X	X	X	X	X	X		X	X	X	X			X
SH-30-WC-12	Wood Waste	X	X	X	X	X			X	X	X	X			
Archived Samples															
SH-01-SC-01	Subsurface														
SH-01-SC-23	Subsurface														
SH-01-SC-34	Subsurface														
SH-02-SC-01	Subsurface														
SH-02-SC-23	Subsurface														
SH-02-SC-34	Subsurface														
SH-03-SC-01	Subsurface														
SH-03-SC-34	Subsurface														
SH-04-SC-01	Subsurface														
SH-04-SC-23	Subsurface														
SH-04-SC-34	Subsurface														
SH-05-SC-01	Subsurface														
SH-05-SC-23	Subsurface														
SH-05-SC-34	Subsurface														
SH-06-SC-01	Subsurface														
SH-06-SC-23	Subsurface														
SH-06-SC-34	Subsurface														
SH-07-SC-01	Subsurface														

Table 4-5 (continued). Summary of samples to be collected from Shelton Harbor.

Sample ID [a]	Description	TOC/GS	SVOC	Resin	Pest	PCB [b]	Dioxin/ Furan	TPH	TBT	Metal	S2/NH3	TVS	Pb210	Cs137	Bioassay
SH-07-SC-23	Subsurface														
SH-07-SC-34	Subsurface														
SH-08-SC-01	Subsurface														
SH-08-SC-23	Subsurface														
SH-08-SC-34	Subsurface														
SH-09-SC-01	Subsurface														
SH-09-SC-23	Subsurface														
SH-09-SC-34	Subsurface														
SH-10-SC-01	Subsurface														
SH-10-SC-23	Subsurface														
SH-10-SC-34	Subsurface														
SH-11-SC-01	Subsurface														
SH-11-SC-23	Subsurface														
SH-11-SC-34	Subsurface														
SH-12-SC-01	Subsurface														
SH-12-SC-23	Subsurface														
SH-12-SC-34	Subsurface														
SH-13-SC-01	Subsurface														
SH-13-SC-23	Subsurface														
SH-13-SC-34	Subsurface														
SH-14-SC-01	Subsurface														
SH-14-SC-23	Subsurface														
SH-14-SC-34	Subsurface														
SH-15-SC-01	Subsurface														
SH-15-SC-23	Subsurface														
SH-15-SC-34	Subsurface														
SH-16-SC-01	Subsurface														
SH-16-SC-23	Subsurface														

Table 4-5 (continued). Summary of samples to be collected from Shelton Harbor.

Sample ID [a]	Description	TOC/GS	SVOC	Resin	Pest	PCB [b]	Dioxin/ Furan	TPH	TBT	Metal	S2/NH3	TVS	Pb210	Cs137	Bioassay
SH-16-SC-34	Subsurface														
SH-18-WC-01	Wood Waste														
SH-18-WC-23	Wood Waste														
SH-18-WC-34	Wood Waste														
SH-19-WC-01	Wood Waste														
SH-19-WC-23	Wood Waste														
SH-19-WC-34	Wood Waste														
SH-20-WC-01	Wood Waste														
SH-20-WC-23	Wood Waste														
SH-20-WC-34	Wood Waste														
SH-21-WC-01	Wood Waste														
SH-21-WC-23	Wood Waste														
SH-21-WC-34	Wood Waste														
SH-22-WC-01	Wood Waste														
SH-22-WC-23	Wood Waste														
SH-22-WC-34	Wood Waste														
SH-23-WC-01	Wood Waste														
SH-23-WC-23	Wood Waste														
SH-23-WC-34	Wood Waste														
SH-24-WC-01	Wood Waste														
SH-24-WC-23	Wood Waste														
SH-24-WC-34	Wood Waste														
SH-25-WC-01	Wood Waste														
SH-25-WC-23	Wood Waste														
SH-25-WC-34	Wood Waste														
SH-26-WC-01	Wood Waste														
SH-26-WC-23	Wood Waste														
SH-26-WC-34	Wood Waste														

Table 4-5 (continued). Summary of samples to be collected from Shelton Harbor.

Sample ID [a]	Description	TOC/GS	SVOC	Resin	Pest	PCB [b]	Dioxin/ Furan	TPH	TBT	Metal	S2/NH3	TVS	Pb210	Cs137	Bioassay
SH-27-WC-01	Wood Waste														
SH-27-WC-23	Wood Waste														
SH-27-WC-34	Wood Waste														
SH-28-WC-01	Wood Waste														
SH-28-WC-23	Wood Waste														
SH-28-WC-34	Wood Waste														
SH-29-WC-01	Wood Waste														
SH-29-WC-23	Wood Waste														
SH-29-WC-34	Wood Waste														
SH-30-WC-01	Wood Waste														
SH-30-WC-23	Wood Waste														
SH-30-WC-34	Wood Waste														

[a] Example of sample ID: SH-17-RI-04 = Shelton Harbor, Station 17, Radioisotope, 0-4 ft interval. Additional identifiers: SC = sediment core; SS = surface sediment; WC = wood waste sediment core; WS = wood waste surface sediment. See Section 6.1.1.
[b] PCBs analyzed as Aroclors for sediment and wood waste sediment samples.
Bioassay = Sediment Management Standards acute and chronic tests
Ce137 = Cesium-137
Dioxin/furan = 2,3,7,8-substituted isomers and congeners
Metals = Antimony, arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc
Pb210 = Lead-210
PCB = Polychlorinated biphenyls
Resin = Wood waste indicator compounds, e.g., guaiacols and fatty acids
Pest = Chlorinated pesticides
SVOC = Semi-volatile organic compounds
TBT = Tributyltin
TOC = Votal organic carbon
TPH = Total petroleum hydrocarbons as NWTPH-HCID (hydrocarbon identification)
TVS = Total volatile solids
X = Samples submitted for laboratory analysis.

The SMS provides criteria used to identify surface sediment that have no adverse acute or chronic effects on biological resources and no significant risk to humans, which will be used to help determine additional analyses. Specifically, surface sediment with SQS exceedances, bioassay toxicity, or exceedances of other criteria not having an SQS value (see Section 8.1) may trigger subsurface analysis. Additional analyses may be conducted on archived sediment core samples collected over other depth intervals based on this initial data.

4.3.2 Wood Waste

Wood waste cores will be collected and submitted for analysis to help measure the vertical extent of wood waste in areas of historical log rafting and other wood handling activities. Accumulations of wood waste have been identified across the entire harbor, as defined by nine sub-areas (strata) in the Ecology 2000 Reconnaissance Survey. One or two sample stations have been established in each of the nine strata (SH-18 to SH-28, and SH-30) to characterize the extent of wood waste across Shelton Harbor. An additional station (SH-29) was established outside the original reconnaissance survey area to help establish the extent of wood waste leading from Shelton Harbor into Oakland Bay.

4.3.2.1 Surface Wood Waste Sediment Samples

Representative surface wood waste sediment (0 to 10 cm) samples will be collected at each of these 13 locations within Shelton Harbor (Figure 4-3). An aliquot from each location will be homogenized and submitted for chemical and bioassay analysis. Sample aliquots for ammonia and sulfide will be separated out prior to sample homogenization to minimize losses due to volatilization. Refer to Section 6 for recommended holding times for analyses. As shown in Tables 4-4 and 4-5, samples from all of these locations will be analyzed for the broad spectrum of industrial discharge COPCs. Surface wood waste sediment samples will also be analyzed for TVS and other wood waste indicators (resins and guaiacols), dioxins/furans, and bioassay toxicity. The chemical analyte list, analytical methods, TDLs, and comparative criteria are discussed in Section 7.1.

4.3.2.2 Subsurface Wood Waste Sediment Cores

Wood waste sediment cores will be collected to determine the vertical extent of potential contamination. Core sampling locations will be co-located at the 13 surface wood waste sediment stations (Figure 4-3). Cores will be advanced to 4+ ft below the surface using a Vibracore sampler. If significant wood waste is encountered, based on visual observations, cores will be advanced to to the bottom of the wood waste, to a maximum of 12 ft. Core samples will be collected by sectioning each core into 1-ft intervals and then containerizing sediment from each interval.

Sample aliquots for ammonia and sulfide will be separated from the 1-2 ft increment prior to sample homogenization. The remaining 1-2 ft core sample material will be homogenized and sample aliquots for all other analyses will then be containerized in the appropriate sample bottles. As shown in Tables 4-4 and 4-5, 1-2 ft interval samples from these locations will be analyzed for the broad spectrum of industrial discharge COPCs, TVS, and other wood waste

indicators (resins and guaiacols). The chemical analyte list, analytical methods, TDLs, and comparative criteria are discussed in Section 7.1.

All other 1-ft increments will be homogenized and placed in large sample jars for archiving and stored frozen (identified in Table 4-5). Core collection and evaluation will include a physical description of the stratigraphy.

The SMS provides criteria used to identify surface sediment that have no adverse acute or chronic effects on biological resources and no significant risk to humans, which will be used to help determine additional analyses. Specifically, surface sediment with SQS exceedances, bioassay toxicity, or exceedances of other criteria not having an SQS value (see Section 8.1) may trigger subsurface analysis. Additional analyses may be conducted on archived sediment core samples collected over other depth intervals based on this initial data.

4.3.3 Bioassays

Bioassays will be conducted to determine the extent of acute and chronic toxicity of sensitive test organisms to contaminants found in Shelton Harbor sediments. The 16 surface sediment samples collected across Shelton Harbor will be submitted for toxicity testing. In addition, sediment collected at the 13 surface wood waste sediment sample locations will be submitted for toxicity testing. Toxicity tests to be conducted on Shelton Harbor sediments and wood waste sediments include amphipod mortality, juvenile polychaete growth, bivalve larvae development, and Microtox® (porewater) bioluminescence. Details on toxicity testing methodology are provided in Section 7.2.

4.4 Hammersley Inlet

The study consists of a non-random design to spatially characterize sediment conditions in the western portion of Hammersley Inlet. Sampling stations are placed at locations with potential for sediment redistribution from Shelton Harbor and Oakland Bay and at locations associated with WWTP outfalls. Station locations were based on guidance for initial investigation of sediment contamination in the *Sediment Sampling and Analysis Plan Appendix* (Ecology 2008) and review of previous studies in and near the inlet (Herrera 2008). Sampling locations within Hammersley Inlet are presented on Figure 4-2.

Sediment chemistry analyses and bioassay toxicity analyses will be completed concurrently. A surface (0-10 cm) sediment sample will be collected at each sediment sampling station and submitted for analyses. In addition, a 4-ft core will be collected at each sediment sampling station. Core samples will be collected by sectioning each core into 1-ft intervals and containerizing sediment from each interval. Each surface and core sample will be visually evaluated for gross wood content to allow estimates of wood waste thickness, type (bark, chips, sawdust), and abundance.

The analyses to be conducted on individual samples are based on *Sediment Sampling and Analysis Plan Appendix* (Ecology 2008) guidance and review of previous studies (Herrera 2008).

4.4.1 Sediment

The Data Gaps report (Herrera 2008) did not identify any creeks discharging to the western portion of the inlet or any sites with documented or potential releases of hazardous substances (including log rafting). Sampling stations have been established at locations with natural sediment accumulation. Five stations will be sampled along the shoreline and study area boundary of the inlet to evaluate conditions resulting from fluvial redistribution processes (stations HI-1 to HI-4, and HI-6). Two additional discharge points associated with the former and existing WWTPs located at the transition area between Shelton Harbor, Oakland Bay, and Hammersley Inlet will also be sampled (stations HI-5 and HI-7). Samples from all of these locations will be analyzed for the broad spectrum of industrial discharge COPCs. Surface samples will also be analyzed for dioxins/furans and bioassay toxicity.

4.4.1.1 Surface Sediment Samples

Representative surface sediment (0 to 10 cm) samples will be collected at seven locations within Hammersley Inlet (Figure 4-2). An aliquot from each location will be homogenized and submitted for chemical and bioassay analysis. Sample aliquots for ammonia and sulfide will be collected prior to sample homogenization to minimize losses due to volatilization. Refer to Section 6 for recommended holding times for analyses. As shown in Tables 4-6 and 4-7, samples from all locations will be analyzed for the broad spectrum of industrial discharge COPCs. Surface sediment samples will also be analyzed for dioxins/furans and bioassay toxicity. The chemical analyte list, analytical methods, TDLs, and comparative criteria are discussed in Section 7.1.

4.4.1.2 Subsurface Sediment Cores

Sediment cores will be collected to determine the vertical extent of potential contamination. Core sampling locations will be co-located at the seven surface sediment locations (Figure 4-2). Cores will be advanced to 4+ ft below the surface using a Vibracore sampler. If significant wood waste is encountered, based on visual observations, cores will be advanced to to the bottom of the wood waste, to a maximum of 12 ft. Cores will be archived as sample aliquots in 1-ft increments beginning at the sediment surface and may be submitted for chemical analysis at a later time. The 1-2 ft segment from each core will be divided into multiple aliquots. Each other 1-ft increment will be homogenized and archived (identified in Table 4-7).

