TERMINAL 91: SUBMERGED LANDS AREA PRELIMINARY INVESTIGATION SAMPLING AND ANALYSIS PLAN

FINAL

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Acronyms

ARI	Analytical Resources, Inc.
COC	chemical of concern
CRM	certified reference material
CSL	cleanup screening level
CSO	combined sewer overflow
CV	coefficient of variation
DGPS	differential global positioning system
DQI	data quality indicator
dw	dry weight
EcoChem	EcoChem, Inc.
Ecology	Washington State Department of Ecology
EDD	electronic data deliverable
EIM	Environmental Information Management
EPA	US Environmental Protection Agency
HASL	Health and Safety Laboratory
HPAH	high-molecular-weight polycyclic aromatic hydrocarbon
FC	field coordinator
GPS	global positioning system
LCS	laboratory control sample
LPAH	low-molecular-weight polycyclic aromatic hydrocarbon
MLLW	mean lower low water
MS	matrix spike
MSD	matrix spike duplicate
NAD83	North American Datum of 1983
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
OC	organic carbon
PACS	Professional Analytical and Consulting Services
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl

Port	Port of Seattle
PSEP	Puget Sound Estuary Program
QA/QC	quality assurance / quality control
RER	replicate error ratio
RPD	relative percent difference
SAP	sampling and analysis plan
SCO	sediment cleanup level
SDG	sample delivery group
SIM	selected ion monitoring
SLA	Submerged Lands Area
SMS	Washington State Sediment Management Standards
SVOC	semivolatile organic compound
T-91	Terminal 91
TBT	tributyltin
TOC	total organic carbon
UCT-KED	Universal Cell Technology-kinetic energy discrimination
USCG	US Coast Guard
Windward	Windward Environmental LLC

Contractor Signature Sheet

Sampling and Analysis Plan

Terminal 91 Submerged Lands Area Preliminary Investigation

Terminal 91, Seattle Washington

By signing below, I acknowledge that I have reviewed the Sampling and Analysis plan and agree to follow the methods and quality assurance procedures contained therein.

_____ **Date**_____

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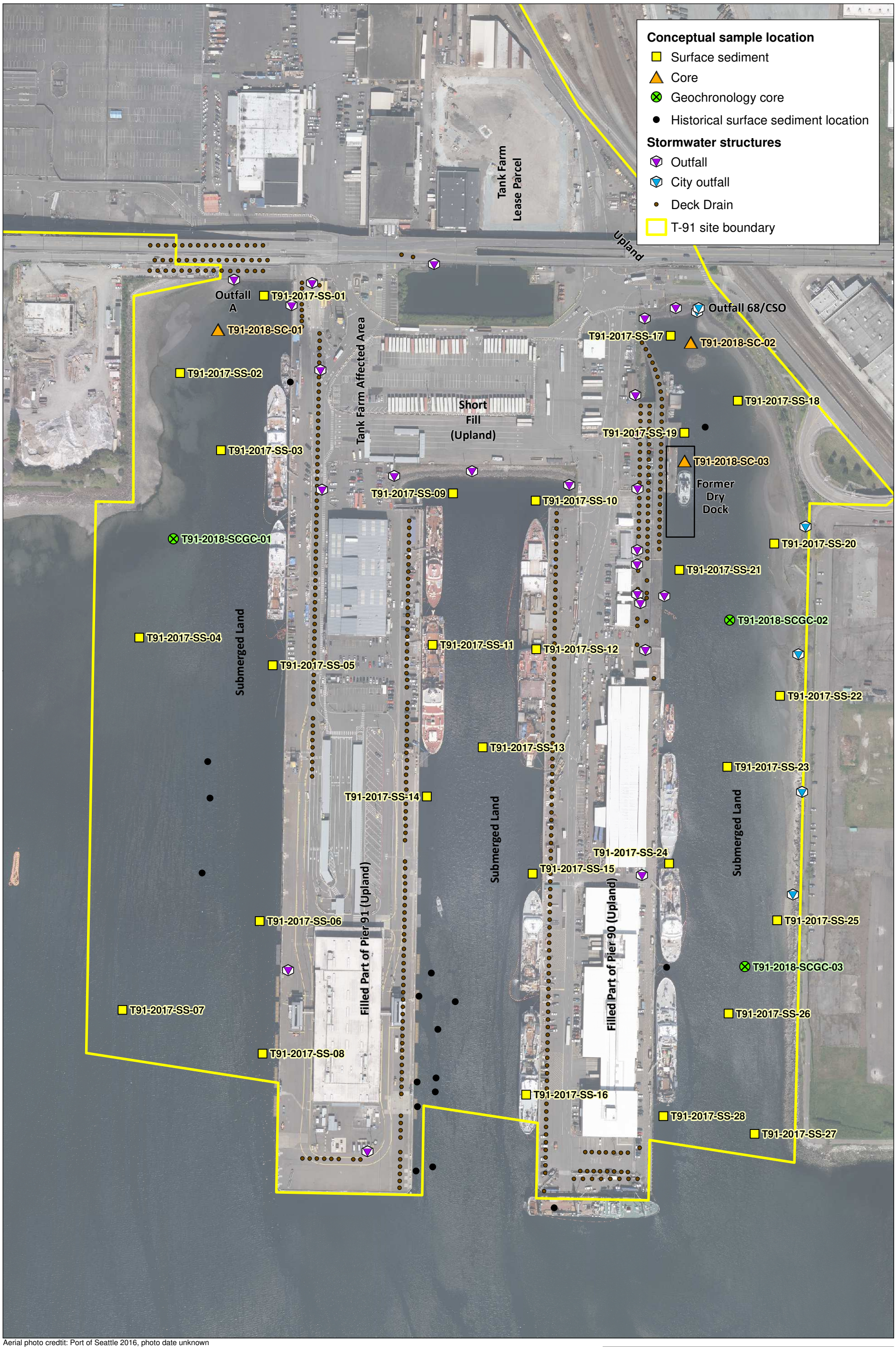
1 Introduction

This sampling and analysis plan (SAP) for the Port of Seattle's (Port) Terminal 91 (T-91) is required under Section VII(B) Task 2 of Amendment 1 to Washington State Department of Ecology (Ecology) / Port of Seattle Agreed Order No. DE8938. The *T-91 Historical Review Report* (Windward 2017) provides the basis for the development of this plan. Additional sediment chemistry data are needed to address potential releases to the Submerged Lands Area (SLA).

