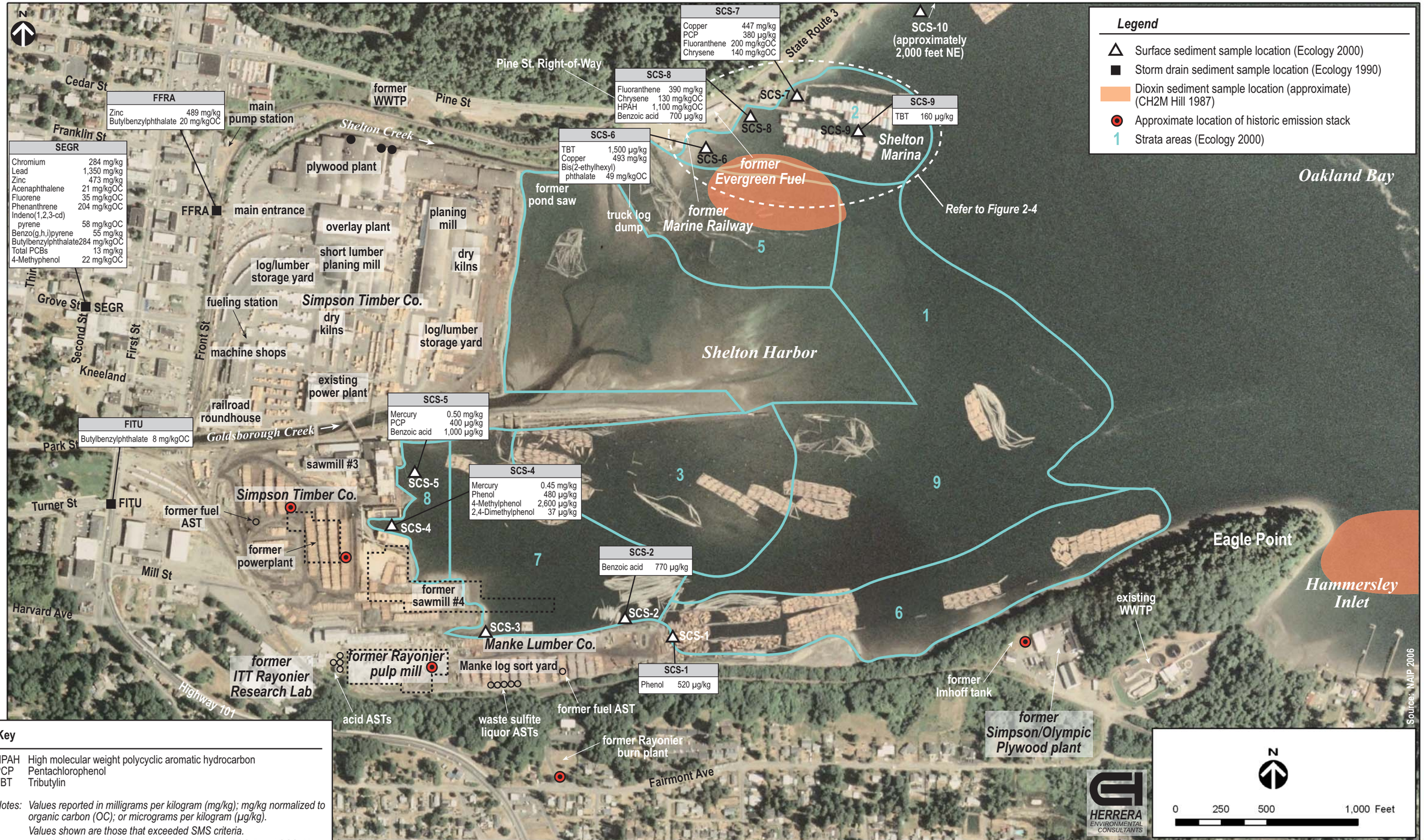

Key

HPAH High molecular weight polycyclic aromatic hydrocarbon
PCP Pentachlorophenol
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.
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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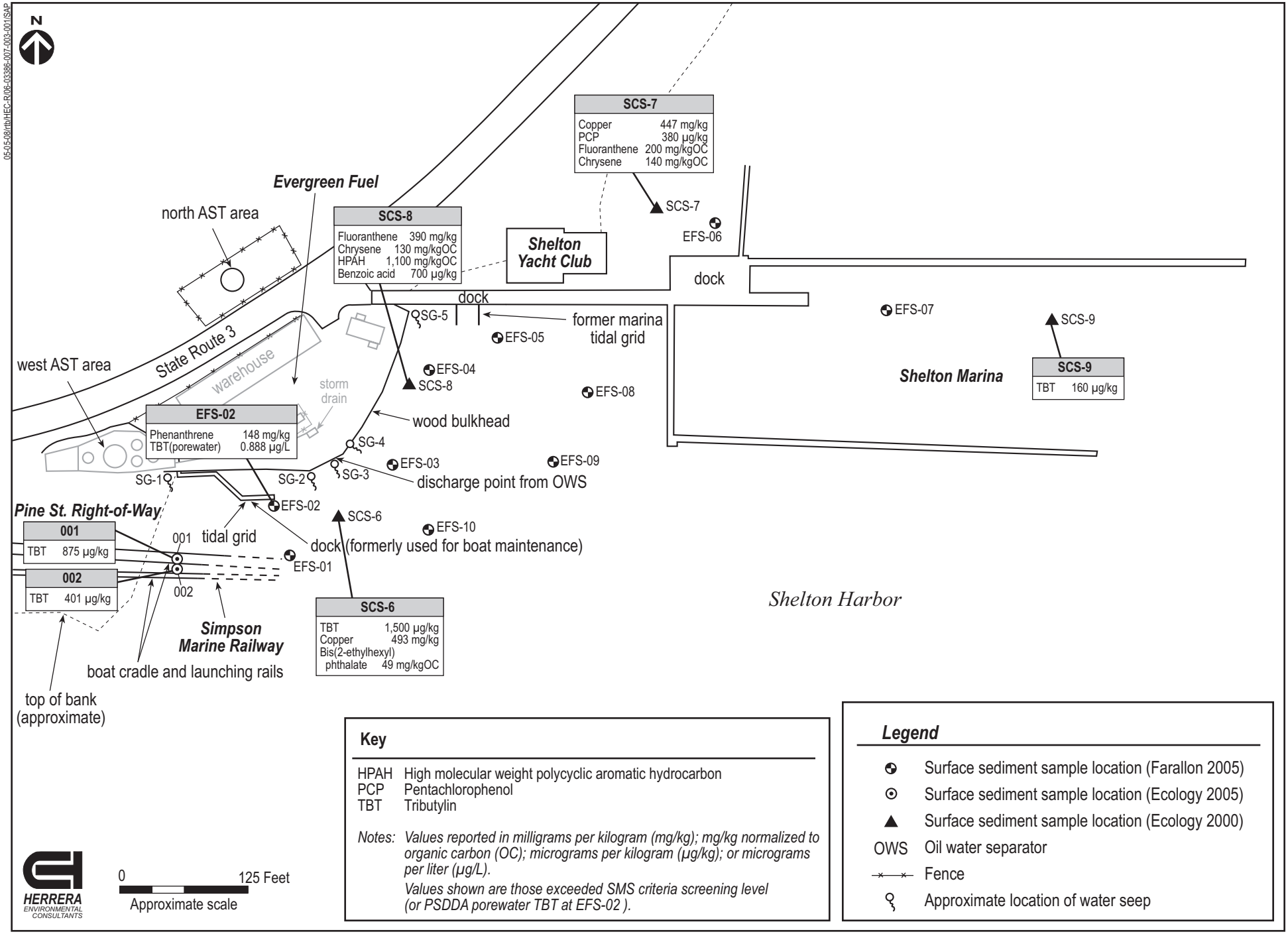

Figure 2-4. Previous investigation sample locations, former Evergreen Fuel site, Shelton Yacht Club and Marina, and former marine railway, Shelton, Washington.

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

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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 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 one 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, 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; PCP exceeded the SQS criterion at SCS-5.

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- 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 near the vessel haul-out area adjacent to the boat crib and benzoic acid exceeded the CSL criterion east of Evergreen Fuel. 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. 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 screening criterion of 73 µg/kg for butyltin in sediments.

- No SMS exceedances were identified at SCS-10, located approximately 2,000 feet 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 three samples from the south harbor and one sample near the marina; and included benzoic acid, phenol, 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). 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

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- 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 feet east and offshore the Evergreen Fuel site within the marina
