
2025 Elliott Bay Marine Sediments: Sampling and Analysis Plan



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1 Introduction

Pollutants, such as harmful organic chemicals and metals, enter Puget Sound through a variety of sources, including wastewater, industries, atmospheric deposition, and runoff from urban and agricultural sources. Many chemicals stick to particles in the water and sink, which makes sediment a great record of chemical contamination. Puget Sound sediments trap and can release many of these chemicals, which can make their way up the food chain into the fish that orcas and humans eat. King County (KC) monitors marine sediment chemistry, as part of its Routine Marine Sediment Monitoring Program, to help us better understand what impacts chemical pollution may be having to the bottom of Puget Sound, and how it may be changing due to anthropogenic influences.

This Sampling and Analysis Plan describes the goals, objectives, and study design for the 2025 Elliott Bay Sediment Sampling event, one component of King County's Routine Marine Sediment Monitoring Program.

1.1 Program Background/History

King County (formerly METRO) has collected data on sediment chemistry in the Central Basin of Puget Sound since at least the 1970s. Early sampling targeted sites near specific point sources such as wastewater outfalls and combined sewer overflows (CSO). Starting in 1988, King County began monitoring many of the sediment chemistry parameters that we measure today at routine marine subtidal (offshore) sites located further away from specific point sources¹.

Changes to what became the Routine Marine Sediment Monitoring Program, have occurred over time:

Prior to 2007: Routine samples from subtidal sites were collected roughly annually from the late 1980s until 1996 and biennially between 1996 and 2004. These subtidal monitoring stations were located within Elliott Bay and in the Central Basin of Puget Sound, near the City of Seattle. Sampling sites were located to monitor sediment quality in areas within the general vicinity, but away from the direct impact of potential point-source pollution such as wastewater and stormwater outfalls, as well as near general nonpoint sources such as the Duwamish River. The routine subtidal sediment monitoring was temporarily paused after 2004 (no samples collected 2005-2006) to allow King County staff scientists to evaluate data generated from the program as well as other data collection efforts within the region.

2007-2024: The goal of the refreshed subtidal component of the Routine Marine Sediment Monitoring Program was to use subtidal sediment data to assess the health of the Puget Sound marine environment within King County. These data were also used as a comparative aid to confirm that discharges from the County's wastewater outfalls are not adversely affecting the marine environment. Locations sampled included three different types of sites:

- Elliott Bay stations were selected due to their long data record, location near vessel traffic or industry, or due to recreational use (scuba diving) (sampled every 2 years, most recently in 2023).
- Central Basin stations were selected to represent deep depositional areas away from point sources (sampled every 5 years, most recently in 2022).
- Embayment stations were selected to represent specific areas of interest due to potential anthropogenic impacts (sampled every 5 years with Central Basin stations, most recently in 2022).

¹ While some sites, including Point Jefferson (KSBP01), were sampled before 1988, they were monitored for different parameters than are measured today.

During this period, sediment-dwelling invertebrate community (benthos) analysis was added to help better understand the overall health of Puget Sound's benthic habitat. Initially, in 2015, four sites were sampled in Elliott Bay. The number of sites sampled expanded to all routine monitoring sites starting in 2017².

For more details on the former Routine Marine Sediment Monitoring Program, refer to historical sampling and analysis plans (SAPs), including the most recent for each sampling area (King County, 2022a, 2023).

2025: The most recent update of the program in 2025 (King County, 2025a) focused on making changes that would assist with creating a sediment monitoring program that was more supportive of understanding biological responses to physical and chemical factors. The changes to subtidal sediment monitoring included:

- Discontinuing sampling at some stations
- Adding new stations that corresponded to fish/crab tissue monitoring sites.
- Changing the sampling depth of most stations to the top 10 cm (from 0–2 cm) to characterize the biologically active zone.
- Preserving the ability to track changes over time in surface sediments (0–2 cm) at a subset of sites.
- Dropping specific parameters that were no longer adding value to the program.
- Focusing benthic community monitoring to six sites and sampling these sites annually³.