This plan addresses project management responsibilities; sampling and analytical procedures; assessment and oversight; and data reduction, validation, and reporting. Field collection forms are provided in Appendix A. The field work will follow the health and safety procedures outlined in the health and safety plan which is provided as Appendix B.

1.1 SITE DESCRIPTION

T-91 is an approximately 210-ac property owned by the Port, located at 2001 West Garfield Street in the Interbay neighborhood of Seattle, Washington. The property consists of an upland area, two piers (Piers 90 and 91), and about 35 ac of submerged lands around the piers (i.e., SLA) (Map 1).



Aerial photo credtit: Port of Seattle 2016, photo date unknown

Windward environmental LLC

N

0 50 100 Yards

0 50 100 Meters

Map 1. T-91 proposed sediment sampling locations

Prepared by craigh, 8/14/2017; W:\Projects\Port of Seattle - T91 Sediment Investigation\GIS\Maps and Analyses\Sampling and Analysis Plan\Map 1 6541 Proposed locations.mxd

T-91 supports marine enterprises such as a cruise ship terminal; cargo handling facilities for high-value, high-employment commodities (e.g., fish products); a factory trawler homeport and support facility; a seafood processing plant, distribution, and major cold storage warehouses; an industrial marine fuel distribution facility; and short- and long-term moorage for tugs, barges, and other large vessels.

The T-91 area was formerly the Seattle Naval Supply Depot and was used by US Navy vessels during World War II. This facility was not used as an ammunition resupply facility, and there are no records of live-fire actions ever occurring at this site. However, during a regular underwater inspection of the facility by the Port Police Department, military munitions were found in the sediments in April 2010. That same year, the US Army Corps of Engineers initiated the Piers 90 and 91 remedial investigation, conducted extensive mapping of the area, and removed all identified munitions. The field personnel who will perform sampling in the SLA have been made aware of the potential presence of munitions; safety protocols have been developed in the event that munitions are present in the sediment samples collected.

1.2 PREVIOUS SEDIMENT TESTING

The sediment chemistry available for the T-91 SLA is limited. Sediment investigations have been conducted in the vicinity of T-91 for the purposes of dredged material characterization, post-dredge characterization, and Elliott Bay monitoring programs. None of the investigations were designed to characterize the sediment throughout the SLA of T-91. Sediment dredging and regrading was conducted to maintain adequate depth to accommodate cruise ships. Sediment was dredged in the berth west of Pier 91 in 1991 and in late fall 2007 / early winter 2008. The berth east of Pier 91 was regraded from February 6 through 8, 2016. Previous sediment investigations are described in the *T-91 Historical Review Report* (Windward 2017). The available surface sediment data exceed the Washington State Sediment Management Standards (SMS) criteria for some contaminants, including polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and metals.

2 Project Team and Responsibilities

The overall project organization and individuals responsible for implementing the work elements presented in this SAP are described below.

The Port will be ultimately responsible for the implementation of the project. Windward Environmental LLC (Windward) will be responsible for sample collection, laboratory coordination, appropriate quality assurance / quality control (QA / QC) review, and preparing the final sampling and analysis report. Susan McGroddy will be Windward's project manager, responsible for implementation of this SAP.

Thai Do will be the Windward field coordinator (FC), responsible for day-to-day technical and QA / QC oversight. He will ensure that appropriate protocols for sample collection, preservation, and holding times are observed, and will submit environmental samples to the designated laboratory for chemical and physical analyses.

Amara Vandervort of Windward will serve as the QA / QC manager for the project providing oversight for both the field sampling and laboratory programs. She will also serve as the laboratory coordinator for chemical analyses, confirming that samples are collected and documented appropriately, coordinating with the analytical laboratories, ensuring data quality, overseeing data validation, and supervising project QA coordination.

Independent third-party data review and validation will be performed by EcoChem, Inc. (EcoChem). Analytical Resources, Inc. (ARI) will perform all chemical and geotechnical analyses of the sediment samples.

The analytical testing laboratory will be responsible for the following:

- Perform the methods outlined in this plan, including those methods referenced for each analytical procedure.
- Follow documentation, custody, and sample logbook procedures.
- Implement QA / QC procedures required by the Puget Sound Estuary Program (PSEP) (1986, 1997a, b, c).
- Meet all reporting requirements.
- Deliver electronic data deliverables (EDDs) as specified in this plan.
- Meet turnaround times for deliverables as described in this plan.

Project personnel can be reached as follows:

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3 Conceptual Sediment Investigation Scheme

The sampling and analysis program has been developed based on the *T-91 Historical Review Report* (Windward 2017). As described therein, the pathways most likely to have impacted the SLA are stormwater discharge from T-91 storm drains and the municipal outfalls located in the vicinity of T-91, and the release of contaminants associated with overwater activities. The sediment chemistry available for the T-91 SLA is limited. The available surface sediment data exceed the SMS criteria for some contaminants, including PCBs, PAHs, and metals.

The objective this preliminary investigation is to provide sufficient sediment data to:

1) Characterize surface sediment contaminant concentrations throughout the SLA.
2) Characterize subsurface sediment contaminant concentrations in areas associated with potential historical sources of contamination to the SLA.
3) Characterize sedimentation rates.

Sampling will be conducted using a phased approach. Phase 1 will include surface sediment collection and analysis. Phase 2 will include the collection and analysis of sediment cores. All sampling locations are provided on Map 1. Based on the results of the surface sediment sampling and analysis from Phase 1, the final sediment core locations will be identified. All of the proposed samples will be analyzed as individual samples. No compositing is proposed.

3.1 SURFACE SEDIMENT (PHASE 1)

Surface sediment grab samples will be collected at 28 locations in order to characterize sediment contaminant concentrations throughout the SLA (Map 1). Surface sediment samples will be taken from a sediment depth from 0 to 10 cm and will be analyzed for SMS chemicals, grain size, and total organic carbon (TOC). The surface sediment results will be compared to SMS criteria in order to characterize the contaminant concentrations. Surface sediment data will be evaluated to determine if additional sediment cores may be useful in further characterizing contaminant concentrations throughout the SLA.