- EFS-10 – Approximately 130 feet 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

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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 (Farallon 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. 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 are 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.

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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 PSAMPNOA (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.

2.1.2.2 2004/2005 Fecal Coliform Bacteria TMDL Studies

These studies, conducted by WDOH, involved bi-monthly sampling at 27 sites on 10 major tributaries draining to Oakland Bay and Hammersley Inlet, including: Mill, Goldsborough, Coffee, Shelton, John's, Cranberry, Deer, Malaney, Uncle John's, and Campbell Creeks. The water quality standard for fecal coliform bacteria in these Class A streams are that the geometric mean of samples cannot exceed 100 cfu/100 ml of water and the 90th percentile of samples cannot exceed 200 cfu/100 ml of water. In August 2005, Shelton Creek, Deer Creek, and Uncle John's Creek exceeded the 90th percentile portion of the standard, but not the geometric mean portion (WDOH 2005).

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All of Hammersley Inlet and most of Oakland Bay are classified as Class A water bodies. The marine water quality standard for fecal coliform bacteria in these water bodies are that the geometric mean of samples cannot exceed 14 cfu/100 ml of water and the 90th percentile of samples taken cannot exceed 43 cfu/100 ml of water. Shelton Harbor is classified as Class B, with a water quality standard of 100 cfu/100ml for the geometric mean and 200 cfu/100ml for the 90th percentile.