Sample aliquots for ammonia and sulfide will be collected from the 1-2 ft increment prior to sample homogenization. The remaining 1-2 ft core sample material will be homogenized and sample aliquots for grain size and TOC will then be collected. Because archiving (freezing and deferring analyses until a later date) of sediments may affect results for some analyses (total sulfides, ammonia, TOC, and grain size), 1-2 ft increment samples will be initially analyzed for these parameters only. The remaining material will be placed in the applicable sample containers as if they were to be analyzed immediately (these samples are marked with a “P” in Table 4-7 to indicate that they are ready for potential additional analyses). As with the archived samples, these containerized samples will be stored frozen. Each other 1-ft increment will be homogenized and placed in large sample jars for archiving. Core collection and evaluation will also include a physical description of the stratigraphy. The chemical analyte list, analytical methods, TDLs, and comparative criteria are discussed in Section 7.1.

Table 4-6. Rationale for samples to be collected from Hammersley Inlet and Carr Inlet (reference site).

Sample ID [a]	Description [b]	Sample Justification
HI-01-SS-00	Surface	Located across inlet from Millers Point – extent of study area. COPCs (SVOCs, pesticides, PCB, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
HI-01-SC-12	Subsurface	Located across inlet from Millers Point – extent of study area. COPCs (SVOCs, pesticides, PCB, and metals). Samples analyzed based on surface sample sediment results.
HI-02-SS-00	Surface	Located near Millers Point – extent of study area. COPCs (SVOCs, pesticides, PCB, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
HI-02-SC-12	Subsurface	Located near Millers Point – extent of study area. COPCs (SVOCs, pesticides, PCB, and metals). Samples analyzed based on surface sample sediment results.
HI-03-SS-00	Surface	Located near Eagle Point – characterize study area. COPCs (SVOCs, pesticides, PCB, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
HI-03-SC-12	Subsurface	Located near Eagle Point – characterize of study area. COPCs (SVOCs, pesticides, PCB, and metals). Samples analyzed based on surface sample sediment results.
HI-04-SS-00	Surface	Located south of Munson Point – characterize study area. COPCs (SVOCs, pesticides, PCB, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
HI-04-SC-12	Subsurface	Located south of Munson Point – characterize study area. COPCs (SVOCs, pesticides, PCB, and metals). Samples analyzed based on surface sample sediment results.
HI-05-SS-00	Surface	Current WWTP outfall. COPCs (SVOCs, pesticides, PCB, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
HI-05-SC-12	Subsurface	Current WWTP outfall. COPCs (SVOCs, pesticides, PCB, and metals). Samples analyzed based on surface sample sediment results.
HI-06-SS-00	Surface	Located near Munson Point – characterize study area. COPCs (SVOCs, pesticides, PCB, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
HI-06-SC-12	Subsurface	Located near Munson Point – characterize study area. COPCs (SVOCs, pesticides, PCB, and metals). Samples analyzed based on surface sample sediment results.
HI-07-SS-00	Surface	Historic WWTP outfall. COPCs (SVOCs, pesticides, PCB, metals, and dioxin/furans). Bioassay to assess sediment toxicity on benthic organisms.
HI-07-SC-12	Subsurface	Historic WWTP outfall. COPCs (SVOCs, pesticides, PCB, and metals). Samples analyzed based on surface sample sediment results.

Table 4-6 (continued). Rationale for samples to be collected from Hammersley Inlet and Carr Inlet (reference site).

Reference Samples (Carr Inlet)		
RF-01-SS-00	Surface	Quantification of reference surface sediment contaminant concentrations. Bioassay to assess sediment toxicity on benthic organisms.
RF-02-SS-00	Surface	Quantification of reference surface sediment contaminant concentrations. Bioassay to assess sediment toxicity on benthic organisms.
RF-03-SS-00	Surface	Quantification of reference surface sediment contaminant concentrations. Bioassay to assess sediment toxicity on benthic organisms.

[a] Example of sample ID: HI-01-SS-00 = Hammersley Inlet, Station 01, Surface Sediment, 0-10 cm interval. Additional identifiers: SC = sediment core; SS = surface sediment. See Section 6.1.1.
[b] Description of matrix: surface or subsurface sediment

Table 4-7. Summary of samples to be collected from Hammersley Inlet and Carr Inlet (reference site).

Sample ID [a]	Description	TOC/ GS	SVOC	Resin	Pest	PCB [b]	Dioxin/ Furan	TPH	TBT	Metal	S2 NH3	TVS	Pb210	Cs137	Bioassay
HI-01-SS-00	Surface	X	X		X	X	X			X	X				X
HI-01-SC-12	Subsurface	X	P		P	P				P	X				
HI-02-SS-00	Surface	X	X		X	X	X			X	X				X
HI-02-SC-12	Subsurface	X	P		P	P				P	X				
HI-03-SS-00	Surface	X	X		X	X	X			X	X				X
HI-03-SC-12	Subsurface	X	P		P	P				P	X				
HI-04-SS-00	Surface	X	X		X	X	X			X	X				X
HI-04-SC-12	Subsurface	X	P		P	P				P	X				
HI-05-SS-00	Surface	X	X		X	X	X			X	X				X
HI-05-SC-12	Subsurface	X	P		P	P				P	X				
HI-06-SS-00	Surface	X	X		X	X	X			X	X				X
HI-06-SC-12	Subsurface	X	P		P	P				P	X				
HI-07-SS-00	Surface	X	X		X	X	X			X	X				X
HI-07-SC-12	Subsurface	X	P		P	P				P	X				
Reference Samples															
RF-01-SS-00	Surface	X	X	X	X	X	X	X	X	X	X	X			X
RF-02-SS-00	Surface	X	X	X	X	X	X	X	X	X	X	X			X
RF-03-SS-00	Surface	X	X	X	X	X	X	X	X	X	X	X			X
Archived Samples															
HI-01-SC-01	Subsurface														
HI-01-SC-23	Subsurface														
HI-01-SC-34	Subsurface														
HI-02-SC-01	Subsurface														
HI-02-SC-23	Subsurface														
HI-02-SC-34	Subsurface														
HI-03-SC-01	Subsurface														
HI-03-SC-23	Subsurface														

Table 4-7 (continued). Summary of samples to be collected from Hammersley Inlet and Carr Inlet (reference site).

Sample ID [a]	Description	TOC/ GS	SVOC	Resin	Pest	PCB [b]	Dioxin/ Furan	TPH	TBT	Metal	S2 NH3	TVS	Pb210	Cs137	Bioassay
HI-03-SC-34	Subsurface														
HI-04-SC-01	Subsurface														
HI-04-SC-23	Subsurface														
HI-04-SC-34	Subsurface														
HI-05-SC-01	Subsurface														
HI-05-SC-23	Subsurface														
HI-05-SC-34	Subsurface														
HI-06-SC-01	Subsurface														
HI-06-SC-23	Subsurface														
HI-06-SC-34	Subsurface														
HI-07-SC-01	Subsurface														
HI-07-SC-23	Subsurface														
HI-07-SC-34	Subsurface														

[a] Example of sample ID: HI-01-SS-00 = Hammersley Inlet, Station 01, Surface Sediment, 0-10 cm interval. Additional identifiers: SC = sediment core; SS = surface sediment; WC = wood waste sediment core; WS = wood waste surface sediment. See Section 6.1.1.
[b] PCBs analyzed as Aroclors for sediment and wood waste sediment samples.
Bioassay = Sediment Management Standards acute and chronic tests
Ce137 = Cesium-137
Dioxin/furan = 2,3,7,8-substituted isomers and congeners
Metals = Antimony, arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc
P = For sediment cores, 1-2 ft interval samples analyzed pending surface sample results.
Pb210 = Lead-210
PCB = Polychlorinated biphenyls
Resin = Wood waste indicator compounds, e.g., guaiacols and fatty acids
Pest = Chlorinated pesticides
SVOC = Semi-volatile organic compounds
TBT = Tributyltin
TOC = Total organic carbon
TPH =Total petroleum hydrocarbons as NWTPH-HCID (hydrocarbon identification)
TVS = Total volatile solids
X =Samples submitted for laboratory analysis.

Based on surface sediment analytical results, additional analysis of the 1-2 ft interval may be conducted on archived sediment core samples. The SMS provides criteria used to identify surface sediment that have no adverse acute or chronic effects on biological resources and no significant risk to humans, which will be used to help determine additional analyses. Specifically, surface sediment with SQS exceedances, bioassay toxicity, or exceedances of other criteria not having an SQS value (see Section 8.1) may trigger subsurface analysis. Additional analyses may be conducted on archived sediment core samples collected over other depth intervals based on this initial data.

4.4.2 Bioassays

Bioassays will be conducted to determine the extent of acute and chronic toxicity of sensitive test organisms to contaminants found in Hammersley Inlet sediments. The seven surface sediment samples collected across Hammersley Inlet will be submitted for toxicity testing. Toxicity tests will include amphipod mortality, juvenile polychaete growth, bivalve larvae development, and Microtox® (porewater) bioluminescence. Details on toxicity testing methodology are provided in Section 7.2.

4.5 Reference Sample Location

The purpose of a reference station is to reflect the natural condition of sediments in the absence of anthropogenic influences. It provides a point of comparison for evaluating the potential biological effects of the site sediments. Washington State Department of Ecology's *Sediment Sampling and Analysis Plan Appendix – Guidance on the Development of Sediment Sampling and Analysis Plans Meeting the Requirements of the Sediment Management Standards (Chapter 172-204 WAC)* dated February 2008 references the Puget Sound Program (PSEP) protocols for bioassay testing. PSEP's *Laboratory Sediment Bioassays – General QA/QC Guidelines* (revised July 1995) specifies the need for reference test samples and identifies several potential Puget Sound reference areas. The primary reference areas identified include: Sequim Bay, Samish Bay, Dabob Bay, and Carr Inlet. Of these options, Carr Inlet has been selected as the most reasonable reference area for Oakland Bay. A summary of sample locations for reference sediment is presented in Table 4-6 and a summary of sample analyses is presented in Table 4-7. Sampling locations within Carr Inlet are presented on Figure 4-5.

Reference sediments, which closely match the grain size characteristics of the test sediments, will be run with each test batch for all three bioassays. Reference sediment should have a percent fine content within 20 percent of the sample sediment content (Ecology 2008). The wet sieving protocol (see Section 6.4.2) will be used in the field to determine the percent fines content of the sample sediment collected.

Reference sediment samples will also be analyzed for all COPCs plus conventional parameters to evaluate whether Oakland Bay results are elevated above what are considered to be Puget Sound background concentrations.

Figure 4-5. Reference sediment sample locations (to be collected) in Carr Inlet, Washington.

08-2-2-08/rtb/HEC-R/06-03388-007-003-001/Sampling Plan

4.5.1 Sediment

Representative surface sediment (0 to 10 cm) samples will be collected at three locations within the Carr Inlet reference area (Figure 4-5). An aliquot from each location will be homogenized and submitted to each laboratory for chemical analysis. Sample aliquots for ammonia and sulfide will be collected prior to sample homogenization to minimize losses due to volatilization. Refer to Section 6 for recommended holding times for analyses. As shown in Tables 4-6 and 4-7, samples from all locations will be analyzed for the broad spectrum of industrial discharge COPCs. Surface sediment samples will also be analyzed for TPH, TBT, TVS, resins and guiucols, dioxins/furans, and bioassay toxicity. The chemical analyte list, analytical methods, TDLs, and comparative criteria are discussed in Section 7.1.

4.5.2 Bioassays

Bioassays will be conducted to determine acute and chronic toxicity of sensitive test organisms as a comparison to Oakland Bay, Shelton Harbor, and Hammersley Inlet samples. Toxicity tests will include amphipod mortality, juvenile polychaete growth, bivalve larvae development, and Microtox® (porewater) bioluminescence. Details on toxicity testing methodology are provided in Section 7.2.

5.0 Quality Assurance / Quality Control

The purpose of the project QA/QC is to provide confidence in project data results through a system of quality control performance checks with respect to data collection methods, laboratory analysis, data reporting, and appropriate corrective actions to achieve compliance with established performance and data quality criteria. This section presents the QA/QC procedures to ensure that the investigation data results are defensible and usable for their intended purpose.

5.1 Measurements of Data Quality

Data quality objectives (DQOs) are qualitative or quantitative statements derived from the planning process. DQOs are used to clarify the study objectives and define the appropriate type of data to collect to support project decisions. Additional guidance on the development of DQOs is found in *Guidance for the Data Quality Objective (DQO) Process,* USEPA 600/R-96/005 (USEPA 1996). Acceptance and performance criteria establish the quality and quantity of data needed to meet the project DQOs (Table 5-1). DQOs are based on PSDDA guidelines established for QA1 data review (PTI 1989a), and as updated by DMMP clarification paper *Modifications to the Chemical Testing Quality Assurance Guidelines* (Fox 2002). General acceptance or performance criteria for the collection, evaluation, or use of environmental data for this investigation are outlined in Section 7 – Laboratory Analytical Procedures.

Table 5-1. Project-specific data quality objectives.

	Replicate Criteria		Matrix Spike Criteria		Surrogate Spike Criteria	
Parameter	Warning Limits [a]	Action Limits [b]	Warning Limits [a]	Action Limits [b]	Warning Limits [a]	Action Limits [b]
Conventionals	None	20 %	NA	NA	NA	NA
Metals	None	20 %	None	75 - 125 %	NA	NA
Semivolatiles	35 %	50 %	50 - 150 %	None	50 %	EPA CLP
Pesticides	35 %	50 %	50 - 150 %	None	60 %	EPA CLP

[a] PSEP defines warning limits as "numerical criteria that serve to alert data reviewers and users to possible problems within the analytical system. When a warning limit is exceeded, the laboratory is not obligated to halt analyses, but the reported data may be qualified during subsequent QA/QC review."
[b] PSEP defines action limits as "numerical criteria that, when exceeded, require specific action by the laboratory before data may be reported. Action limits are intended to serve as contractual controls on laboratory performance".
Conventionals include the following analyses: TOC, ammonia, sulfides, grain size, TVS.
Metals include the following analyses: Metals and TBT.
Semivolatiles include the following analyses: SVOCs, PCBs, dioxin/furans, resins.
EPA CLPControl limits are compound specific limits established by EPA's Contract Laboratory Program (CLP).