3.2 SEDIMENT CORES (PHASE 2)

Three core locations have been identified within the SLA. Two sediment cores (T91-20187-SC-01 and T91-2018-SC-02) will be collected in the vicinity of outfalls/combined sewer overflows (CSOs). One sediment core (T91-2018-SC-03) will be collected in an area where a former dry dock was located.

At each location, single cores (up to 3 m [10 ft] deep or until refusal, whichever is reached first) will be collected. Each core will be divided into a maximum of six intervals (i.e., 0–1, 1–2, 2–4, 4–6, 6–8, and 8–10 ft, depending on the length of core

recovered). Samples from the first three intervals (0–1, 1–2, and 2–4 ft) will be submitted for initial chemical analyses. Samples collected from the lower three depth intervals (4–6, 6–8, and 8–10 ft) will be archived. The selection of archived samples from the lower three depth intervals for additional analyses will be determined in consultation with Ecology based on a review of the data for the first three depth intervals. Factors that will be considered in selecting archived samples for chemical analyses will include the exceedance of SMS criteria in the upper intervals or in nearby cores, or the presence of staining / discoloration, sheen, or odor. All sediment core samples will be analyzed for SMS chemicals, grain size, and TOC. The sediment core sample collected from the former dry dock area (T91-2018-SC-03) will also be analyzed for tributyltin (TBT). The final sediment core locations will be determined following review of the results from the surface sediment samples.

3.3 GEOCHRONOLOGICAL CORES (PHASE 2)

Geochronological cores will be collected to obtain estimates of net sedimentation rate, grain size distribution, bulk density, and percent solids at each location. A total of three geochronological cores are proposed (Map 1). These locations were selected based on the following criteria:

- Provide reasonable spatial coverage in the T-91 SLA
- Located in areas that have not been previously dredged (since 1964)
- Not located in areas that are anticipated to have experienced excessive erosion or sediment mixing

Cores will be collected to a maximum depth of 90 cm or until refusal. The cores will be divided into 2-cm section samples. One 2-cm sample from each 6-cm increment will be analyzed, and all other samples from that increment will be archived. Samples will be analyzed for two radioisotopes, Cs-137 and Pb-210, which are commonly used to age-date sediments and establish sedimentation rates. In addition, grain size, TOC content, bulk density, and total solids will be measured. The average sedimentation rates will be calculated for interpretable cores. Excessive mixing or sediment movement may produce complex radioisotope profiles that cannot be used to calculate average long-term sedimentation rates.

4 Field Sampling and Processing

This section presents the sample collection, processing, and handling procedures that will be followed for the T-91 SLA preliminary investigation.

4.1 ANTICIPATED SCHEDULE

SLA sampling will be scheduled to avoid cruise boat traffic. Phase 1 (surface sediment) sampling will occur in October / November 2017. Phase 2 (sediment core) sampling will occur in the spring of 2018.

Chemical analysis of the samples from each sampling event will require approximately four weeks. Data validation will be completed approximately three weeks after receipt of the chemistry data. Ecology will be notified when the final data validation report has been received. Draft data reports will be submitted to Ecology within 45 days of the receipt of final validated data for both the surface sediment samples (Phase 1) and the sediment cores (Phase 2). Final validated data will be submitted to Ecology's Environmental Information Management (EIM) system within 30 days of the approval of the final data report.

4.2 STATION POSITIONING

On the day of sampling, US Coast Guard (USCG) personnel will be contacted and advised that the sampling operations outlined in this SAP will be occurring within their Vessel Traffic Service area. During sampling, VHF-FM channels 13 and 14 will be monitored by Windward staff.

Horizontal positioning will be determined using a differential global positioning system (DGPS) receiver on the sampling vessel. The DGPS will include a global positioning system (GPS) receiver unit affixed to the end of the sampling vessel's deployment boom and a USCG beacon differential receiver. The GPS unit will receive radio broadcasts of GPS signals from satellites, and the USCG beacon receiver will acquire corrections to the GPS signals to accurately determine positioning within 1 to 2 m. The vertical elevation of each core will be measured using a fathometer or lead line, and will be converted to mean lower low water (MLLW) with the National Oceanic and Atmospheric Administration's (NOAA's) tide prediction data from the Seattle tide gauge station. Target coordinates for sampling locations are presented in Table 1. The mudline depths for these locations could not be accurately estimated from the existing bathymetry data.

Table 1. Coordinates for proposed sampling locations

Sample ID	Easting (ft)[a]	Northing (ft)[a]	Longitude (°W)	Latitude (°N)
Surface sediment				
T91-2017-SS-01	1258107	234795	47.63312	-122.384021
T91-2017-SS-02	1257876	234582	47.632524	-122.38494
T91-2017-SS-03	1257988	234369	47.631947	-122.384467

Table 1. Coordinates for proposed sampling locations

Sample ID	Easting (ft)[a]	Northing (ft)[a]	Longitude (°W)	Latitude (°N)
T91-2017-SS-04	1257764	233853	47.630521	-122.385336
T91-2017-SS-05	1258131	233777	47.630332	-122.38384
T91-2017-SS-06	1258095	233072	47.628399	-122.383929
T91-2017-SS-07	1257717	232828	47.627707	-122.385439
T91-2017-SS-08	1258103	232707	47.627398	-122.383867
T91-2017-SS-09	1258627	234251	47.631658	-122.381869
T91-2017-SS-10	1258854	234231	47.631615	-122.380947
T91-2017-SS-11	1258571	233833	47.63051	-122.382063
T91-2017-SS-12	1258856	233821	47.630493	-122.380906
T91-2017-SS-13	1258708	1258708	47.629365	-122.382094
T91-2017-SS-14	1258555	233416	47.629365	-122.382094
T91-2017-SS-15	1258846	233203	47.628798	-122.380896
T91-2017-SS-16	1258828	232594	47.627128	-122.38092
T91-2017-SS-17	1259225	234684	47.632879	-122.379479
T91-2017-SS-18	1259410	234506	47.632399	-122.378715
T91-2017-SS-19	1259263	234417	47.632149	-122.379302
T91-2017-SS-20	1259510	234112	47.631327	-122.378276
T91-2017-SS-21	1259249	234040	47.631114	-122.379328
T91-2017-SS-22	1259526	233693	47.630178	-122.378177
T91-2017-SS-23	1259381	1259381	47.628895	-122.379376
T91-2017-SS-24	1259221	233231	47.628895	-122.379376
T91-2017-SS-25	1259518	233074	47.628483	-122.378159
T91-2017-SS-26	1259384	1259384	47.628483	-122.378159
T91-2017-SS-27	1259456	232486	47.626867	-122.378364
T91-2017-SS-28	1259205	232535	47.626988	-122.379385
Sediment cores				
T91-2018-SC-01	1257980	234701	47.632856	-122.384527
T91-2018-SC-02	1259280	234666	47.632831	-122.379253
T91-2018-SC-03	1259263	234339	47.631936	-122.379298
Geochronological cores				
T91-2018-SCGC-01	1257858	234125	47.631271	-122.384977
T91-2018-SCGC-02	1259388	233901	47.630741	-122.378755
T91-2018-SCGC-03	1259429	232947	47.628128	-122.378508