1.1.1 Problem Definition

Sediments act as a record of chemical contamination in Puget Sound. Sediment chemistry data, compared to Washington State marine Sediment Quality Standards (SQS) of Chapter 173-204 WAC (Ecology, 2013), help us assess the status of sediment quality and identify sites where concentrations of specific chemicals may be harmful to marine benthos. Additionally, due to the link of marine benthos to the rest of the food web, this dataset, paired with fish and crab tissue monitoring, can help us better understand where we have elevated chemical concentrations that may impact people fishing in Elliott Bay.

Data collected with similar methods over long periods of time help us track changes in chemical contamination. These types of data can help us understand if there have been improvements in sediment chemistry and how we might want to focus future efforts such as targeting individual pollutants or increasing treatment/control of wastewater or stormwater.

1.2 Study Area

This sampling and analysis plan focuses on the subtidal Elliott Bay sediment monitoring component of the Routine Marine Sediment Monitoring Program. Elliott Bay is an estuarine system dominated by the marine water of Puget Sound and influenced by the fresh water of the Duwamish Estuary, which discharges into the southeastern corner of the bay. The estuary tidelands, now filled, drained, and dredged, support industrial and port activities both in Elliott Bay and upstream in the Duwamish Estuary. The bay is bordered on the east, north, and south by Seattle neighborhoods, including the downtown area to the east and industrialized Harbor Island in the southeast corner, and on the west by the waters of the Central Basin of Puget Sound.

² KSBP01 Point Jefferson was also sampled decades earlier for benthos, but with lower taxonomic resolution

³ Benthic sampling, since it includes both within and outside of Elliott Bay, will be addressed separately in King County, 2025b.

In addition to industrial and shipping activities, Elliott Bay hosts fishing, boating, scuba diving, and beach activities. As an estuary, it supports a high diversity of fish, invertebrate, bird, and mammal species and acts as a transitory pathway for salmon migrating through the Duwamish Estuary and into the Green River, and for juvenile salmon leaving the river system and entering salt water.

2 Program Description

2.1 Overview

Marine sediment chemistry data collected as part of this program have been useful for identifying areas with sediment contamination issues and for highlighting trends in certain chemicals over time (King County, 2022b). Chemistry and physical data alone can only tell us so much about the status of the benthic habitat and ripple effects it may have to humans.

Starting in 2025, we aim to preserve our ability to detect trends and monitor the status of sediments in Puget Sound as outlined by the primary goals of the program described below. Additionally, we hope to use these data to support other King County monitoring programs in understanding the biological implications of sediment quality. Through these supporting goals, we aim to better understand how sediment chemistry and benthic community composition (King County, 2025b) relate to the food-web via links with zooplankton, juvenile fish, and the seafood from Puget Sound that people eat.

2.2 Program Goals

The program goals stated below are specific to Elliott Bay sediment chemistry monitoring. This list includes primary goals and those that integrate chemistry data with other program data to support an integrated understanding of the health of Puget Sound. All goals for the larger Routine Marine Sediment Monitoring Program, including those for benthos monitoring, can be found in King County, 2025a.

2.2.1 Primary Subtidal Sediment Goals

- Evaluate sediment chemical concentrations relative to the marine Sediment Quality Standards (SQS) of Chapter 173-204 WAC (Ecology, 2013) and compare those concentrations to Puget Sound-wide values.
- Evaluate the spatial and temporal variation of chemical concentrations among monitored sites.

2.2.2 Supporting Subtidal Sediment Goals

- Use information about physical factors, water quality, and sediment chemistry to better understand spatial and temporal differences in the benthic community.
- Use sediment chemistry data (along with other factors) to better understand the potential relationship to fish and crab tissue chemical concentrations and further refine King County's marine tissue chemical exposure model.

2.3 Study Question and Design Overview

This program was designed to answer the following core question: What is the status of sediment chemistry, in terms of chemical concentrations, in Elliott Bay, and how is it changing over time?