Acceptance and performance criteria are often specified in terms of the precision, accuracy, representativeness, completeness, and comparability (PARCC) parameters. Numerical acceptance criteria cannot be assigned to all PARCC parameters, but general performance goals

are established for most data collection activities. Data assessment procedures throughout this SAP outline the steps to be taken, the responsible individuals, and the implications if QA objectives are not met. PARCC parameters are briefly defined below.

5.1.1 Precision

Precision measures the reproducibility of measurements under a given set of conditions. Specifically, it is a quantitative measure of the variability of a group of measurements compared to their average value, usually stated in terms of standard deviation or coefficient of variation. It also may be measured as the relative percent difference (RPD) between two values. Precision includes the interrelated concepts of instrument or method detection limits (MDLs) and multiple field sample variance. Sources of this variance are sample heterogeneity, sampling error, and analytical error.

5.1.2 Accuracy

Accuracy measures the bias of the measurement system. Sources of this error include sampling process, field contamination, preservation, handling, sample matrix, sample preparation, and analysis. Data interpretation and reporting may also be significant sources of error. Typically, analytical accuracy is assessed through the analysis of spiked samples and may be stated in terms of percent recovery or the average (arithmetic mean) of the percent recovery. Blank samples are also analyzed to assess sampling and analytical bias (i.e., sample contamination). Background measurements similarly assess measurement bias.

5.1.3 Representativeness

Representativeness expresses the degree to which data represent a characteristic of a population, a parameter variation at a sampling point, or an environmental condition. Representativeness is a qualitative parameter, which is most concerned with proper design of the measurement program. Sample/measurement locations may be biased (judgmental) or unbiased (random or systematic). For unbiased schemes, the sampling must be designed not only to collect samples that represent conditions at a sample location, but also to select sample locations that represent the total area to be sampled.

5.1.4 Completeness

Completeness for sample collection is defined as the percentage of specified samples listed in the SAP that were actually collected. Completeness shall be 95% for this project. Completeness for acceptable data is defined as the percentage of acceptable data out of the total amount of data generated. Acceptable data includes data that passes all QC criteria or data that may not pass all of the QC criteria but has appropriate corrective actions taken.

5.1.5 Comparability

Comparability is a qualitative parameter expressing the confidence with which one data set may be compared to another. Sample data should be comparable with other measurement data for similar samples and sample conditions. This goal is achieved through the use of standard techniques to collect and analyze samples.

5.2 Quality Assurance and Quality Control for Chemistry Sediment Samples

Laboratory QC samples will be used to evaluate the data precision, accuracy, representativeness, and comparability of the analytical results.

Analytical performance is monitored through QC samples and spikes, such as laboratory method blanks, surrogate spikes, QC check samples, matrix spikes, matrix spike duplicates, duplicate samples, and duplicate injections. All QC samples are applied on the basis of a laboratory batch. Two basic types of batches are used: the preparation batch and the run (i.e., analytical) batch. The preparation batch includes all samples processed as a unit during organic sample preparation, metals digestion, or wet chemistry preparation. Preparation batches do not exceed 20 samples excluding associated QC samples. The QC samples associated with sample preparation include method blanks, laboratory control samples (LCS), matrix spikes, and duplicates. The run batch includes all samples analyzed together in the run sequence. The run sequence is typically defined by the analytical method. For some analyses, such as TOC, the run batch is equivalent to the preparation batch. The QC samples associated with the run sequence include calibration standards, instrument blanks, and reference standards.

Instances may arise where high sample concentrations, nonhomogeneity of samples, or matrix interferences preclude achieving the detection limits or associated QC target criteria. In such instances, data will not be rejected *a priori* but will be examined on a case-by-case basis. The laboratory will report the reason for deviations from these detection limits or noncompliance with QC criteria in the case narrative.

5.2.1 Laboratory Method Blanks

A laboratory method blank is an analyte-free material processed in the same manner and at the same time as a project sample. The laboratory method blanks serve to demonstrate a contamination-free environment in the laboratory. The goal is for method blanks to be free of contamination. Low level contamination may be present, but must be less than the PQL as defined by the method standard operating procedure (SOP). If contamination is greater, the samples are reanalyzed. If contaminants are present in the method blank but not in project samples, no further action is required. All sources of contamination that are not common laboratory contaminants as defined in the method SOPs must be investigated as part of the

corrective action process. Sample results must not be blank-subtracted unless specifically required by the analytical method.

5.2.2 Surrogate Standards

For certain organic methods, all samples, including the laboratory method blank and standards, are spiked with a set of specific surrogate standards to monitor the accuracy of the analytical determination. Surrogate spikes are added at the start of the laboratory preparation process.

Surrogate recoveries must be within QC criteria for method blanks and LCSs to demonstrate acceptable method performance. If surrogate recoveries are outside QC criteria for method blanks or LCSs, corrective action is required and the QC Manager should be notified. Surrogate recoveries in the samples indicate the method performance on the particular sample matrix. Surrogate recoveries that are outside QC criteria for a sample indicate a potential matrix effect. Matrix effects must be verified based on review of recoveries from the method blank or LCS, sample reanalysis, or evaluation of interfering compounds. Sample clean-up procedures required by Ecology-approved SOPs must be implemented to alleviate potential matrix problems

5.2.3 Laboratory Control Sample

An LCS consists of a method blank spiked with target compounds of interest near the mid-point of the calibration range. The LCS is processed by the same sample preparation, standard addition, and analysis as the project samples. The recovery of target analytes in the LCS is an estimation of method accuracy.

LCS recovery must be within the control limits to demonstrate acceptable method performance. If the LCS recovery values are outside QC criteria for the target analytes, recovery values are significantly low, or the compounds were detected in the samples, then corrective action is required. After corrective action is complete, sample re-analysis is required for the failed parameters. For any deviations from the LCS control limits that cannot be resolved by sample re-analysis within holding times, the QC Manager must be notified immediately. If critical samples are affected, the Project Manager may determine that re-sampling is required.

5.2.4 Matrix Spike Sample

A matrix spike (MS) sample consists of a project sample split into two parts and processed as two separate samples in a manner identical to that of the rest of the samples. In addition to the regular addition of monitoring standards (internal standards, surrogate), spiking analytes are added to the sample aliquot. Generally, all method target analytes, if compatible, are added. A subset of target analytes may be used if indicated in the method SOP and approved during review of the SOP. An MS must be prepared for every batch of 20 samples (or fewer) for a given matrix if sufficient sample allows. Field and trip blanks must not be chosen for spiking. The laboratory must analyze a site-specific MS sample for every batch that contains samples from the site, even if the batch contains samples from other sites.

MS recovery values are a measure of the performance of the method on the sample being analyzed. MS recovery values outside the control limits applied to the LCS indicate matrix effects. Sample clean-up procedures may be warranted for samples with severe matrix effects. The laboratory should notify the QC Manager of these instances to determine an appropriate corrective action.

5.2.5 Matrix Spike Duplicate Sample

The matrix spike duplicate (MSD) sample is commonly prepared in conjunction with the MS sample. The MSD sample is prepared from a separate portion of the client sample and processed with the same additions as the MS. The MSD is prepared for methods that do not typically show concentrations of target analytes above MDLs, such as organic methods. The RPD values between the recovery values in the MS and MSD measure the precision of the analytical method on the actual project samples. For this project, QC criteria for RPDs are 35 percent for sediments unless the laboratory provides additional statistical criteria.

5.2.6 Duplicate Sample

A duplicate sample consists of a set of two samples obtained in an identical manner from the same project sample. The collection of duplicate samples from a heterogeneous matrix requires homogenization to ensure that representative portions are analyzed. One sample per batch of 20 samples or fewer per matrix is analyzed in lieu of a MSD.

The duplicate is prepared for methods that typically show concentrations of target analytes above MDLs, such as metals and wet chemistry analytes. The RPD values between the recovery values in the original and duplicate measure the precision of the analytical method on the actual project samples. For this project, QC criteria for RPDs are 35 percent for sediments unless the laboratory provides additional statistical criteria.

5.2.7 Other Laboratory QC Samples

The laboratory performs analysis of other QC samples or standards, depending on the analytical method. Standard QC samples or standards are documented in the specific method SOP. Method-specific QC samples or standards include internal standard spikes for gas chromatography (GC)/mass spectrometry (MS) methods; post-digestion spikes and serial dilutions for metals analysis; and interference check samples for inductively-plasma analysis. Results of all associated QC should be reported.

5.2.8 Performance Evaluation Samples

As part of the laboratory approval process, the laboratory must analyze external performance evaluation (PE) samples provided by an outside certifying agency on an annual basis. The laboratory must maintain acceptable scores on PE samples as part of the approval process. For this project any PE failures for project target compounds must be reported to the QC Manager immediately.

5.3 Quality Assurance and Quality Control for Bioassay Sediment Samples

The detailed SOPs for the bioassay tests proposed for this investigation will be provided by the selected biological laboratory upon request. This section summarizes toxicity test QA/QC procedures to be implemented to ensure the test results are valid. Standard QA/QC procedures include the use of negative controls, positive controls, reference sediment samples, laboratory replicates, and daily water quality measurements. In addition, close contact with the biological laboratory will be maintained prior to and during the testing period to resolve any QA/QC problems or testing methodology issues in a timely manner.

5.3.1 Negative Control

The negative control consists of clean, inert material (deionized or distilled water used for Microtox® [porewater] bioluminescence) tested in parallel with the test sediments under identical test conditions. The biological testing laboratory provides this clean material, which usually consists of sediment collected from the original location from which the test organisms were harvested. Test acceptability criteria are based on results of the negative control. A test with at least 90% survival (70% mean normal survivorship for larval development) in negative control test chambers is considered acceptable.

5.3.2 Positive Control

A positive control will be run for each bioassay. Positive controls are chemicals known to be toxic to the test organism and that provide an indication of the sensitivity of the particular organisms used in a bioassay. Cadmium chloride or another appropriate reference toxicant will be used for the amphipod mortality, larval development, and juvenile polychaete growth bioassays.

5.3.3 Reference Sediment

Reference sediments, which closely match the grain size characteristics of the test sediments, will be run with each test batch for all four bioassays. The reference sediment is used for test comparisons and interpretations. Carr Inlet will be used as the reference area; the specific collection sites will be determined based on sample physical characteristics. All reference sediments will be analyzed for SVOCs, pesticides, PCBs, metals, dioxins, furans, total solids, TOC, bulk ammonia, bulk sulfides, and grain size.

All bioassays have performance standards for reference sediments (PSEP 1995). Failure to meet these standards may result in the requirement to retest.

5.3.4 Laboratory Replication

Five laboratory replicates of each test sediment, reference sediment, negative control, and elutriate concentration will be run for each respective bioassay. The replication of tests provides multiple observations of effects to test organisms so that statistical comparisons can be made between test and reference sediments.

5.3.5 Bioassay Water Quality

Water quality monitoring will be conducted for the amphipod, larval development, juvenile polychaete growth, and Micortox® (porewater) bioluminenscence bioassays. This consists of daily measurements of salinity, temperature, pH, dissolved oxygen for amphipod, and larval development (every third day for juvenile polychaete growth bioassay). The temperature and pH for the Microtox® (porewater) bioluminenscence bioassay will be determined during test setup. For the amphipod, larval development, and juvenile polychaete growth bioassays, ammonia and sulfides will be determined at test initiation and termination and interstitial salinity will be determined prior to the test setup. Monitoring will be conducted for all test and reference sediments and negative controls (including seawater controls). Parameter measurements must be within the limits specified for each bioassay as listed in Table 5-2. Measurements for each treatment will be made on a separate chemistry beaker set up to be identical to the other replicates within the treatment group. In addition, interstitial ammonia measurements at test initiation and test termination will be conducted for the amphipod test.

Table 5-2. Water quality control limits.

Test (*Test Species*)	Temperature	Salinity	Dissolved Oxygen	pH
Amphipod Mortality (*E. estuarius; R. abronius*)	15 ± 1 °C	Ambient; [a] 28 ± 1 ppt	NA [b]	NCL
Larval Development (*D. excentricus*)	15 ± 1 °C	28 ± 1 ppt	> 60% saturation	NCL
Juvenile Polychaete Growth (*N. arenaceodentata*)	20 ± 1 °C	28 ± 2 ppt	NA [b]	NCL
Microtox® (porewater) bioluminescence	15 °C	20 ± 2 ppt [c]	50 to 100% saturation	7.9 to 8.2

[a] Same as interstitial salinity of test sediment
[b] Continuous aeration is required by the protocol, so the dissolved oxygen should not be a cause of concern
[c] If porewater salinity exceeds 20 ppt, the artificial seawater control should be adjusted to match the test sample salinity ± 2 ppt (Ecology 2008).
NCL – No control limit (pH is monitored as a water quality parameter. There are generally no control limits for pH; however, measurements of pH may be useful in interpreting results [Ecology 2003]).