[a] Washington North Zone, NAD83 geographic and state plane coordinates – US survey feet.

ID – identification

NAD83 – North American Datum of 1983

4.3 SURFACE SEDIMENT SAMPLING

Surface sediment collection and processing will follow standardized procedures for the Puget Sound area that have been developed by the PSEP (1997b). Surface sediments will be collected at each location using a pneumatic power grab sampler from a sampling vessel. The 0–10-cm sediment interval will be collected to represent the biologically active horizon.

The surface sediment samples will be collected as described in the following steps:

1. Using GPS, maneuver the sampling vessel to the approximate pre-identified sampling location.
2. Open the grab sampler jaws into the deployment position.
3. Guide the sampler overboard until it is clear of the vessel.
4. Using GPS, position the sampling vessel such that the GPS receiver, mounted on the winch arm directly over the grab sampler, is within 1–2 m of the intended sampling location.
5. Lower the sampler through the water column to the bottom at approximately 0.3 m/s.
6. Record the GPS location of the boat when the sampler reaches bottom.
7. Record the water depth and time.
8. Retrieve the sampler and raise it at approximately 0.3 m/s.
9. Guide the sampler aboard the vessel and place it on the work stand on the deck, using care to avoid jostling that might disturb the integrity of the sample.
10. Examine the sample using the following sediment acceptance criteria:
    - Sediment is not extruded from the upper face of the sampler.
    - Overlying water is present (indicating minimal leakage).
    - The sediment surface is relatively flat (indicating minimal disturbance or winnowing).
    - A penetration depth of at least 11 cm is achieved.

If these sample acceptance criteria are not achieved, the sample will be rejected. If an acceptable grab sample cannot be obtained in three attempts, the target sampling location will be moved as close as possible to the original location. If the station location needs to be moved more than 10 ft from the original location, then Ecology will be notified to approve the new sampling location.

After sample acceptance, the following observations will be noted on the Surface Sediment Collection Form (Appendix A, Form 1) or in the field logbook:

- GPS location
- Depth as read by the boat's depth sounder or lead line
- Gross characteristics of the surficial sediment including texture, color, biological structures, odor, and presence of debris or oily sheen
- Gross characteristics of the vertical profile (i.e., changes in sediment characteristics and redox layer, if visible)
- Maximum penetration depth (nearest 0.5 cm)
- Comments relative to sample quality

Any deviations from the approved sampling plan will be noted on a Protocol Modification Form (Appendix A, Form 2).

4.4 SEDIMENT CORE COLLECTION

4.4.1 Chemistry cores

Subsurface sampling will be conducted using a vibracorer deployed from the research vessel *Carolyn Dow*, which is owned and operated by Research Support Services. The RIC-3500 vibracoring system consists of a vibrating power head attached to a 6-ft-long, 4-in.-diameter core barrel with a check valve and core catcher to create suction and retain sediment within the core tube. Sediment core samples will be collected according to the following procedures:

1. Maneuver the sampling vessel to the proposed sampling location.
2. Deploy the vibracorer and a decontaminated core tube.
3. Collect continuous core samples to a depth of 10 ft or until refusal.
4. Measure and record the depth of core penetration. Measure the depth of the drive from the sediment surface to refusal depth using a lead line attached to the vibracoring unit.
5. Extract the sample core tube and retrieve the assembly aboard the vessel or on land.
6. Evaluate the core sample at the visible ends of the core tube to verify retention of the sediment in the core tube. If the sediment core is acceptable (see criteria below), begin processing the core on the boat.

Sediment core logging and processing will be done on the boat. Acceptance criteria for a sediment core sample are as follows:

- Material is collected to an acceptable depth.
- Recovery (determined by measuring the headspace and subtracting that measurement from the length of the core tube upon retrieval) is greater than 75%.
- The core tube appears to be intact without obstructions or blocking.

If sample acceptance criteria are not achieved, the sample will be rejected. If repeated deployment (i.e., maximum three attempts) as close as possible to the original location does not result in a sample that meets the appropriate acceptance criteria, a different sampling location may be selected based on consultation and coordination with the Port and Ecology.

4.4.2 Geochronological cores

Geochronological cores will be collected using a diver-operated hammer corer with a 4-in. (outer diameter) steel core tube and a butyl acetate (or polycarbonate) core tube liner. The hammer corer will be supported by a piston line that is drawn tight and secured to the sampling vessel and will be manually advanced by the diver into the sediment to achieve the target penetration depth of 90 cm (with a minimum penetration of 78 cm), or to refusal.

4.4.3 Field documentation

Logs and field notes of all core samples will be maintained as samples are collected and correlated to the sampling location map. The following information will be included:

- Water depth and tide elevation at the time of sampling for each sediment core location relative to MLLW
- Location of each sediment core as determined using DGPS measurements
- Date and time of collection of each sediment core
- Names of field supervisor and person(s) collecting and logging the sample
- Observations made during sample collection, including weather conditions, complications, ship traffic, and other details associated with the sampling effort
- The core identification (ID) (see Section 5.2)
- Depth of sediment recovered using the vibracorer or hammer corer
- Any deviations from the approved sampling plan on a Protocol Modification Form (Appendix A, Form 2)

Additionally, photographs of sediment cores will be taken with a digital camera.