To answer this question, we have targeted eight sites with different distances from the shoreline and various point sources. Different sediment sampling depths will be targeted depending on if the site is used for evaluation of current status or trends.

Six of the sites will be sampled for the top 0–10 cm sediment, the biologically active zone, and will be used for evaluating the current status of sediment chemistry. This will be done by comparing sediment

chemistry values to SQS as well as comparing them to concentrations elsewhere in King County and Puget Sound. These data help us understand if and where chemistry-related issues exist that may negatively impact the benthic invertebrate community.

- Five of these sites overlap with marine tissue monitoring locations (King County, 2015, 2018a), and perform a secondary function of informing tissue monitoring results as they related to that program's conceptual model.
- Four of the sites will also be sampled for benthos to help us identify if physical factors and sediment chemistry help explain differences in the benthic community.

Three of the eight sites⁴, which form a rough transect from nearshore to the outer edge of Elliott Bay, will be sampled for the most recently deposited sediments (0–2 cm) and will be used for long-term trend analysis. These sites each have 30+ years of sampling data targeting the same sampling depth.

Because we can't sample every location in Puget Sound, status and trends results will only be applicable for the locations sampled. The transect, which extends from near the shoreline to the western edge of the Bay, will help us better understand how sediment chemistry profiles change with distance from the shore and potential sources of pollution.

2.4 Program Objectives

We will document the physical and chemical condition of sediment characteristics at each sampling location in Elliott Bay. Measuring the concentrations of chemicals of concern, including comparing them to SQS (see [Appendix A](#)), will help us understand if those chemicals are a potential problem to animals interacting with the sediment.

Additionally, at a subset of sites, we will use data on physical and chemical sediment characteristics to inform our understanding of how these chemicals affect the benthic community as well as fish and crab tissue concentrations at co-located sites.

Analyzing trends in chemical concentrations at a subset of long-term monitoring sites can help us identify if chemical concentrations have changed.

At co-located benthos and tissue monitoring sites, we will evaluate how the benthic community or tissue chemistry relate to physical or chemical conditions in the sediments.

Together, this information will allow us to provide rigorous scientific data to environmental managers, tribes, scientists, and the public. These results can help inform policy makers/managers who are making decisions related to the reduction of chemicals in the environment and in fish/crab tissue. Information on trends will inform us if efforts to reduce chemicals in wastewater and stormwater, or enacted policy/legislation around reducing chemicals, have had a generally positive impact on Puget Sound.

2.5 Information Needs and Sources

Existing data, collected by King County's Routine Marine Sediment Monitoring Program, will be used to answer the questions outlined in Section 2.3. These data include physical and chemical data collected by King County (formerly Metro) from as far back as 1988 for long-term monitoring sites. These data are available through King County's Open Data Platform (<https://data.kingcounty.gov/d/s9uc-py3h>) and can also be found in the Washington department of Ecology's (Ecology) Environmental Information Management System (EIM) database (<https://apps.ecology.wa.gov/eim/search/default.aspx>).

⁴ One of these three, located near the Seattle Waterfront, will also be sampled for the top 0–10 cm for current status assessment.

Benthos data, collected from four co-located benthos sites will be essential for understanding the link between the physical and chemical characteristics of the sediment, and the benthic community it supports. These data will be collected annually in late May or early June, near the time of subtidal sediment chemistry sampling (King County, 2025b). Reviewed benthos data from King County’s Open Data Platform (<https://data.kingcounty.gov/d/er5r-bf3q>) will be used for analysis.

Washington State Department of Ecology also collects Puget Sound sediment chemistry and benthos data as part of their Puget Sound Sediment Monitoring Program (Ecology, 2023). While this data is not needed to meet the goals of our program, these data can supplement ours and provide context to patterns we see in our data. These data can be accessed through Ecology’s EIM database.

Additionally, we will be sharing sediment chemistry data with King County’s Toxicology and Contaminant Assessment Unit. Sediment data, along with English sole and crab tissue data collected by that team (King County, 2015, 2018a), will be compared and analyzed to help update the County’s marine tissue chemical exposure model.