5.4 Data Validation

At a minimum, all laboratory data will undergo a QA1 review (PTI 1989a). If requested by Ecology, the data will be reviewed following QA2 procedures (PTI 1989b). If data fail the

review, the laboratory will be contacted and the data will be reanalyzed, qualified, or unqualified with an explanation. For each data type, the quality of the data will be summarized in validation memos.

In addition, laboratory data packages will be provided for the chemistry data to allow independent data verification and validation. The data packages will consist of the sample results followed by a cover letter describing procedures used and analytical problems encountered, qualifiers used, reconstructed ion chromatogram (GC/MS), mass spectra of detected target compounds (GC/MS), chromatograms, quantification reports, and calibration data summaries. Dilution volumes, sample sizes, percent moisture, and surrogate recoveries will be presented on each summary sheet with the analytical results. A similar package is also assembled for each quality control sample (e.g., method blank).

The following types of data will be reviewed:

- Analytical laboratory summary reports including QC summary data for surrogates, method blanks, LCSs, and MS/MSD samples. Acceptance and performance criteria will be developed from the current laboratory control limits even if those limits differ from the limits listed in Section 7
- Calibration summary data will be checked to verify that all positive results for target compounds were generated under an acceptable calibration as defined by the analytical method.
- Field QC results for blanks.
- Field data such as sample identifications and sample dates will be checked against the laboratory report.

Raw data files from the field and laboratory may not be reviewed unless there is a significant problem noted with the summary information.

After receipt from the laboratory, project data will be validated as described in the following section.

5.4.1 Evaluation of Completeness

The QC Manager verifies that the laboratory information matches the field information and that the following items are included in the data package:

- Chain-of-custody forms
- Case narrative describing any out-of-control events and summarizing analytical procedures
- Data report forms

- QA/QC summary forms
- Calibration summary forms
- Chromatograms documenting any QC problems.

If the data package is incomplete, the QC Manager contacts the laboratory, which must provide all missing information within one day.

5.4.2 Evaluation of Compliance

The actual data validation follows the procedures that are briefly outlined below:

- Review the data to check field and laboratory QC results to verify that holding times and acceptance and performance criteria were met, and to note any anomalous values
- Review chromatograms, mass spectra, and other raw data if provided as backup information for any apparent QC anomalies
- Ensure all analytical problems and corrections are reported in the case narrative and that appropriate laboratory qualifiers are added
- For any problems identified, review concerns with the laboratory, obtain additional information if necessary, and check all related data to determine the extent of the error
- Apply data qualifiers to the analytical results to indicate potential limitations on data usability.

QC Managers will follow qualification guidelines in applicable QA1 or QA2 guidelines. If no QA1 or QA2 guidelines exist, then applicable USEPA National and Regional Data Review guidelines will be used.

5.4.3 Data Validation Reporting

The QC Manager will perform the following reporting functions:

- Alert the Project Manager to any QC problems, obvious anomalous values, or discrepancies between the field and laboratory data, and resolve any issues.
- Discuss QC problems in a data validation memo for each laboratory report, the data validation memo and copy of the data package will be sent to Project Manager.

- Review the laboratory electronic data deliverable (EDD) and electronic field data, enter the data qualifiers into the database, and prepare analytical data summary tables. The tables will summarize those samples and analytes for which detectable concentrations were exhibited as well as complete analytical summary tables. The tables will include field QC samples
- At the completion of all field and laboratory efforts for site, the QC Manager will prepare a data review/validation memorandum. The memorandum will summarize planned versus actual field and laboratory activities and data usability concerns.

6.0 Field Procedures

This section describes the procedures for positioning, sample collection, processing, identification, documentation, equipment decontamination, and waste handling for the proposed field investigation. Samples will be collected for sediment and wood waste sediment chemistry, sediment toxicity, and radioisotope dating. The laboratory methods for chemical analysis, toxicity testing, and radio isotope analysis are presented in Section 7. Field activity SOPs are provided in Appendix A and field forms are presented in Appendix B. The Site-Specific Health and Safety Plan is provided in Appendix C. Sampling station coordinates and property landowner information are provided in Appendix D.

A total of 59 stations will be visited across the study area to collect surface grab and subsurface core samples (including reference samples). All samples will be comprised of sediment submitted to the laboratory for analysis, including those samples designated as wood waste (chunks of wood will be removed from the sample when filling the sample containers). A summary of sample numbers is provided in Table 6-1.

Table 6-1. Sample number summary for Oakland Bay Sediment Study.

	Surface Sediment	Subsurface Sediment [a]	Surface Wood waste	Subsurface Wood waste	Sediment Dating Core
Oakland Bay	14	14	3	3	2
Shelton Harbor	16	16	13	13	1
Hammersley Inlet	7	7	0	0	0
Carr Inlet	3	0	0	0	0
Total	40	37	16	16	3

[a] Oakland Bay and Hammersley Inlet samples to be analyzed based on surface sediment analytical results

6.1 Sampling Platforms

Two vessels, owned and operated by Research Support Services and Bio-Marine Enterprises, will be used for the surface and subsurface sediment/wood waste collection; the geophysical survey will be conducted by Global Geophysics from their vessel equipped with specialized survey equipment.

6.2 Station Positioning and Navigation

A differential global positioning system (DGPS) will be used for station positioning of all vessel sediment sampling stations. The vessels used for these activities will operate navigation equipment that provides accurate station positioning, and that assures sample stations and water depths are accurately recorded. The DGPS will be used aboard the vessel for station positioning.

The DGPS receiver will be capable of surveying positions to within 2 meter (m) accuracy. Horizontal coordinates will be referenced to the Washington State Plane coordinate system under the North American Datum of 1983 (NAD 83). The vertical datum will be the National Ocean Service mean lower low water (MLLW) datum. Vertical control collected by the vessel depth finder will be corrected for tidal influence after completion of the field activities.

Prior to initiating field work, a control check point will be established that can be accessed by the sampling vessel (e.g., dock, piling). At the beginning and end of each day, the check point will be surveyed from the vessel and compared to the known coordinates. The control check point position as recorded by the vessel should not differ by more than 2 m from the land-surveyed coordinates.

For vessel-deployed sampling, the DGPS receiver will be placed above the sampling device deployment boom to accurately record the position. At surface sediment grab stations, once the sampling device has been deployed, the actual position will be recorded when the device reaches the sediment floor and the deployment cable is in a vertical position. At these locations, water depths will be measured directly by lead-line and converted to mudline elevations after correction for tide.

Coordinates of the proposed sampling stations will be programmed as waypoints into the vessel's navigation system and used to guide the vessel to the appropriate locations. The target sample coordinates are provided in Appendix D.

6.3 Geophysical Survey Data Collection

Global Geophysics will perform the geophysical surveys in Shelton Harbor and Oakland Bay. The instrumentation and field methods are described below.

6.3.1 Navigation

The position of the vessel will be determined using the differential global positioning system (DGPS). A Trimbel Ag132, with differential correctors obtained from the U.S. Coast Guard beacon will be used for real-time positioning of the vessel. The navigation computer will be interfaced with the other geophysical instrumentation described below.

6.3.2 Precision Echosounder

Bathymetric data will be acquired with a Reson precision echosounder using a 300 kHz transducer. An analog paper record of data will be produced during the survey.

6.3.3 Seismic Reflection System

Subsurface relection data will be acquired with an EdgeTech Chirp system, high frequency (4 to 24 kHz) seismic reflection system that will discharge 3 times per second. A computer record of subsurface reflection data will be produced during the survey.

6.3.4 Side Scan Sonar

A digital image of the sea bottom will be created using side scan sonar. Lowrance Sonar/M1 side scan sonar (300 kHz) instrumentation will be used during the survey.

6.3.5 Electrical resistivity imaging (ERI) and Induced Polarization (IP)

Both ERI and IP will be collected simultaneously during the geophysical survey. The ERI method detects differences in electrical (resistivity) properties of geologic materials. These differences can result from variations in lithology and mineralogy, water content, or pore-water chemistry. The IP method detects differences in the metal content in sediment. The method involves transmitting an electric current into the ground between two current electrodes and measuring the voltage between two separate potential electrodes. The measured point, called a sounding, represents the apparent resistance of the entire area beneath the electrodes. A combination of different electrode arrangements is used to collect enough soundings to produce an apparent resistivity profile below the ERI survey transects.

The ERI and IP data will be acquired with an AGI SuperSting R8 system using up to 50 electrodes spaced at a three to five ft interval. Once the marine cable is laid out on the bottom of the bay, multiple soundings will be automatically conducted by the control unit. The data will be downloaded into a computer and processed using specialized inversion software.

6.4 Cultural Resources

This section addresses cultural resource procedures to be followed during the Oakland Bay Sediment Characterization Study. While sampling is limited to the collection of surface sediment and wood waste grabs and 4 inch diameter cores, and Oakland Bay is not a known archeological site, some potential exists for the inadvertent discovery of cultural resources within these samples. Archaeological, cultural, or historical objects, such as ruins, sites, buildings artifacts, fossils, or other objects of antiquity that may have significance from a cultural, historical, or scientific standpoint, may be inadvertently encountered during ground-disturbing activities. Typical examples of artifacts may include: bone and bone tools, shells, fibrous objects, projectile points and any other stone tools, flakes from stone tool production, and thermally altered rocks.

Field team members will follow the protocols listed in this document. In the event of a conflict between this document and any applicable law, the applicable law shall govern. These protocols are in part based on recommendations supplied by the Squaxin Island Tribe.

As requested by the Tribe, the Tribe's Cultural Resource Specialist/Archeologist, Mr. Larry Ross, will be notified prior to the field event and offered an opportunity to observe on-shore sediment sample handling. In cases where there is no Tribal representative present, sampling personnel will visually examine the sediment/wood waste samples, prior to and during processing, for the presence of artifacts of cultural significance, including human remains. In the event of an inadvertent discovery, Mr. Ross, or his representative from the Tribe's Cultural Resources Department (CRD), will act for the Tribe during the initial period after the discovery.

The following procedures will be followed in the event of an inadvertent discovery:

- Should the Tribe's representative or field personnel, using best professional judgment, identify the presence of potential artifacts of cultural significance, including human remains, during sample processing, all processing of that sample will cease. No further sampling will take place within 50 ft of this location until the Tribe and Department of Archaeology and Historic Preservation (DAHP) have been consulted concerning avoidance or minimization of further impacts.

- The find will immediately be documented using photographs, drawings and written descriptions with the exception of human remains. Documentation and handling of human remains will be left to the local authorities and the Tribe. For finds other than human remains, the entire sample will be placed in an appropriate container attempting to maintain strata or layers if present. The sample will be secured to ensure custody is maintained until turned over to the property owner, Tribe, or repository.

- The field leader will notify the Ecology Project Manager, Cynthia Erickson, and the cultural resource contact, Connie Groven. Ecology will contact the Tribe's CRD, DAHP, and the property owner, as soon as feasible.

- In the unlikely discovery of human remains, Ecology will treat the remains with dignity at all times. Ecology will not handle the remains, the remains will be covered, and reasonable efforts will be made to protect the area from further disturbance. The Shelton Police and the Medical Examiner/Coroner will immediately be contacted.

- Ecology's Project Manager will allow the Tribe and DAHP to determine the significance of the find and will consult with them to assess the potential effects on the project.

- With the property owner's permission, the samples and artifacts may be temporarily taken for identification or analysis by the Tribe or DAHP. Any samples or artifacts collected will be held in secure storage until such time as they can be analyzed or conveyed to an agreed repository, or returned to the property owner. Ecology agrees to encourage property owners to donate cultural materials discovered as the result of the project activities or to have them curated at the Tribe's Museum Library and Research Center (MLRC). If the artifact is exhibited in the Tribe's MLRC, the display information will include the property owner's name if they request it.

6.5 Sample Collection

6.5.1 Surface Samples

The following sections describe the collection and processing of surface samples. Tables 4-3, 4-5, and 4-7 list surface samples to be collected; Table 6-2 lists the analytical and biological testing methods, and sample container, volume, and preservation requirements.

Surface sediment and wood waste will be collected from a boat using a stainless-steel van Veen (modified 0.1 square meters [m^2]), Ekman, Petite Ponar, or similar grab device. A total of three grab attempts will be made at each proposed sampling location. If unsuccessful, the station will be moved to a new location within 10 m (33 ft) of the original station (sampling will be deemed unsuccessful if the sampler meets refusal or if the entire sample is composed of wood). If it is not possible to obtain a sample within this distance, the Ecology project manager will be consulted to determine an appropriate alternate action.

Surface sediment and wood waste samples will be collected from the 0 to 10 cm (0 to 4 inches [in]) interval. Multiple grabs will be necessary to obtain an adequate sample volume for all analyses. Samples will be collected as described in the SOP for surface sediment sampling (Appendix A). Samples will be carefully collected to ensure the following conditions are met, as required by Ecology (2008):

1. Make logbook and field form entries as necessary throughout the sampling process to ensure accurate and thorough record-keeping. Field documentation is described in Section 6.8.

2. Position the sampling vessel at the targeted sampling location.

3. Set the sampler jaws in the open position, place the sampler over the edge of the boat, and lower the sampler to the bottom.

4. Trip the sampler to collect the sample.

5. Record the location using the DGPS; measure and record the water depth.

Table 6-2. Sediment sample analysis summary, preservation, sample container, and holding times.