4.5 SEDIMENT SAMPLE PROCESSING AND HANDLING PROCEDURES

This section describes the equipment decontamination procedures, sample containers, and processing procedures.

4.5.1 Equipment decontamination procedures

Sample containers, instruments, working surfaces, technician protective gear, and other items that may come into contact with sediment sample material must meet high standards of cleanliness. All equipment and instruments that come into direct contact with the sediment collected for analysis must be made of glass, stainless steel, or polycarbonate, and will be cleaned prior to each day's use and between sampling or compositing events. Decontamination of all items will follow PSEP protocols. The decontamination procedure is as follows:

1. Pre-wash and rinse the item with site or tap water.
2. Wash the item with a solution of site or tap water and Alconox® soap (brush).
3. Rinse the item with site or tap water.
4. Rinse the item with distilled water.
5. Cover (no contact) all decontaminated items with aluminum foil.
6. Store the item in a clean, closed container for next use.

4.5.2 Sample containers for analysis

The laboratory will provide certified, pre-cleaned, US Environmental Protection Agency (EPA)-approved containers for all samples. Prior to shipping, the analytical laboratory will add preservative, as required, according to PSEP protocols.

4.5.3 Sample processing procedures for surface sediment

All working surfaces and instruments will be thoroughly cleaned, decontaminated, and covered with aluminum foil to minimize outside contamination between sampling events. Disposable gloves will be discarded after processing the samples at each sampling location, and new gloves will be put on prior to handling decontaminated instruments or work surfaces.

Sample containers (i.e., jars and bottles) will be kept in the original packaging as received from the analytical laboratory (i.e., coolers and / or boxes) until they are used to collect the samples; a sample container will be removed from the original packaging only when a sample is to be collected and placed within. The container will immediately be labeled and placed in a sturdy, plastic cooler containing ice and / or frozen gel packs.

The steps for processing the samples are as follows:

1. Record a description of the grab samples on Form 1 (Appendix A) for surface sediment; note the following parameters, as appropriate:
   - Elevation of bed at sampling location
   - Penetration depth
   - Sediment color, density, consistency, and stratification
   - Odor (e.g., hydrogen sulfide, petroleum)
   - Vegetation
   - Debris
   - Biological activity (e.g., detritus, shells, tubes, bioturbation, live or dead organisms)
   - Presence of oil sheen
   - Any other distinguishing characteristics or features
2. Transfer material that will make up the sample for laboratory analysis into a single clean stainless steel bowl and homogenize until textural and color homogeneity are achieved.
3. Using a clean stainless steel spoon, completely fill pre-labeled sample containers (see Section 5) for the remaining analyses.
4. Thoroughly check all sample containers for proper identification, analysis type, and lid tightness.
5. Pack each container carefully to prevent breakage, and place it inside a cooler with ice or frozen gel packs for storage at the proper temperature (0 to 6°C for all samples).
6. Return excess sediment to the sampling location.

4.5.4 Sample processing procedures for sediment cores

Sediment core processing for chemistry and geochronology will be performed on the boat. All working surfaces and instruments will be thoroughly cleaned, decontaminated, and covered with aluminum foil to minimize outside contamination between sampling events. Disposable gloves will be discarded after processing at each sampling location, and new gloves will be put on prior to handling decontaminated instruments or work surfaces.

Sample containers (i.e., jars and bottles) will be kept in the original packaging as received from the analytical laboratory (i.e., coolers and/or boxes) until they are used to collect the samples; a sample container will be removed from the original packaging only when a sample is to be collected and placed within. The container will immediately be labeled and placed in a sturdy, plastic cooler containing ice and/or frozen gel packs.

The steps for processing the samples are as follows:

1. Carefully cut along the butyl acetate or polycarbonate core liner to expose the sediment core for processing.
2. Each core will be sliced into target depth intervals as described in Sections 3.2 (sediment chemistry cores) and 3.3 (geochronology cores).
3. Record a description of each core on the log form (Appendix A, Form 3); note the following parameters, as appropriate:
   - Elevation of bed at sampling location
   - Penetration depth
   - Length of recovered core (in inches)
   - Sediment core sample depth intervals and excess material
   - Sediment color, density, consistency, and stratification
   - Odor (e.g., hydrogen sulfide, petroleum)
   - Vegetation
   - Debris
   - Biological activity (e.g., detritus, shells, tubes, bioturbation, live or dead organisms)
   - Presence of oil sheen
   - Any other distinguishing characteristics or features
4. Place the collected sediment samples into separate stainless steel containers, homogenize, label, subsample for archive, and store on ice.
5. Using a clean stainless steel spoon, completely fill pre-labeled sample containers, as indicated in Section 5.1, for the remaining analyses.
6. For geochronology cores, weigh the sediment sample collected from the core section in a tared sample container and record the weight.
7. Thoroughly check all sample containers for proper identification, analysis type, and lid tightness.
8. Pack each container carefully to prevent breakage, and place it inside a cooler with ice or frozen gel packs for storage at the proper temperature (0 to 6°C for all samples).

4.6 SURFACE SEDIMENT FIELD QUALITY ASSURANCE SAMPLES

Field duplicate surface sediment samples will be collected to evaluate variability attributable to sample homogenization and subsequent sample handling. Field duplicate samples will be collected from the same homogenized material as the original sample and analyzed as a separate sample; this type of field QA / QC sample is also

referred to as a field split sample (PSEP 1997b). A minimum of 1 field duplicate will be analyzed for each 20 samples.

Although data validation guidelines have not been established for field QC samples, the data resulting from the analyses of these samples is useful in identifying possible problems caused by sample collection or processing in the field. All field QC samples will be documented in the field logbook and verified by the project QA / QC manager or a designee.

4.7 SAMPLE TRANSPORT AND CHAIN-OF-CUSTODY PROCEDURES

Following sample processing, samples will be transferred into ARI's custody. Specific sample transport procedures are as follows:

1. Each container with the sediment samples will be delivered to ARI or to the Windward storage area within 24 hours of being sealed.
2. A sufficient amount of ice, double-bagged in sealed plastic bags, or frozen gel packs will be placed within the container. Chain-of-custody forms will be enclosed in a sealed plastic bag and taped to the inside lid of the container.
3. Signed and dated chain-of-custody seals will be placed on all containers prior to shipping.