2.6 Required Resources and Risks

Sampling is conducted with a dual van Veen grab sampler. Samples must be collected from a vessel with a hydraulic winch system that has enough line to reach the prescribed sampling depth and can extract the sampler from the sediment once a grab is collected.

Funding for this work is provided through operational transfer funds from the Wastewater Treatment Division to the Science and Technical Support Section and KCEL.

3 Program Management

3.1 Roles and Responsibilities

The major tasks involved for the 2025 Elliott Bay sediment sampling event and the King County personnel who will assume responsibility for those tasks are listed in Table 1.

Table 1. Roles and responsibilities for tasks involved in benthos sampling.

Name	Position	Contact	Role(s)
Wendy Eash-Loucks	Marine Scientist/ Program Manager KC Marine and Sediment Assessment Group	206-477-4683 wendy.eash-loucks@kingcounty.gov	Program management, study coordination, preparation of SAP, data validation and analysis, and preparation of final study reports or data dashboards.
Bob Kruger	Environmental Lab Scientist IV Field Science Unit, KCEL	206-477-7147 bob.kruger@kingcounty.gov	SAP review, coordination of all field sampling activities.
Erin McCabe	Laboratory Project Manager KCEL	206-477-7205 erin.mccabe@kingcounty.gov	SAP review, laboratory coordination, and data reporting.
Arina Podnozova	Quality Assurance Officer KCEL	206-263-7864 apodnozova@kingcounty.gov	SAP review, coordination of KCEL quality assurance/quality control (QA/QC) activities.
Beth leDoux	Supervisor KC Lakes Streams, Sound, and Ground Unit	206-477-4750 beth.ledoux@kingcounty.gov	Directing and overseeing the program and ensuring that deliverables and outcomes are achieved as defined in

Name	Position	Contact	Role(s)
			the Charter, and review of SAP and final study report.
Josh Latterell	Section Manager KC Science and Technical Support Section	206-477-4748 josh.latterell@kingcounty.gov	Approval of program changes and review of final study reports.

3.2 Schedule

- **February 2025** – Begin draft of sampling event SAP
- **March 2025** – Complete first draft of SAP and send to staff in Science and Technical Support Section and KCEL for review.
- **Early May 2025** – Finalize SAP
- **Last week of May/first week of June 2025** – Collect sediment samples
- **December 2025** – Laboratory data and corresponding report provided to program manager
- **January 2026** – Data reviewed by program manager
- **February 2026** – Data uploaded to King County [Open Data](#) And EIM.

3.3 Program Deliverables

Sediment Chemistry Dataset – Data from the 2025 Elliott Bay sampling event will be reviewed and uploaded/appended to King County’s Open Data platform: <https://data.kingcounty.gov/d/s9uc-py3h>.

Data Dashboard – Data will be reported on a data dashboard that summarizes current conditions (e.g., comparison to SQS) as well as trends at three long-term monitoring stations. This dashboard is currently in the scoping process but will hopefully be completed in 2026.

3.4 Health and Safety Procedures

The following general health and safety guidelines have been provided in lieu of a site-specific Health and Safety Plan. These guidelines will be read and understood by all members of the sampling crew.

- All crew of the research vessel will follow all aspects of the KCEL Vessel Safety Plan.
- Samplers will wear chemical-resistant gloves when coming into contact with sediment.
- No eating or drinking by sampling personnel will be allowed outside the cabin during active sampling operations.
- All sampling operations will be conducted during daylight hours.
- All accidents, “near misses,” and symptoms of possible exposure will be reported to a crew member’s supervisor within 24 hours of occurrence.
- All crew members will be aware of the potential hazards associated with any chemicals used during the sampling effort.

More details and instructions are available in KCEL’s Vessel Safety Plan. Several hazards are inherent to marine sediment sampling. General vessel safety, physical hazards unique to sediment grab sampling, and chemical hazards are discussed in Sections 3.4.1 through 3.4.3.