Number of Samples [a]	Analytical Parameters/ Method	Sample Preservation	Technical Holding Time [b]	Sample Container(s)
109	SVOCs/SW-846 Method 8270D	Cool to 4°C	Extract within 14 days of collection; analyze within 40 days of extraction.	One 8-oz wide-mouth glass jar with Teflon-lined lid.
		Freeze, -18°C	Extract within 1 year of collection, analyze within 40 days of extraction	
35	Wood Resin/ SW-846 Method 8270D	Cool to 4°C	Extract within 14 days of collection; analyze within 40 days of extraction.	One 8-oz wide-mouth glass jar with Teflon-lined lid.
		Freeze, -18°C	Extract within 1 year of collection, analyze within 40 days of extraction	
35	Chlorinated Guaiacols /NCASI CP-86.07	Cool to 4°C	Extract within 30 days of collection; analyze within 40 days of extraction.	One 8-oz wide-mouth glass jar with Teflon-lined lid.
		Freeze, -18°C	Extract within 1 year of collection, analyze within 40 days of extraction	
56	Dioxin/Furans/ USEPA Method 1613B	Cool to 4°C	Extract within 14 days of collection; analyze within 40 days of extraction.	One 8-oz wide-mouth glass jar with Teflon-lined lid.
		Freeze, -18°C	Extract within 1 year of collection, analyze within 40 days of extraction	
109	Pesticides/SW-846 Method 8081B	Cool to 4°C	Extract within 14 days of collection; analyze within 40 days of extraction.	One 8-oz wide-mouth glass jar with Teflon-lined lid.
		Freeze, -18°C	Extract within 1 year of collection, analyze within 40 days of extraction	
109	PCBs/SW-846 Method 8082	Cool to 4°C	Extract within 14 days of collection; analyze within 40 days of extraction.	One 8-oz wide-mouth glass jar with Teflon-lined lid.
		Freeze, -18°C	Extract within 1 year of collection, analyze within 40 days of extraction	
13	NWTPH-HCID/Ecology NWTPH-HCID	Cool to 4°C	Extract within 14 days of collection; analyze within 40 days of extraction.	One 8-oz wide-mouth glass jar with Teflon-lined lid.
9	Organotins /(Krone, et. al., 1989)	Cool to 4°C	Extract within 14 days of collection; analyze within 40 days of extraction.	One 8-oz wide-mouth glass jar with Teflon-lined lid.
		Freeze, -18°C	Extract within 1 year of collection, analyze within 40 days of extraction	

Table 6-2 (continued). Sample analysis summary, preservation, sample container, and holding times.

Number of Samples [a]	Analytical Parameters/ Method	Sample Preservation	Technical Holding Time [b]	Sample Container(s)
109	Metals/SW-846 Methods 6000/7000 Series	Cool to 4°C	180 days (28 days for mercury).	One 8-oz wide-mouth glass jar with Teflon-lined lid.
		Freeze, -18°C	2 years (28 days for mercury)	
130	TOC/SW-846 9060 (Plumb)	Cool to 4°C	14 days from collection.	One 8-oz wide-mouth glass jar with Teflon-lined lid.
		Freeze, -18°C	6 months from collection	
130	Grain Size/PSEP	Cool to 4°C	180 days from collection	One 16-oz wide-mouth glass jar with Teflon-lined lid.
35	Total Volatile Solids/ USEPA Method 160.4	Cool to 4°C	14 days from collection.	One 8-oz wide-mouth glass jar with Teflon-lined lid. No headspace
		Freeze, -18°C	6 months from collection	
130	Sulfide/SW-846 9030	Cool to 4°C, with 5ml of zinc acetate	7 days from collection.	One 2-oz wide-mouth glass jar with Teflon-lined lid. No headspace.
130	Ammonia/PSEP	Cool to 4°C	7 days from collection.	One 8-oz wide-mouth glass jar with Teflon-lined lid.
3 Cores	Core Dating (cesium 137 and lead 210)	Cool to 4°C	Analyze Cores as soon as possible.	Two 8-oz wide-mouth glass jar with Teflon-lined lid.
56	Sediment Toxicity (Bioassay) [d]	Cool to 4°C	14 days from collection	5.5 L in a poly bag
		Cool to 4°C, nitrogen atmosphere	8 weeks from collection	

[a] The number of samples presented is an estimate; the actual number of samples to be collected will be determined in the field.
[b] Holding times established in Ecology 2008, Table 10
[c] Samples will be analyzed by alpha and gamma spectroscopy.
[d] Bioassay consist of four toxicity tests: amphipod mortality, larval development, polychaete growth, and Microtox® (porewater) bioluminescence.
°C = Degrees Celsius.
Ecology =Washington Department of Ecology.
USEPA = U.S. Environmental Protection Agency
HCID = Hydrocarbon Identification.
NWTPH = Northwest total petroleum hydrocarbon.
oz = ounce.
PCBs = Polychlorinated Biphenyl Compounds.
Pesticides = Chlorinated Pesticides.
PSEP = Puget Sound Estuary Program Methods.
SVOCs = Semivolatile Organic Compounds.
SW-846 = *Test Methods for Evaluating Solid Waste, Physical Chemical Methods*, 3rd edition, SW-846, 1986.

6. Retrieve the sampler and place it securely in the sampling vessel.

7. Examine the sample for the following sample acceptance criteria:

   - ☐ The sampler is not overfilled with sample so that the sediment surface is not pressed against the top of the sampler.
   - ☐ The sample does not contain large foreign objects (i.e., trash or debris). A sample that is primarily wood or rock/gravel fill will be rejected in favor of depositional material (i.e., sand/silt/clay).
   - ☐ Overlying water is present in the sampler (indicates minimal leakage).
   - ☐ The overlying water is not excessively turbid (indicates minimal sample disturbance).
   - ☐ The sediment surface is relatively flat (indicates minimum of disturbance or winnowing).
   - ☐ The desired penetration depth is achieved (e.g., several centimeters more than the targeted sample depth).

8. If sample acceptance criteria are not achieved, the sample will be rejected and another sample collection attempt will be made.

9. Siphon off any overlying surface water.

10. Collect samples for total sulfides and ammonia analysis directly from the grab sampler and place the sediment aliquots in appropriate, pre-cleaned, labeled sample containers. Containers will be filled to the brim to minimize headspace (Table 6.1). The Microtox® sample will be containerized with a minimal disturbance of sediment.

11. Measure and collect the top 10 cm (4 in) with a stainless steel spoon, avoiding any sediment that is in contact with the inside surface of the grab sampler, then place the sediment into a stainless steel bowl, homogenize, and cover with aluminum foil.

12. Record the following observations of sediment sample characteristics on the field form (Appendix B); if more sample volume is required, repeat steps 4 through 12.

    - ☐ Texture
    - ☐ Color

- Biological organisms or structures (i.e., shells)
- Presence of debris (i.e., natural or anthropogenic objects, including wood and its general size, – identifying bark, wood chips, and sawdust relative abundance by percent)
- Presence of oily sheen or obvious contamination
- Odor (e.g., hydrogen sulfide, petroleum).

13. Wash excess sediment back into the water away from any areas remaining to be sampled.

14. Once sufficient sediment volume has been collected, samples should be placed in the appropriate, pre-cleaned, labeled sample containers as described in Section 6.6, placed in a cooler maintained at 4 ºC, and prepared for shipment to the analytical or biological laboratory as described in Section 6.7.

15. Confirm all relevant documentation has been completed, entries are accurate, and paperwork has been signed.

16. Decontaminate all sampling equipment as described in Section 6.9 before proceeding to the next sampling location.

Additional sample volume will be collected at stations requiring MS/MSD analysis (collected randomly at the field supervisor's discretion). Aliquots of homogenized sediment will also be collected for toxicity testing at designated locations.

Manual sampling methods (e.g., stainless steel spoon and bowl) may be used at locations exposed during low water conditions. Surface sediment will be collected from the 0 to 10 cm (0 to 4 in) interval. Samples will be collected as described in the SOP for surface sediment.

6.5.2 Wet Sieving

A homogenized sample aliquot of sediment collected at locations designated for toxicity testing will be wet sieved in the field. The purpose for wet sieving is to separate the coarse and fine-grained material comprising a sediment sample in order to match appropriate test and reference locations for toxicological testing. A 63-micron sieve is used to separate the silt and clay (fines), from the sand and gravel portion of the sediment sample. The grain size distribution of a given sediment sample is an important physical parameter when conducting bioassays in order to determine an appropriate reference sample for comparison with test sediments. The wet sieving of surface sediment samples is conducted in the field at the time of collection, so that reference samples with similar grain size distributions (as percent fines) can be targeted for the bioassays. The procedure for wet sieving is as follows:

1. Measure and record the exact volume of a small (100 ml) flat-topped beaker. (Note: the 100 ml gradation is generally located slightly below the rim of the beaker; hence, the actual beaker volume is greater than 100 ml).

2. Completely fill the beaker to the rim with an aliquot of homogenized sediment. Lightly tap the beaker on a hard surface to remove any air bubbles, and level the surface.

3. Rinse the entire contents of the beaker through a 63-micron (#230, 4 phi) sieve. Aggregates of material should be gently broken to facilitate sieving. Continue sieving until clear rinsewater passes through the sieve.

4. Carefully transfer the coarse-grained material from the sieve into a 250 ml graduated cylinder.

5. Divide the amount of material measured in the bottom of the graduated cylinder by the capacity of the beaker to determine the decimal percentage of coarse-grained material. Subtract the decimal percentage of coarse-grained material from 1 to determine the decimal percentage of fines (silt and clay).

6. Record the percentages of coarse and fine-grained material in the field logbook.

6.5.3 Subsurface Samples

Core samples will be collected using a vibracoring device. In most cases, the cores will be advanced to a little more than 4 ft to ensure adequate sediment retrieval (actual depth will depend on sediment characteristics). Each core will be divided into 1-ft intervals, depending on limitations of the equipment to reach targeted depth horizons. If significant wood waste is encountered, based on visual observations, another core will be advanced adjacent to the first core to the bottom of the wood waste, up to a maximum of 12 ft.

The general procedure for collecting sediment cores is as follows:

1. Make logbook and field form entries as necessary throughout the sampling process to ensure accurate and thorough record-keeping. Field documentation is described in Section 6.8.

2. Position the sampling vessel at the targeted sampling location.

3. Record the location using the DGPS; measure and record the water depth.

4. Insert pre-cleaned acetate core tubes equipped with an “eggshell” core catcher to retain material in the core barrel for deployment.

5. The core-sampler is positioned vertically on the bottom and advanced to a sampling depth of approximately 4 ft (1.2 m) or 12 ft (3.7 m) to include all targeted sampling intervals or until refusal.

6. Once sampling is complete, the sampler is extracted and core tube detached from the vibracorer. The core sample will be examined at each end to verify that sufficient sediment was retained. The condition and quantity of material within the core will then be inspected to determine acceptability. If sample acceptance criteria are not achieved, the sample will be rejected and another sample collection attempt will be made.

   - To verify whether an acceptable core sample has been collected the following criteria must be met:

     – Target penetration depth or refusal was achieved

     – Sediment recovery of at least 65 percent of the penetration depth;

     – Sample appears undisturbed and intact without any evidence of obstruction or blocking within the core tube or core catcher.

   - Percent sediment recovery will be determined by dividing the length of material recovered in the core tube by the depth of core penetration below the mudline. If the sample is deemed acceptable, overlying water will be siphoned from the top of the core tube, and each end of the tube will be capped and sealed with duct tape for storage until processing. The cores will be stored on ice until they are processed. The station number, station coordinates, date and time of collection, sediment description, field crew, and weather conditions will be recorded in the sediment coring log (Appendix B).

7. Record observations of sediment sample characteristics on the field form (Appendix B); if more sample volume is required repeat steps 4 through 11.

8. Process cores at a predetermined location onshore. Label the core, cap it, and store it in an upright vertical position in a container packed with ice until processed. Cores are to be processed as soon as possible.

9. Confirm all relevant documentation has been completed, entries are accurate, and paperwork has been signed.

10. Wash excess sediment back into the water away from any remaining sample areas.

11. Decontaminate all sampling equipment as described in Section 6.9 before proceeding to the next sampling location.

A single acceptable sample for each subsurface interval will be collected. All sediment cores will be processed at a designated processing location (extrusion, documentation, and sample collection for analysis). Disposable nitrile gloves will be worn for all handwork such as sectioning and extruding the core, sub-sampling, mixing samples, and filling sample containers. The gloves will be disposed of between sample composites in order to prevent cross contamination between samples. Sampling implements and processing equipment will be decontaminated prior to processing the sediment cores. Sediment cores will be processed in the same order as collected to minimize holding time. Each core tube will be cut open length-wise using electric snips or knife. Care will be taken to preserve the integrity of the core section strata. Once the sediment has been exposed, a visual characterization of the sample material will be immediately conducted. The core will then be visually described in the core log and will include the following information and characteristics:

- Station number
- Date and time of collection
- Station coordinates
- Weather conditions
- Names of persons collecting and logging the sample
- Penetration depth
- Percent sediment recovery
- Physical soil description in accordance with the Unified Soil Classification System (USCS)
- Color
- Odor (e.g., hydrogen sulfide, petroleum)
- Visual stratifications and lenses
- Vegetation
- Woody debris (identify bark, wood chips, and sawdust relative abundance by percent)

- Biological activity (e.g., detritus, shells, tubes, bioturbation, live or dead organisms)
- Presence of oil sheen or obvious contamination
- Any other distinguishing characteristics or features.