The persons who transfer custody of the sediment sample containers and archival samples will sign the chain-of-custody form upon transfer of sample possession to the analytical laboratory. The shipping container seal will be broken upon receipt of samples at the laboratory, at which time the receiver will record the condition of the samples. Chain-of-custody procedures will be used internally by the laboratory to track sample handling and final disposition.

5 Chemical/Conventional Analyses

Laboratory methods, QA / QC procedures, laboratory sample handling, and data quality indicators (DQIs) for the sediment samples collected for chemistry testing are described in this section.

5.1 METHODS AND SAMPLE HANDLING

Surface sediment and sediment chemistry core samples will be analyzed for all SMS chemicals of concern (COCs), TOC, grain size, and total solids. One sediment chemistry core (T91-2018-SC-03) will also be analyzed for TBT. Geochronology cores will be analyzed for Cs-137 and Pb-210, TOC, grain size, bulk density, and total solids. Table 2 summarizes the parameters for analysis, analysis methods, and target reporting limits for the collected sediment samples. The surface sediment and sediment chemistry results will be compared to SMS criteria. All samples will be maintained according to the appropriate holding times and temperatures for each analysis, as presented in Table 3.

Table 2. SMS criteria, analysis methods, and target detection limits

Parameter	Unit	SMS Criteria		Analysis Method	Target Reporting Limit[a,b]
		SCO	CSL		
Conventional Parameters					
TOC	%	nc	nc	Plumb 1981 Combustion IR	0.02
Grain size	%	nc	nc	PSEP 1986	0.1
Total solids	%	nc	nc	SM 2540 G-97	0.04
Metals					
Arsenic	mg/kg dw	57	93	EPA 6020A UCT-KED	0.2
Cadmium	mg/kg dw	5.1	6.7	EPA 6020A UCT-KED	0.1
Chromium	mg/kg dw	260	270	EPA 6020A	0.5
Copper	mg/kg dw	390	390	EPA 6020A UCT-KED	0.5
Lead	mg/kg dw	450	530	EPA 6020A	0.1
Mercury	mg/kg dw	0.41	0.59	EPA 7471B	0.025
Silver	mg/kg dw	6.1	6.1	EPA 6020A	0.2
Zinc	mg/kg dw	410	960	EPA 6020A UCT-KED	4
Organometals					
TBT (bulk sediment)	µg/kg dw	nc	nc	EPA 8270-SIM	3.9
Organics					
Total LPAH	µg/kg dw	370 mg/kg OC	780 mg/kg OC	EPA 8270D (calculated)	20 (2 mg/kg OC)
Naphthalene	µg/kg dw	99 mg/kg OC	170 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
Acenaphthylene	µg/kg dw	66 mg/kg OC	66 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
Acenaphthene	µg/kg dw	16 mg/kg OC	57 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
Fluorene	µg/kg dw	23 mg/kg OC	79 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
Phenanthrene	µg/kg dw	100 mg/kg OC	480 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
Anthracene	µg/kg dw	220 mg/kg OC	1,200 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
2-Methylnaphthalene[c]	µg/kg dw	38 mg/kg OC	64 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
Total HPAHs	µg/kg dw	960 mg/kg OC	5,300 mg/kg OC	EPA 8270D (calculated)	20 (2 mg/kg OC)
Fluoranthene	µg/kg dw	160 mg/kg OC	1,200 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)

Table 2. SMS criteria, analysis methods, and target detection limits, cont.

Parameter	Unit	SMS Criteria		Analysis Method	Target Reporting Limit[a,b]
		SCO	CSL		
Pyrene	µg/kg dw	1,000 mg/kg OC	1,400 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
Benzo(a)anthracene	µg/kg dw	110 mg/kg OC	270 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
Chrysene	µg/kg dw	110 mg/kg OC	460 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
Total benzofluoranthenes	µg/kg dw	230 mg/kg OC	450 mg/kg OC	EPA 8270D (calculated)	40 (4 mg/kg OC)
Benzo(a)pyrene	µg/kg dw	99 mg/kg OC	210 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
Indeno(1,2,3-cd)pyrene	µg/kg dw	34 mg/kg OC	88 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
Dibenz(a,h)anthracene	µg/kg dw	12 mg/kg OC	33 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
Benzo(g,h,i)perylene	µg/kg dw	31 mg/kg OC	78 mg/kg OC	EPA 8720D	20 (2 mg/kg OC)
Chlorinated Hydrocarbons					
1,2-Dichlorobenzene	µg/kg dw	2.3 mg/kg OC	2.3 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
1,2,4-Trichlorobenzene	µg/kg dw	0.81 mg/kg OC	1.8 mg/kg OC	EPA 8270D-SIM	5 (0.5 mg/kg OC)
1,4-Dichlorobenzene	µg/kg dw	3.1 mg/kg OC	9 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
Hexachlorobenzene	µg/kg dw	0.38 mg/kg OC	2.3 mg/kg OC	EPA 8081B	1 (0.1 mg/kg OC)
Phthalates					
Dimethyl phthalate	µg/kg dw	53 mg/kg OC	53 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
Diethyl phthalate	µg/kg dw	61 mg/kg OC	110 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
Di-n-butyl phthalate	µg/kg dw	220 mg/kg OC	1,700 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
Butyl benzyl phthalate	µg/kg dw	4.9 mg/kg OC	64 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
Bis(2-ethylhexyl) phthalate	µg/kg dw	47 mg/kg OC	78 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
Di-n-octyl phthalate	µg/kg dw	58 mg/kg OC	4,500 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
Phenols					
Phenol	µg/kg dw	420	1,200	EPA 8270D	20
2-Methylphenol	µg/kg dw	63	63	EPA 8270D	20
4-Methylphenol	µg/kg dw	670	670	EPA 8270D	20
2,4-Dimethylphenol	µg/kg dw	29	29	EPA 8270D-SIM	25
Pentachlorophenol	µg/kg dw	360 mg/kg OC	690 mg/kg OC	EPA 8270D	100 (10 mg/kg OC)
Other SVOCs					
Benzyl alcohol	µg/kg dw	57	73	EPA 8270D	20

Table 2. SMS criteria, analysis methods, and target detection limits, cont.