In Shelton Harbor, two samples exceeded the 90th percentile portion of the water quality standard. In Oakland Bay, only at the mouth of Chapman Cove was the 90th percentile portion of the standard exceeded, with a 90th percentile value of 209 cfu/100ml. All Hammersley Inlet sites met the water quality standard.

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 cfu/100 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).

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. The specific objectives of the sediment characterization include the following:

- Conduct a sampling and analysis effort based on previous investigations and existing data gaps to characterize the overall nature and extent of sediment contamination in Oakland Bay.
- Conduct a geophysical survey to determine the distribution of wood waste across Oakland Bay.
- Characterize horizontal and vertical extent of contamination in sediment.
- Characterize wood waste using chemical and toxicity testing.

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- Estimate sedimentation rate in Oakland Bay using radioisotope dating.
- Conduct bioassays to determine the extent of acute and chronic toxicity of sediment.
- Collect shellfish for tissue residue analysis for bioaccumulative and toxic compounds.
- Analyze Oakland Bay sediments and shellfish tissue for contaminants of concern to provide adequate information to evaluate the concentrations relative to human health and ecological health concerns.
- Conduct a screening-level "fingerprinting" evaluation of TPH, PAH, and dioxin/furan sediment data to provide a preliminary indication of the usefulness of the analytical data to differentiate between sources of contaminants.

Data generated from site characterization efforts will be used to complete human health and ecological risk assessments. The Risk Assessment Work Plan is provided in Appendix C.

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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, performing a geophysical survey, and completing HHRA/ERAs. 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
- Erinn Birmingham (Herrera), Human Health and Ecological Risk Assessor
- Alma Feldpausch (E & E), Human Health Ecological Risk Assessor
- Carl Mach (E & E), Ecological Risk Assessor

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, risk assessment support, 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 and PCBs analyses.

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- Analytical Resources, Inc. for grain size, TOC, SVOCs, sulfide, ammonia, TBTs, total volatile solids (TVS) and wood resins analyses.
- Nautilus Environmental for bioassay tests.

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
Draft Work Plan	February 19, 2008
Final Work Plan	March 5, 2008
Draft Existing Information and Data Gaps Memorandum	April 4, 2008
Final Existing Information and Data Gaps Memorandum	April 22, 2008
Ecology Draft SAP/HSP/RA Work Plan	April 11, 2008
Public Review Draft SAP/HSP/RA Work Plan	May 8, 2008
Geophysical Study	mid-May, 2008
Public Comment Period	June 1 - 30, 2008
Public Meeting	June 16, 2008
Final SAP/HSP/RA Work Plan	July 7, 2008
Commence Field Work	July 7, 2008
Preliminary Analytical Data Tables	November 8, 2008
Human Health/Ecological Risk Assessment Exposure Memorandum	November 26, 2008
Ecology Draft Sediment Investigation Report (SIR)	February 1, 2009
Public Review Draft SIR (tentative)	March 1, 2009
Final SIR	April 15, 2009
Ecology Draft Human Health/Ecological Risk Assessments	May 15, 2009
Public Review Draft Human Health/Ecological Risk Assessments (tentative)	June 1, 2009
Final Human Health/Ecological Risk Assessments	July 30, 2009

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4.0 Study Design

This section describes the study design for each data type to be collected for the Oakland Bay Sediment Characterization Study. 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
Hammersley Inlet	Southeast portion of Oakland Bay and Hammersley inlet to Miller Point	WWTP effluent discharges, log rafts, sediment redistribution from Shelton Harbor
Background	North Oakland Bay near park (potential)	Background
Reference Samples	Carr Inlet	Reference

Sediment, wood waste, and tissue 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, to determine the concentrations of toxics in shellfish tissue, 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. Sediment samples will be collected from the sediment surface (0 to 10 cm) and from 4-foot or 12-foot (wood waste) 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; wood waste build up can be determined through analysis of total volatile solids. Tissue COPCs include SVOCs, metals, PCBs (measured as congeners), and dioxins/furans. A summary of total sample numbers and analyses required is provided in Table 6-1.

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:

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- 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 and biota near industrial discharge points along the Shelton Harbor shoreline.
- COPC concentrations in sediment and biota near creek discharge points.
- SVOC concentrations associated with dense areas of intact, degrading, and/or submerged creosote pilings.
- Sediment and biota toxic 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, wood waste, and bivalve tissue 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.

4.1.1 Geophysical Mapping

Electrical resistivity of marine sediments is capable of resolving wood waste horizons and estimating wood waste thicknesses. Resistivity mapping in areas of known wood waste (inner Shelton Harbor) will 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.

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). These sections will identify depositional units along the shores of the main basins, as well as provide a

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