Representative aliquots of sediment will be collected from the 1 ft (0.3 m) intervals using decontaminated stainless steel spoons, to generate the composite sample. Up to 12 samples will be collected from each core representing a 1 ft (0.3 m) vertical horizon. Sediment will be collected from the center of the core that has not been smeared by, or in contact with, the core tube. The volumes removed will be placed in a decontaminated stainless steel bowl or pan, and mixed until homogenous in texture and color.

Sample aliquots for ammonia and sulfide will be separated from the 1-2 ft increment prior to sample homogenization and placed in appropriate, pre-cleaned, labeled sample containers. Containers will be filled to the brim to minimize headspace. The sample will be homogenized and sample aliquots for grain size and TOC will be collected for analysis. The remaining 1-2 ft core material will be placed in the applicable sample containers and analyzed immediately for Shelton Harbor, but stored for potential future analysis for Oakland Bay and Hammersley Inlet. Each of the remaining 1-ft core increments will be separately homogenized and placed in large sample jars for archiving.

6.5.4 Radioisotope Cores

Each core will be approximately 4 ft (1.2 m) in length. Cores will be divided by the laboratory into 2 cm intervals and only every third interval will be analyzed for lead-210. It is anticipated that each core will have 20 intervals analyzed for lead-210 and two intervals analyzed for cesium-137.

6.6 Sample Identification, Containers, and Labels

6.6.1 Sample Identification

Samples will be identified based on the sampling area, location, and sample depth. All samples collected during the investigation will be labeled clearly and legibly. Each sample will be labeled with a unique alphanumeric sample identification number that identifies characteristics of the sample as follows:

<u>Study Location</u>
SH - Shelton Harbor
OB - Oakland Bay
HI - Hammersley Inlet
RF - Reference

Station Location (associated with each Study Location)
01 - Sample Station 1

Matrix
SS - Sediment Surface
SC - Sediment Core
RI - Radioisotope
WS - Wood Waste Surface Sediment
WC - Wood Waste Core Sediment

Depth
00 - Surface
01 - 0-1 ft
12 - 1-2 ft
23 - 2-3 ft
34 - 3-4 ft
04 - 0-4 ft (radioisotope only)

For example:

- SH-01-RI-04 = Shelton Harbor, Station 1, Radioisotope, 0-4 ft interval
- OB-09-SC-12 = Oakland Bay, Station 9, Sediment Core, 1-2 ft interval.

6.6.2 Sample Containers

Pre-cleaned sample containers will be supplied by the analytical laboratory for the required analyses. Spare sample containers will be carried by the field samplers for archive sample collection, and in case of breakage or possible contamination. Sample containers, preservation techniques, and holding times will follow SAPA (Ecology 2008) guidelines (see Table 6-2).

6.6.3 Sample Labels

Sample labels will be made of self-adhering, waterproof material. An indelible pen will be used to fill out each label. Each sample label will contain:

- Project name
- Sample identification number
- Date of collection (day/month/year)
- Time of collection (military format)
- Analysis
- Preservative (as applicable)
- Company name and sampler initials (Herrera/GC).

Sample labels will be protected by packaging tape wrapped around the entire jar to prevent loss or damage of the labels during handling and storage.

6.7 Sample Storage and Delivery

An SOP for sample packing and shipment is provided in Appendix A. All samples will be stored in insulated coolers and preserved by cooling with ice or frozen gelpacks to a temperature of 4°C or below. Maximum sample holding and extraction times will be strictly adhered to by field personnel and the analytical and testing laboratories. Preparation of jars for shipment to fixed laboratories will be performed in the following manner:

- Samples will be packaged and shipped in accordance with U.S. Department of Transportation regulations as specified in 49 Code of Federal Regulations (CFR) 173.6 and 49 CFR 173.24.
- Place sample containers in plastic zip-loc bubble-pack bags, or wrap in bubble pack and secure with packaging tape.
- Prepare an empty insulated cooler by placing three to four ice packs in a garbage bag at the bottom of the cooler. Place sample containers in a garbage bag and fill with the sample bottles. Add additional bags of ice as needed to surround the bag containing the samples.
- Chain of custody (COC) forms will be enclosed in a plastic bag and taped to the inside lid of the cooler.
- Seal the cooler with strapping tape and a custody seal.

Samples for chemical analyses will be hand-couriered or shipped via overnight delivery to the analytical laboratories once per day or whenever a cooler is filled, and accompanied by the COC record, which identifies the shipment contents. The COC will be signed by the individual relinquishing samples to the onsite laboratory representative. Upon receipt of samples at the laboratory, the shipping container seal will be broken and the condition of the samples will be recorded by the receiver. The field personnel will be responsible for the following:

- Packaging the samples
- Signing the COC before placing inside the cooler to be sealed;
- Applying a shipping label, a waybill, a custody seal, and strapping tape to the cooler
- Shipping the samples in accordance with the maximum holding time allowed for the analyses to be performed
- Notifying the laboratory of when the samples are shipped
- Confirming receipt of the samples by the laboratory and that the samples were received in good condition.

All sediment samples to be archived by the laboratory will be frozen. Sediment cores will be processed in the field and placed into appropriate sample jars based on core depth interval. All sediment samples will be retained for a minimum of six months from the time they were received using standard laboratory handling procedures. They may be removed from the laboratory prior to the end of the six-month period only at the direction of the Ecology project manager.

6.8 Field Documentation

A complete record of field activities will be maintained. Documentation necessary to meet QA objectives for this project includes field notes and field forms, sample container labels, and COC forms. An SOP for field documentation is provided in Appendix A. The field documentation will provide descriptions of all sampling activities, sampling personnel, and weather conditions, and will record all modifications, decisions, and/or corrective actions to the study design and procedures identified in this SAP.

6.8.1 Field Notebooks

Field logbooks will be kept on site during field operations. Daily activities will be recorded in a bound field logbook of water-resistant paper. Separate logbooks consisting of bound, paginated field forms will be kept for sediment core sampling, sediment grab sampling, and an inventory of sample containers (separate from the COC documentation). All entries will be made legibly, in indelible ink, and will be signed and dated. Information recorded will include the following:

- Date, time, place, and location of sampling
- Onsite personnel and visitors
- Daily safety discussion and any safety issues
- Quality control samples (i.e., duplicate samples, field blanks, etc.)
- Field measurements and their units
- Number of attempts at each sampling station
- Observations about site and location (weather, current, odors, appearance, etc.)
- Observations about the samples (DGPS locations, depth as recorded by vessel depth sounder, maximum penetration depth, comments)
- General sediment characteristics (texture, color, biota, odor, sheen, etc.)
- Equipment decontamination verification.

Field logbooks are intended to provide sufficient data and observations to enable participants to reconstruct events that occur during project field activities. Entries should be factual, detailed, and objective. Unless restricted by weather conditions, all original data recorded in field logbooks, on sample identification tags, on COC records, and on field forms will be written in waterproof ink. If an error is made, the individual responsible may make corrections simply by crossing out the error and entering the correct information. The erroneous information will not be obliterated. All corrections will be initialed and dated. All documentation, including voided entries, will be maintained within project files.

6.8.2 Chain-of-Custody Procedures

Samples will be retained at all times in the field crew's custody until samples are delivered or shipped to the appropriate laboratory by field personnel. COC forms will be initiated at the time of sample collection to ensure that all collected samples are properly documented and traceable through storage, transport, and analysis. When all line items on the form are completed or when the samples are relinquished, the sample collection custodian will sign and date the form, list the time, and confirm the completeness of all descriptive information contained on the form. Each individual who subsequently assumes responsibility for the samples will sign and date the COC form. The field COC terminates when the laboratory receives the samples. The field sample custodian will retain a copy of the completed, signed COC form(s) for project files.

6.9 Equipment Decontamination Procedures

The vessel-deployed grab samplers, compositing pans, and sampling utensils will be thoroughly decontaminated prior to use in accordance with Sediment Sampling and Analysis Plan Appendix (SSAPA) guidance (Ecology 2008). The equipment will be washed with non-phosphate detergent and in situ water or by repeatedly submersing the equipment overboard. A final rinse with distilled water also will be performed. If a noticeable oily sheen or petroleum odor is observed, sampling bowls and utensils used to process those samples will not be used for subsequent sample processing.

All handwork will be conducted with disposable nitrile gloves, which will be changed after handling each individual sample and between sampling stations to prevent cross-contamination between samples.

Personal non-disposable field equipment (i.e., boots and waterproof gloves and garments) will be rinsed with water and brushed clean prior to leaving the immediate vicinity of the sample collection area. Special attention will be given to removing mud and sediments that may adhere to boot treads.

6.10 Waste Disposal

Investigation-derived waste (IDW) expected to be generated by sampling activities during the Oakland Harbor sediment study include:

- Sediment sample material not submitted to the laboratories
- Equipment decontamination fluids
- Disposable protective clothing and sampling supplies.

The disposal procedures identified below are consistent with guidance provided in Section 5.7 of the SSAPA (Ecology 2008).

6.10.1 Sediment Sample/Sediment Core

Surface sediment samples will be processed onboard the vessel and sediment core samples will be processed at an onshore station established for this investigation. To the extent practicable, excess sediment material will be returned to the site following completion of sample processing. Any sediment not returned to the site will be packed in sealable containers and disposed of properly.

6.10.2 Equipment Decontamination Fluids

Water-based decontamination fluids will be disposed of on site. Organic solvent fluids generated during equipment decontamination will be contained in sealable containers and disposed of properly following field activities.

6.10.3 Disposable Protective Clothing and Sampling Equipment

Used personal protective equipment (PPE), such as gloves and disposable supplies, such as paper towels and packaging, will be placed in plastic storage bags and disposed of as municipal waste. If PPE contains residual sediment, the PPE will be decontaminated using the procedures outlined in Section 6.9, and will be disposed of as non-hazardous waste. Waste material will be recycled as feasible (e.g., cardboard, aluminum).

7.0 Laboratory Analytical Procedures

All of the chemical analytical procedures used in this program will be performed in accordance with the most current SMS, PSEP, and Ecology's SSAPA (Ecology 2008) documentation, as applicable. Analytes include metals, SVOCs (PAHs, phthalates, and phenols), polychlorinated dibenzo-p-dioxin compounds (dioxins), polychlorinated dibenzofuran compounds (furans), chlorinated pesticides, total PCBs as Aroclors,, wood resin compounds, petroleum hydrocarbons, total volatile solids, grain size, TOC, ammonia, and sulfides. In addition, three cores will be analyzed for lead-210 and cesium-137.

Each laboratory participating in this program will be National Environmental Laboratory Accreditation Program - and/or Ecology-certified to perform the analyses. Each laboratory analysis will be required to conform to accepted standard methods and internal QA/QC.

7.1 Chemical Analyses

Chemical analysis will be conducted by laboratories subcontracted to Herrera. The specific analyses and conventional parameters to be measured, sample preparation methods, analytical methods, TDLs, and SMS numeric criteria (SQS and CSL) are presented in Table 7-1. The TDLs listed are the laboratory reporting limits (RLs); and may be subject to modification due to elevated sample concentrations, heterogeneous samples, and potential matrix interferences that may preclude obtaining the desired quantification limit. Several organic compounds in the SMS criteria are corrected for percent OC content. In the event the laboratory is unable to meet the OC-corrected SQS and CSL numeric values, the reasons for the deviation will also be reported.

Analytical laboratory reports will be accompanied by sufficient backup data and QC results to enable independent reviewers to evaluate the quality of the data results. Analytical data will be reported in the units specified by the RLs listed in Tables 7-1 and 7-2.

Analytical laboratory deliverables will include the following:

- Case narrative (including any problems encountered, protocol modifications, and/or corrective actions taken)
- Sample analytical and QA/QC results with units
- All protocols used during analyses
- Any protocol deviations from the approved sampling plan
- Surrogate recovery results

Table 7-1. Sediment SMS analyte list for the Oakland Bay Sediment Study.

Analyte	Prep Method [a]	Analytical Method [b]	Sediment RL [c,d]	SQS	CSL
Conventional Parameters					
Total Solids (%)	---	PSEP [5]	0.1 (wet weight)	---	---
Total Organic Carbon (%)	---	PSEP [5]	0.1	---	---
Total Sulfides (mg/kg)	---	PSEP [5]	10	---	---
Ammonia (mg/kg)	---	PSEP [5]	0.1	---	---
Grain Size (%)	---	PSEP [5]	1	---	---
Metals			mg/kg	mg/kg	
Arsenic	PSEP/3050B	6010B/6020	19	57	93
Cadmium	PSEP/3050B	6010B/6020	1.7	5.1	6.7
Chromium	PSEP/3050B	6010B/6020	87	260	270
Copper	PSEP/3050B	6010B/6020	130	390	390
Lead	PSEP/3050B	6010B/6020	150	450	530
Mercury	---	7471A	0.14	0.41	0.59
Silver	PSEP/3050B	6010B/6020	2	6.1	6.1
Zinc	PSEP/3050B	6010B/6020	137	410	960
Low Molecular Polycyclic Aromatic Hydrocarbons (LPAH)			µg/kg	mg/kg OC	
Naphthalene	3540C/3550B	8270C	700	99	170
Acenaphthylene	3540C/3550B	8270C	433	66	66
Acenaphthene	3540C/3550B	8270C	167	16	57
Fluorene	3540C/3550B	8270C	180	23	79
Phenanthrene	3540C/3550B	8270C	500	100	480
Anthracene	3540C/3550B	8270C	320	220	1,200
2-Methylnaphthalene	3540C/3550B	8270C	223	38	64
Total LPAH				370	780
High Molecular Polycyclic Aromatic Hydrocarbons (HPAH)			µg/kg	mg/kg OC	
Fluoranthene	3540C/3550B	8270C	567	160	1,200
Pyrene	3540C/3550B	8270C	867	1,000	1,400
Benzo(a)anthracene	3540C/3550B	8270C	433	110	270
Chrysene	3540C/3550B	8270C	467	110	460
Benzofluoranthenes, total	3540C/3550B	8270C	1,067	230	450
Benzo(a)pyrene	3540C/3550B	8270C	533	99	210
Indeno(1,2,3-c,d)pyrene	3540C/3550B	8270C	200	34	88
Dibenzo(a,h)anthracene	3540C/3550B	8270C	77	12	33
Benzo(g,h,i)perylene	3540C/3550B	8270C	223	31	78
Total HPAH				960	5,300
Chlorinated Benzenes			µg/kg	mg/kg OC	
1,2-Dichlorobenzene	3540C/3550B	8270C	35	2.3	2.3
1,4-Dichlorobenzene	3540C/3550B	8270C	37	3.1	9
1,2,4-Trichlorobenzene	3540C/3550B	8270C	31	0.81	1.8
Hexachlorobenzene	3540C/3550B	8270C	22	0.38	2.3

Table 7-1 (continued). Sediment SMS analyte list for the Oakland Bay Sediment Study.