Parameter	Unit	SMS Criteria		Analysis Method	Target Reporting Limit[a,b]
		SCO	CSL		
Benzoic acid	µg/kg dw	650	650	EPA 8270D	200
Dibenzofuran	µg/kg dw	15 mg/kg OC	58 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
Hexachlorobutadiene	µg/kg dw	3.9 mg/kg OC	6.2 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
n-Nitrosodiphenylamine	µg/kg dw	11 mg/kg OC	11 mg/kg OC	EPA 8270D	20 (2 mg/kg OC)
Total PCB Aroclors	**µg/kg dw**	**12 mg/kg OC**	**65 mg/kg OC**	**EPA 8082A**	**20 (2 mg/kg OC)**
Geochronology[d]					
Pb-210	piC/g dw	nc	nc	HASL-300 by gamma spectroscopy	0.2 piC/g dw
Cs-137	piC/g dw	nc	nc	HASL-300 by gamma spectroscopy	0.2 piC/g dw

[a] Actual reporting limits will vary based on the amount of sample analyzed, the analytical dilution, and the percent solids of the sample.

[b] Non-normalized reporting limits were converted to OC-normalized values using 1% TOC.

[c] 2-Methylnapthalene is not included in the sum of LPAHs.

[d] Only for geochronology sediment core samples.

CSL – cleanup screening level
dw – dry weight
EPA – US Environmental Protection Agency
HASL – Health and Safety Laboratory
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
nc – no criteria
OC – organic carbon
PCB – polychlorinated biphenyl
PSEP – Puget Sound Estuary Program
SCO – sediment cleanup objective
SIM – selected ion monitoring
SMS – Washington State Sediment Management Standards
SVOC - semivolatile organic compound
TBT – tributyltin
TOC – total organic carbon
UCT-KED – Universal Cell Technology-kinetic energy discrimination

Table 3. Guidelines for sample handling and storage of sediment samples

Parameter	Holding Time	Preservative	Sample Size	Container Size and Type[a]
TOC	14 days	cool/0 to 6ºC	25 g	8-oz glass
	6 months	freeze, -18ºC		
Total metals	6 months; mercury sample must be frozen	cool/0 to 6ºC	5 g	
	2 years; 28 days for mercury	freeze, -18ºC		
SVOCs and PCBs	14 days until extraction	cool/0 to 6ºC	100 g	16-oz glass
	1 year until extraction	freeze, -18ºC		
	40 days after extraction	cool/0 to 6ºC, or freeze, -18ºC		
Archive material[b]	na	freeze, -18ºC	na	8-oz glass
Pb-210 and Cs-137	1 year	none	50 g (dw)	16-oz polypropylene

[a] All sample containers will have lids with Teflon® inserts.

[b] Material from the individual samples will be archived, as possible.

dw – dry weight

na – not applicable

PCB – polychlorinated biphenyl

SVOC – semivolatile organic compound

TOC – total organic carbon

5.2 QUALITY ASSURANCE/QUALITY CONTROL AND DATA QUALITY INDICATORS

The frequency of analysis for laboratory QA / QC samples is summarized in Table 4. Project-specific data quality objectives are summarized in Table 5. All reporting limits must be below the SMS screening levels. When analyzing semivolatile organic compounds (SVOCs), PCBs, metals and conventional parameters, initial calibrations will be required before any samples are analyzed, after each major disruption of equipment, and when ongoing calibration fails to meet acceptance criteria. Ongoing calibration will be required before and after the collection of every 10 samples or every 12 hours (depending on the test method).

Table 4. Laboratory QA/QC sample analysis summary

Analysis Type	Initial Calibration	Initial Calibration Verification (second source)	Continuing Calibration Verification	CRM[a]	LCS	Laboratory Replicate[b]	MS[c]	MSD[c]	Method Blank	Surrogate Spike
TOC	prior to analysis	after initial calibration	1 per 10 samples	1 per 20 samples – NIST 1941B	1 per batch or SDG	1 per batch or SDG[d]	1 per batch or SDG	na	1 per prep batch	na
Metals	prior to analysis and as needed[e]	after initial calibration	1 per 10 samples	1 per 20 samples – ERA DO95-540	1 per batch or SDG	1 per batch or SDG	1 per batch or SDG	na	1 per prep batch	na
TBT	prior to analysis and as needed[e]	after initial calibration	prior to each 12-hr analytical batch	1 per 20 samples – PACS-2	1 per batch or SDG	na	1 per batch or SDG	1 per batch or SDG	1 per prep batch	every sample
Semivolatile organics	prior to analysis and as needed[e]	after initial calibration	prior to analytical batch, 1 per 10-20 samples, or every 12 hours	1 per 20 samples – CRM-143	1 per batch or SDG	na	1 per batch or SDG	1 per batch or SDG	1 per prep batch	every sample
PCBs[f]	prior to analysis and as needed[e]	after initial calibration	prior to analytical batch, 1 per 10-20 samples, or every 12 hours	1 per 20 samples – CRM-911	1 per batch or SDG	na	1 per batch or SDG	1 per batch or SDG	1 per prep batch	every sample
Pb-210 and Cs-137	prior to analysis and as needed[e]	after initial calibration	prior to each 12-hr analytical batch	na	1 per batch or SDG	1 per batch or SDG	na	na	1 per prep batch	na

Note: A batch is a group of samples of the same matrix analyzed or prepared at the same time, not exceeding 20 samples.

[a] An LCS may be used to assess accuracy when a CRM is unavailable.

[b] Laboratory replicate sample(s) will be analyzed only if sufficient sample volume is available. Non-project-specific results may also be available to satisfy this QA/QC requirement.

[c] An LCS duplicate sample may be analyzed in lieu of MS/MSD. Non-project-specific MS/MSD results may also be available to satisfy this QA/QC requirement.

[d] TOC analysis includes a triplicate per batch or SDG.

[e] Initial calibrations are considered valid until the ongoing continuing calibration no longer meets method specifications. At that point, a new initial calibration is performed.

[f] PCBs will have all detects confirmed via second column confirmation. The second column must be of a dissimilar stationary phase from the primary column and meet all method requirements for acceptance. The primary column is considered to be the column that results in the highest value with the least interference. Values should have RPDs less than 40%, or they will be P-flagged as estimated by ARI.

ARI – Analytical Resources, Inc.
CRM – certified reference material
LCS – laboratory control sample
MS – matrix spike
MSD – matrix spike duplicate
na – not applicable
NIST – National Institute of Standards and Technology
PACS – Professional Analytical and Consulting Services
PCB – polychlorinated biphenyl
QA/QC – quality assurance/quality control
RPD – relative percent difference
SDG – sample delivery group
TBT – tributyltin
TOC – total organic carbon

Table 5. Data quality indicators for chemical analyses

Parameter	Precision	Accuracy		Completeness
		CRM/LCS	MS/MSD	
TOC	± 30% CV	75–125%	75–125%	95%
Total metals	± 30% RPD	80–120%	75–125%	95%
TBT	± 30% RPD	30–160%	30–160%	95%
SVOCs	± 35% RPD	50–150%	50–150%	95%
PCBs	± 35% RPD	50–150%	50–150%	95%
Pb-210	≤ 3 RER	75–125%	na	95%
Cs-137	≤ 3 RER	75–125%	na	95%

[a] Values listed are performance-based limits provided by the laboratories.

[b] Values represent a range for all parameters.

CRM – certified reference material
CV – coefficient of variation
LCS – laboratory control sample
MS – matrix spike
MSD – matrix spike duplicate
na – not applicable
PCB – polychlorinated biphenyl
RER – replicate error ratio
RPD – relative percent difference
SVOC – semivolatile organic compound
TBT – tributyltin
TOC – total organic carbon

Surrogates will be required (organics only) for every sample, including matrix spike (MS) samples, blanks, laboratory control samples (LCSs), and certified reference materials (CRMs). MS and matrix spike duplicates (MSDs) will be required for SVOCs, and for PCBs for every 20 samples received or at the request of the client. A MS sample and a laboratory duplicate sample will be analyzed for every 20 samples for metals. Matrix triplicates will be analyzed for conventional parameters (e.g., grain size).

All samples will be diluted and re-analyzed if target compounds are detected at levels that exceed their respective established calibration ranges. Re-analyses will be performed if surrogate or internal standard recoveries exceed the control limits to demonstrate matrix effects. QC samples may be re-analyzed once if results are not within control limits, and it cannot be determined that the sample matrix is the cause.

5.3 LABORATORY DATA REPORT

The laboratory will prepare a detailed report that documents all activities associated with the sample analyses. Included in this report will be:

- **Project Narrative:** This portion of the report will detail the samples received, analyses performed, and corrective actions taken.
- **Chain-of-Custody Documentation:** Chain-of-custody documentation must be available for all samples at all laboratories. The chain-of-custody will document basic sample identifiers such as client and project name, sample name, sample collection date and time, analyses requested, sampler's name or initials, and special instructions.

- **Data Summary Forms:** These forms will include tabular listing of concentrations and reporting limits for all target analytes. The data summary report forms or other supplemental forms will also list other pertinent information, such as amount of sample analyzed, dilution factors, sample processing dates, extract cleanups, and surrogate recoveries.
- **QA Summary:** This portion of the report will include the results of all QC analyses, specifically recovery and precision information. LCSs will be reported with each batch, when applicable, as listed in Table 4. Additional QC analyses will include laboratory replicates, MSs and CRMs.
- **Instrument Calibration Forms and Raw Data:** This portion of the report will include initial and continuing calibration summaries, instrument tuning data for mass spectroscopy analyses, laboratory bench sheets, quantitation reports, chromatograms, preparatory log book pages, and instrument log book pages.

The laboratory will also provide electronic deliverables in standard EDD format as specified by the project QA / QC manager.

5.4 DATA VALIDATION

EcoChem will conduct summary-level data validation, focusing on the results from the analysis of QA / QC samples specified in Table 5.

6 Reporting

Two final reports documenting all activities associated with collecting, transporting, and chemically analyzing sediment samples will be prepared by Windward. One report will include the surface sediment samples and the other report will include the sediment cores. Chemistry data will be provided in EIM format. The chemical laboratory reports will be included electronically on CD-ROM as appendices. The reports will be submitted in both hard copy and electronic formats. At a minimum, the following will be included in the final report:

- Summary of all field activities, including a description of any deviations from the approved SAP and effects of deviations on testing results
- Sampling equipment and protocols used
- Locations of sediment sampling stations in state plane coordinates (North American Datum of 1983 [NAD83]) to the nearest foot, and in latitude and longitude in degrees and minutes to four decimal places; vertical elevations of mudline and water surface to the nearest 0.1 ft relative to MLLW
- Project map with both target and actual sampling locations
- Final QA / QC reports as described in Sections 5.4
- Appendices, including the chemistry data report, validation data report, and all field forms and chain-of-custody documentation
- Data results, including copies of field data and laboratory analysis results; associated QA / QC data and electronic copies of data to be available in a standard EDD format, upon request
- Summary of the comparison of chemical test results with interpretive criteria

7 References

PSEP. 1986. Recommended protocols for measuring conventional sediment variables in Puget Sound. Prepared for the Puget Sound Estuary Program, US Environmental Protection Agency, Region 10. Tetra Tech, Seattle, WA.

PSEP. 1997a. Recommended guidelines for measuring organic compounds in Puget Sound water, sediment and tissue samples. Prepared for Puget Sound Estuary Program, US Environmental Protection Agency Region 10. King County (METRO) Environmental Laboratory, Seattle, WA.

PSEP. 1997b. Recommended guidelines for sampling marine sediment, water column, and tissue in Puget Sound. Prepared for the Puget Sound Estuary Program, US Environmental Protection Agency, Region 10. King County (METRO) Environmental Laboratory, Seattle, WA.

PSEP. 1997c. Recommended quality assurance and quality control guidelines for the collection of environmental data in Puget Sound. Prepared for Puget Sound Estuary Program, US Environmental Protection Agency Region 10. King County (METRO) Environmental Laboratory, Seattle, WA.

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