Analyte	Prep Method [a]	Analytical Method [b]	Sediment RL [c,d]	SQS	CSL
Phthalate Esters			µg/kg	mg/kg OC	
Dimethyl phthalate	3540C/3550B	8270C	24	53	53
Diethyl phthalate	3540C/3550B	8270C	37	61	110
Di-n-butyl phthalate	3540C/3550B	8270C	467	220	1,700
Butyl benzyl phthalate	3540C/3550B	8270C	21	4.9	64
Bis(2-ethylhexyl)phthalate	3540C/3550B	8270C	433	47	78
Di-n-octyl phthalate	3540C/3550B	8270C	2,067	58	4,500
Ionizable Organic Compounds			µg/kg	µg/kg	
Phenol	3540C/3550B	8270C	140	420	1,200
2-Methylphenol	3540C/3550B	8270C	63	63	63
4-Methylphenol	3540C/3550B	8270C	223	670	670
2,4-Dimethylphenol	3540C/3550B	8270C	29	29	29
Pentachlorophenol	3540C/3550B	8270C	120	360	690
Benzyl alcohol	3540C/3550B	8270C	57	57	73
Benzoic acid	3540C/3550B	8270C	217	650	650
Miscellaneous Compounds			µg/kg	mg/kg OC	
Dibenzofuran	3540C/3550B	8270C	180	15	58
Hexachlorobutadiene	3540C/3550B	8270C	11	3.9	6.2
N-Nitrosodiphenylamine	3540C/3550B	8270C	28	11	11
Total PCBs	3540C/3550B	8082	6	12	65

[a] Recommended sample preparation methods are: PSEP (1997a,b) and USEPA 3000 series (sample preparation methods from SW-846 [USEPA 1986])

[b] Recommended sample cleanup methods are: USEPA SW-846 Methods 3640A, 3660B, and 3665A. Alternative cleanup procedures are described in PSEP and SW-846.

[c] RL, SQS, and CSL are on a dry weight basis.

[d] The recommended RL is based on a value equal to one third of the 1988 dry weight lowest apparent effects threshold value (Barrick et al. 1988) except for the following chemicals: 1,2-dichlorobenzene, 1,2,4-trichlorobenzene, hexachlorobenzene, hexachlorobutadiene, n-nitrosodiphenylamine, 2-methylphenol, 2,4-dimethylphenol, and benzyl alcohol, for which the recommended MRL is equal to the full value of the 1988 dry weight. As reported in Table 5, Ecology 2008.

CSL = Cleanup Screening Level.
HPAH = High molecular weight polycyclic aromatic hydrocarbon compounds.
LPAH = Low molecular weight polycyclic aromatic hydrocarbon compounds.
µg/kg = Micrograms per kilogram.
mg/kg = Milligrams per kilogram.
OC = Organic carbon.
PSEP = *Recommended Protocols for Measuring Metals in Puget Sound Water, Sediment and Tissue Samples*, Puget Sound Estuary Program, April 1997.
RL = Reporting limit.
SQS = Sediment Quality Standards
SW-846 = *Test Methods for Evaluating Solid Waste, Physical Chemical Methods*, 3rd edition, USEPA, SW-846, 1986.
USEPA = United States Environmental Protection Agency.

Table 7-2. Sediment non-SMS analyte list summary for Oakland Bay Sediment Study.

Parameter	Analysis Method [a]	Sediment RL
Metals [b]		
Antimony	SW 6010/6020	50
Nickel	SW 6010/6020	47
Chlorinated Pesticides [c]		
Aldrin	SW 8081	1.7
gamma-BHC (Lindane)	SW 8081	1.7
Heptachlor	SW 8081	1.7
Hexachlorobenzene	SW 8081	22
alpha-Chlordane	SW 8081	1.7
4,4'-DDD	SW 8081	3.3
4,4'-DDE	SW 8081	2.3
4,4'-DDT	SW 8081	6.7
Dieldrin	SW 8081	2.3
Organotin Compounds [c]		
Butyltin	Krone, et. al., 1989	4
Dibutyltin	Krone, et. al., 1989	6
TBT	Krone, et. al., 1989	4
Wood Resin Compounds [c]		
Retene	SW 8270	20
Guaiacols	modified SW 8270	20
4-Chloroguaiacol	modified SW 8270	TBD
3,4-Dichloroguaiacol	modified SW 8270	TBD
4,5-Dichloroguaiacol	modified SW 8270	50
4,6-Dichloroguaiacol	modified SW 8270	TBD
3,4,5-Trichloroguaiacol	modified SW 8270	75
3,4,6-Trichloroguaiacol	modified SW 8270	TBD
4,5,6-Trichloroguaiacol	modified SW 8270	50
Tetrachloroguaiacol	modified SW 8270	75
Pimaric acid	modified SW 8270	100
Sandracopimaric acid	modified SW 8270	100
Isopimaric acid	modified SW 8270	100
Palustric acid	modified SW 8270	100
Dihydroabietic acid	modified SW 8270	100
Abietic acid	modified SW 8270	100
Neoabietic acid	modified SW 8270	100
9,10-Dichlorostearic acid	modified SW 8270	TBD
Oleic acid	modified SW 8270	100
Linolenic acid	modified SW 8270	100
12-Chlorodehydroabietic acid	modified SW 8270	100
14-Chlorodehydroabietic acid	modified SW 8270	100
Dichlorodihydroabietic acid	modified SW 8270	100
NWTPH-HCID [c]		
Gasoline	NWTPH-HCID	20
Diesel #2	NWTPH-HCID	50

Table 7-2 (continued). Sediment non-SMS analyte list summary for Oakland Bay Sediment Study.

Parameter	Analysis Method [a]	Sediment RL
Motor Oil	NWTPH-HCID	100
CDD/CDF [d]		
2,3,7,8-TCDD	USEPA 1613B	0.1
Total TCDD	USEPA 1613B	0.1
1,2,3,7,8-PeCDD	USEPA 1613B	0.5
Total PeCDD	USEPA 1613B	0.5
1,2,3,4,7,8-HxCDD	USEPA 1613B	0.5
1,2,3,6,7,8-HxCDD	USEPA 1613B	0.5
1,2,3,7,8,9-HxCDD	USEPA 1613B	0.5
Total HxCDD	USEPA 1613B	0.5
1,2,3,4,6,7,8-HpCDD	USEPA 1613B	0.5
Total HpCDD	USEPA 1613B	0.5
OCDD	USEPA 1613B	1.0
2,3,7,8-TCDF	USEPA 1613B	0.1
Total TCDF	USEPA 1613B	0.1
1,2,3,7,8-PeCDF	USEPA 1613B	0.5
2,3,4,7,8-PeCDF	USEPA 1613B	0.5
Total PeCDF	USEPA 1613B	0.5
1,2,3,4,7,8-HxCDF	USEPA 1613B	0.5
1,2,3,6,7,8-HxCDF	USEPA 1613B	0.5
1,2,3,7,8,9-HxCDF	USEPA 1613B	0.5
2,3,4,6,7,8-HxCDF	USEPA 1613B	0.5
Total HxCDF	USEPA 1613B	0.5
1,2,3,4,6,7,8-HpCDF	USEPA 1613B	0.5
1,2,3,4,7,8,9-HpCDF	USEPA 1613B	0.5
Total HpCDF	USEPA 1613B	0.5
OCDF	USEPA 1613B	1.0

[a] Krone, et al., 1989. A method for analysis of butyltin species and measurement of butyltin in Sediment and Engish sole livers from Puget Sound. Marine Environment Research, **27**, 1-18.
[b] Metal reporting limits (RL) are on a dry weight basis in mg/g.
[c] Organic Compounds RL are on a dry weight basis in µg/g.
[d] CDD and CDF RL are on a dry weight basis in pg/g.
CDD = Chlorinated dibenzo-p-dioxin.
CDF = Chlorinated dibenzofuran.
USEPA 1613B = *Method 1613 Tetra- through Octa-Chlorinated Dioxins and Furans by Isotope Dilution HRGC/HRMS.* U.S. Environmental Protection Agency, Office of Water, Engineering and Analysis Division. October 1994.
HCID = Hydrocarbon Identification.
HxCDD = Hexachlorodibenzo-p-dioxin.
HxCDF = Hexachlorodibenzofuran.
HpCDD = Heptachlorodibenzo-p-dioxin.
HpCDF = Heptachlorodibenzofuran.
NWTPH = Northwest total petroleum hydrocarbon.
OCDD = Octachlorodibenzo-p-dioxin.
OCDF = Octachlorodibenzofuran.
PeCDD = Pentachlorodibenzo-p-dioxin.
PeCDF = Pentachlorodibenzofuran.
RL = Reporting limit.
SW = *Test Methods for Evaluating Solid Waste, Physical Chemical Methods*, 3rd edition, USEPA, SW-846, 1986.
TBD = To be determined.
TCDD = Tetrachlorodibenzo-p-dioxin.
TCDF = Tetrachlorodibenzofuran.

- MS/MSD results
- Laboratory duplicate/triplicate results
- Blank results
- Sample custody records (including original COC forms)
- Analytical results in electronic Environmental Information Management (EIM) system.

7.2 Bioassay Analyses

This section describes specific procedures for the suite of bioassays used for SMS biological analysis. Sediment collected at predetermined locations will be submitted for bioassay testing. Bioassay testing requires that test samples be matched and tests run with appropriate reference sediments to factor out background conditions and sediment grain-size effects on bioassay organisms. The contractor will collect the identified reference sediments at the same time that other samples are collected. The reference sediment sampling location will be recorded to the nearest 0.1 second (NAD 83).

All sediment samples selected for bioassay analysis will be stored at 4 °C with no headspace until bioassay testing commences. All bioassays will commence within 14 days from collection of the first grab sample of the sediment composite to be tested. The laboratory will maintain COC procedures throughout biological testing.

Bioassay testing will be initiated as soon as possible after the last sample (to define a batch) is received by the laboratory. This includes obtaining test organisms and control/reference sediments in a timely manner.

Four bioassays (Table 7-3) including amphipod mortality, larval development, juvenile polychaete growth, and Microtox® (porewater) bioluminescence, will be conducted on each sample identified for biological testing. All biological testing will be conducted in strict compliance with Recommended Guidelines for Conducting Laboratory Bioassays on Puget Sound Sediments (PSEP 1995), with appropriate modifications as specified in the annual review process. General biological testing procedures and specific procedures for each sediment bioassay are summarized in the following sections.

The specific QA/QC measures employed as part of the biological analyses are discussed in detail in Section 5.0.

Table 7-3. Bioassay suite for the Oakland Harbor Sediment Study.

Bioassay Test	Test Organisms
10-day Amphipod Mortality Test	*Eohaustorius estuaries* or *Rhepoxynius abronius*
48-hour Larval Development Test [a] (bivalve)	*Dendraster excentricus*
20-day Juvenile Polychaete Growth Test	*Neanthes arenaceodentata*
Microtox® (porewater) bioluminescence	*Vibrio fischeri* (strain NRRL B-11177)

[a] Actual test length may vary based on larval development stage.

7.2.1 Amphipod Mortality Bioassay

This test involves exposing *Rhepoxynius abronius* or *Eohaustorius estuarius* to test sediment for 10 days and counting the surviving animals at the end of the exposure period. Daily emergence data and the number of amphipods failing to rebury at the end of the test will be recorded as well. The control sediment has a performance standard of 10 percent mortality. The reference sediment has a performance standard of 25 percent mean mortality. The amphipod chosen is based on the interstitial water salinity (i.e., greater than or equal to 25 parts per thousand [ppt], or less than 25 ppt) and the percentage of sediment fines (i.e., greater than or equal to 60 percent fines, or less than 60 percent fines) as described in the SSAPA (Ecology 2008).

E. estuarius is the preferred test organism for sediments with percent fines greater than or equal to 60 percent. *R. abronius* is the preferred amphipod species for coarser-grained sediments (less than 60 percent fines). Based on historical grain size data from previous investigations, both *E. estuarius* and *R. abronius* could be used in the investigation.

No treatment for confounding factors will be performed on the sediment sample during the bioassay procedure. Ammonia reference toxicant tests may be conducted if elevated ammonia concentration is suspected in test sediments.

7.2.2 Larval Development Bioassay

This test monitors larval development of a suitable echinoderm or molluscan species (e.g., *Dendraster excentricus* or *Mytilus galloprovincialus*) in the presence of test sediment. *M. galloprovincialis* is the preferred species, followed by *D. excentricus*. However, the primary factor in selection of species for the larval test is the time of year. Therefore, *D. excentricus* will be used for this study, as indicated in the SSAPA (Section 2.2.1.1) (Ecology 2008). The sediment larval bioassay has a variable endpoint (not necessarily 48 hours) that is determined by the developmental stage of organisms in a sacrificial seawater control (PSEP 1995). At the end of the test, larvae from each test sediment exposure are examined to quantify abnormality and mortality. The seawater control has a performance standard of 70 percent mean normal survivorship. Initial counts will be made for a minimum of five 10 ml (0.34 oz) aliquots. Final counts for seawater control, reference sediment, and test sediment will be made on 10 ml (0.34 oz) aliquots.

No treatment for confounding factors will be performed on the sediment sample during the bioassay procedure. Ammonia reference toxicant tests may be conducted if elevated ammonia concentration is suspected in test sediments.

7.2.3 Juvenile Polychaete Growth Bioassay

This sublethal, static-renewal toxicity test can be used to determine the relative toxicity of marine sediments using the juvenile polychaete, *Neanthes arenaceodentata*. The test is conducted in accordance with the methods described by PSEP (1995) and modifications to the test approved by the Dredged Material Management Program (DMMP) agencies.

The toxicity test involves a 20-day exposure to sediments and the response of the organisms to test sediments as compared to their response in control (clean) and reference sediment. The test endpoint is mean individual growth (expressed as mg/individual/day).

The control sediment has a performance standard of 10 percent mortality. The reference sediment has a performance standard of 80 percent of the control growth. The DMMP agencies have established a target control growth performance guideline of greater than or equal to 0.72 mg/individual/day. The *N. arenaceodentata* negative control performance guideline is a target growth rate of greater than or equal to 0.72 mg/individual/day; the negative control performance standard is greater than 0.38 mg/individual/day (below which the test is considered a QC failure). Use of worms smaller than 0.25 mg (dry weight) at the beginning of the test will also be considered a QC failure.

7.2.4 Full-Spectrum Lighting

Under certain conditions, when PAHs are exposed to ultraviolet (UV) radiation of sufficient quality and quantity, photo-activation may occur (Kosian et al.1998). Photo-activation has been demonstrated to result in increased acute and chronic toxicity (Arfsten et al.1996). Benthic and aquatic organisms exposed to selected PAHs and simultaneously to specific wavelengths and intensities of UV radiation may be at significantly greater risk to toxic effects than organisms exposed to the same PAHs absent the UV radiation (Ahrens 2002). When the following site conditions are encountered, all bioassays will be performed in the presence of full-spectrum lighting that includes UV wavelengths of sufficient intensity to mimic conditions at the site (Ecology 2008):

- If either sediment depth is 12 ft or less (4 m) than MLLW for more than 25 percent of the surface sediment or surface sediment covers more than 1/2 acre

- The presence or presumed presence of any of the photo-activated PAHs listed in Table 7-4 is expected (Nagpal 1993).

Table 7-4. Photo-activated polycyclic aromatic hydrocarbons.

PAHs	PAHs
Anthracene	Benz[c]acridine
Acridine	Benzathrone
Phenazine	Benzo[a]pyrene
Fluoranthene	Benzo[e]pyrene
1H-benzo[a]fluorene	Perylene
1H-benzo[b]fluorene	Dibenz[a,h]acridine
Pyrene	Dibenz[a,h]anthracene
Benz[a]anthracene	Dibenz[a,j]anthracene
Benz[b]anthracene	Benzo[b]chrysene
Chrysene	Dibenz[a,c]phenazine
Benzo[k]fluoranthene	Benzo[b]triphenyline
Benz[a]acridine	Benzo[g,h,i]perylene

Based on historical data from previous sampling events in Oakland Bay, bioassays on sediment samples collected at water depths of 12 ft or less (MLLW) will be conducted using full-spectrum lighting. Samples collected from depths greater than 12 ft will be conducted under standard lighting conditions.

Standard fluorescent laboratory lighting fixtures are not full spectrum and do not produce "natural" wavelengths and intensity of light. Therefore the laboratory must use two light sources with different radiation characteristics. The full spectrum fluorescent lamp needed must include the following (Ecology 2008):

- UV-B output (280 nanometers (nm) < λ < 315 nm) photo-activating wavelengths
- UV-A output (315 nm < λ < 400 nm), this may have an effect upon burial and feeding behavior
- Correct Color temperature: 'warm' red to 'cold' blue expressed in degrees Kelvin. Daylight at noon is typically estimated at 5,500 °K
- High Color Rendering Index (CRI): Color rendering is the degree to which a light source shows the true color of objects it illuminates. This is measured on a CRI rated from 0–100. A normal fluorescent lamp rates 54 on the CRI scale. High quality fluorescent lamps will rate 90–98 on the same scale.

In addition to the quality of the lamp, its proximity to the animal, its output intensity, and duration of use are also critical. It is absolutely critical that nothing is placed between the envelope of the lamp tube and the recipient test organism or vessel. UV-B is greatly attenuated by glass, plastic, and ultra-fine mesh. The amount of UV-B received is also diminished with distance. It is recommended that any UV-B tubes be no further than 12 in (30 cm) away from the organism or vessel (Ecology 2008).

The recommended lab conditions for full spectrum testing include:

- Light intensity: 50–100 ft candles
- Light duration: 16:8 (light/dark)
- Overlying water depth: not greater than 15 cm (6 in)
- Lamp to water surface distance: not greater than 30 cm (12 in)
- UV wavelength range: 3–8 percent UV-B (280 nm < λ < 315 nm), (3-5 percent preferred)
- 20–35 percent UV-A (315 nm < λ < 400 nm).

7.2.5 Microtox® (Porewater) Bioluminescence Bioassay

This test assesses toxicity in sediment porewater using the bioluminescent properties of the marine bacteria *Vibrio fischeri*. The test is conducted in accordance with the methods described in the SSAPA Appendix B (Ecology 2008).

The toxicity test involves a rapid (15 minute) exposure of the bacteria to sediment porewater. The light emitted by the test bacteria is compared to light emission of a control group in clean seawater. The test endpoint is measured luminescence.

The control and reference samples have a performance standard of a final luminescent output greater than or equal to 80 percent of the initial output. In addition, the reference sample and test sample initial outputs must be greater than 80 percent of the control sample initial output (Ecology 2008).

7.2.6 Bioassay Interpretation

Test interpretations consist of endpoint comparisons to controls and reference on an absolute percentage basis as well as statistical comparison to reference. The SMS biological effects criteria are presented in Table 7-5.

7.3 Radioisotope Analyses

Laboratory analysis will consist of lead-210 and cesium-137 radioisotope activity measurements. Percent dry weight and lead-210 in disintegrations per minute per gram (dpm/g) and cesium-137 in dpm/g, will be determined for each sample. Lead-210 analysis will be performed on every third 2 cm (0.8 in) section; cesium-137 will be performed on two core sections.

Table 7-5. SMS biological effect criteria.

Biological Test	Sediment Quality Standards	Cleanup Screening Levels
Amphipod Mortality	The test sediment has a significantly higher (t-test, P≤0.05) mean mortality than the reference sediment, and the test sediment mean mortality is more than 25% greater, on an absolute basis, than the reference sediment mean mortality.	The test sediment has a significantly higher (t-test, P≤0.05) mean mortality than the reference sediment, and the test sediment mean mortality is more than 30% 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≤0.1) than the mean normal survivorship in the reference sediment, and the mean normal survivorship in the test sediment is less than 85% 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≤0.1) than the mean normal survivorship in the reference sediment, and the mean normal survivorship in the test sediment is less than 70% 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% 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 P≤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% 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 P≤0.05) from the reference sediment mean individual growth rate.
Microtox® (porewater) bioluminescence	The mean light output of the highest concentration of the test sediment is less than 80 % of the mean light output of the reference sediment, and the two means are statistically different (t-test, P≤0.05).	Not Applicable

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8.0 Data Analysis and Reporting

This section describes data analysis and reporting requirements for the data collection activities described above.

8.1 Data Analysis

8.1.1 Analysis of Sediment Chemistry Data

The analysis of chemistry data will include a comparison of the results to SMS numeric criteria and to other applicable criteria for analytes without SQS and/or CSL numeric criteria. Results will also be compared to reference area data. Reference sediment samples will be analyzed to evaluate whether Oakland Bay results are elevated above what are considered to be Puget Sound background concentrations. Sediment chemistry data will be summarized and presented in tables indicating sampling locations and detected contaminants and any detection limits that exceed SQS and/or CSL numeric criteria, along with any data qualifiers assigned by the laboratory or during data validation efforts. Sample locations with chemistry exceeding numeric criteria will be mapped to delineate any areas that may require cleanup or other remedial action.

8.1.2 Fingerprinting Analysis of Sediment Data

A screening-level "fingerprinting" evaluation of TPH, PAH, and dioxin/furan sediment data will be conducted to provide a preliminary indication of the usefulness of the analytical data to differentiate between sources of contaminants. Three lines of forensic evidence will be qualitatively investigated: TPH, PAHs, and dioxin/furans (PCDD/PCDFs).

Petroleum hydrocarbons will be analyzed using the TPH method NWTPH-HCID for Hydrocarbon Identification. NWTPH-HCID is a qualitative and semi-quantitative screening tool that will be used to confirm the presence and type of petroleum product in a sediment sample. Results are qualitatively reported as gasoline, diesel, or heavy oils. The method is most useful for elimination of the need for more detailed petroleum analyses where NWTPH-HCID results indicate TPH concentrations are below regulatory limits. The reporting limits for sediment are 20 mg/kg for gasoline, 50 mg/kg for #2 diesel, and 100 mg/kg for motor oil. Pattern matching with known reference product chromatograms is used to identify (i.e. "fingerprint") the type of hydrocarbon. A laboratory analyst will categorize the TPH based on chromatogram identification. Herrera personnel will also visually evaluate the sample chromatograms to identify unique patterns, if any, associated with potential sources.

Both PAHs and PCDD/PCDFs have characteristic patterns and distributions in materials. For example, petroleum and wood combustion sources have different PAH analyte patterns, while wood industry and smelter activities generate different patterns of PCDD/PCDFs. The sediment data will be evaluated for relative analyte concentrations of PAHs and PCDD/PCDFs and compared to published data on the relative ratios in potential source materials. PAH and

PCDD/PCDF analyte distribution in samples from potential source areas will also be visually evaluated to identify unique patterns, if any, associated with those sources.

While the analytical data should meet the data quality objectives necessary to provide qualitative screening for guidance regarding the utility of the data for source differentiation, given the limited number of samples at each potential source, quantitative evaluation of the data on a statistically significant basis will likely not be possible.

8.1.3 Analysis of Biological Data

The analysis of biological data will include comparison to SMS biological effects criteria. Toxicity test data results will be summarized and presented in tables indicating sampling locations and test results that exceed SQS and/or CSL biological effects interpretive criteria, along with the results of statistical comparisons to reference sediment test results. The sampling locations with sediment toxicity exceeding the SMS criteria will be mapped to delineate any areas that may require cleanup or other remedial action.

8.1.4 Radioisotope Dating

Sedimentation rate information, including sediment age in years, year of deposition, sediment accumulation rate (cm/yr), and sedimentation rate ($g/cm^2/yr$) will be determined and reported. The sedimentation rate is normally derived from lead-210 results; however, in some cases the cesium-137 data may be used to determine the sedimentation rate and sediment ages. Cesium-137 results are normally used to verify dates determined with sedimentation rates.

8.2 Sediment Investigation Report

A written SIR documenting all activities associated with collection, management, chemical analyses, and biological testing of collected samples will be prepared. The report will include recommendations for further action or investigation based on data comparisons to established evaluation criteria. Chemical, biological, and QA/QC reports will be included as appendices. As a minimum, the following will be included in the report:

- Description of sampling and analysis activities
- Protocols used during sampling and testing and an explanation of any deviations from SAP protocols
- Physical descriptions of samples
- Methods used for station positioning, sample collection locations reported in latitude and longitude to the nearest tenth of a second (NAD 83)

- Map showing actual locations of sampling stations and results of data comparisons to SMS and other criteria
- Chain-of-custody records
- Chemistry and biological testing results and laboratory reports
- Comparison of data results to interpretive criteria
- Fingerprinting analysis of sediment data results and interpretation
- Radioisotope results and interpretation
- QA/QC summary
- Data validation reports.

A geomorphic assessment of the shoreline and marine waters of Shelton Harbor and the southern shoreline of Oakland Bay will be based on site observations, historical assessment, core logs, and the geophysical surveys. This analysis will include the geomorphic ramifications of human activities cataloged in the historical analysis and the probable fate of past sediment-bound pollutant discharges discovered previously. It will include a listing of the physical processes potentially responsible for transport of existing polluted areas, as compiled from previous hydrographic studies in the area (e.g., Oakland Bay Dye Study), those processes interpreted from the geophysical survey and sedimentological features found in the core logs. In so doing, the assessment will provide the framework to interpret the results of the geophysical surveys and document the limits of particle-born pollutant transport in the study area. A technical memorandum will be produced describing geomorphic conditions in the study area with attached georeferenced graphics illustrating all salient features.

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