3.4.1 General Vessel Safety

To help prevent accidents and ensure adequate preparation for emergencies that may arise, the following safety equipment will be required on the *R/V SoundGuardian*:

- one personal floatation device (PFD) for each crew member and one throwable PFD;

- an accessible, clearly labeled, fully stocked first-aid/CPR kit;
- an accessible and clearly labeled eye wash (when sampling suspected contaminated sediments);
- one (preferably two) VHF marine radio(s) with weather channel;
- a cellular telephone;
- a horn;
- navigation lights;
- an emergency life raft;
- an anchor and suitable line;
- signal flares; and
- a reach pole or shepherd's hook.

Personal protective equipment will be selected and used that will protect workers involved in sediment sampling from the hazards and potential hazards likely to be encountered. Minimum required personal protective equipment for marine sediment sampling shall include the following:

- hard hat;
- steel-toe rubber boots;
- chemical-resistant gloves (e.g., Nitrile); and
- safety glasses.

Recommended additional personal protective equipment will include rain gear and hearing protection when the vessel, *SoundGuardian*, is under way.

3.4.2 Grab Sampling

Sampler deployment and sediment retrieval present physical hazards due, in part, to the heavy weight of the grab sampler, its suspension above the vessel deck, and the risk of accidental or premature closure. Prior to each sampling event, all cabling, shackles, pins, housings, and swivels will be inspected to ensure the integrity of all points along the sampling assembly.

The sampler will always be set while it is resting on a stable surface. Once set, a safety pin will be set in place on the triggering mechanism and remain in place until the sampler is swung outboard of the vessel rail. Special care will be exercised when removing the safety pin to ensure personal safety in the event of a gear or winch failure. Fingers will not be placed through the ring of the pin when it is removed, and hands will be kept completely clear of the sampler interior after the pin has been removed. If a sampler is retrieved that has not been tripped, it will be lowered to a stable surface before any worker contact.

During grab retrieval, one crew member will watch for the appearance of the grab sampler and alert the winch operator when the sampler is first visible below the water surface. Attempting to bring a swinging grab sampler on board poses a serious risk of being hit or knocked overboard. The winch operator will minimize swinging before the grab sampler is brought on board for the crew to secure. Hard hats and gloves will always be worn when handling the grab sampler.

The winch drum, blocks, A-frame, and any area between the grab sampler and railings, the deck, and heavy equipment, all represent significant pinching and crushing hazards. Only trained and experienced crew members will operate the winch or A-frame during a sampling event. Other crew members will exercise care to avoid these potentially hazardous areas.

3.4.3 Chemical Hazards

Contact with marine sediment at some sampling stations may present a health hazard from chemical constituents of the sediment, such as polychlorinated biphenyls (PCBs), mercury, phthalates, and polycyclic aromatic hydrocarbons (PAHs). Potential routes of exposure to chemical hazards include inhalation, skin and eye absorption, ingestion, and injection. Crew members will exercise caution to avoid contact with sediment at all stations during sampling operations. Protective equipment will include chemical-resistant gloves, safety glasses or goggles, and protective clothing (e.g., rain gear). Crew members will exercise good personal hygiene after sampling and prior to eating or drinking.

4 Program Design Details

4.1 Study Design

Eight Elliott Bay sites were selected for sediment sample collection. These sites include three that will be used for analyzing long-term trends and six that will be sampled for assessing current conditions (one site is shared between the two goals). Additional study design details are available below.

4.1.1 Sampling locations and frequency

Monitoring sites will be sampled once every four years in late May or early June. This will allow for sediment from each sampling event to be an accumulation of several years' worth of sedimentation. This timing is consistent with historical monitoring at these sites. Sampling locations of the eight sites (9 samples total) are included in Table 2 and Figure 1.

Table 2. Elliott Bay subtidal sampling site information. Note: two samples (0–2 cm and 0–10 cm) collected at LTDF01.

Locator*	Site Name	Latitude	Longitude	Year Added	Approx. Depth (m)	Sampling Depth (cm)	Sample Type
LTAA02 ^{B,F}	Grain Terminal	47.62304	-122.37093	2007	25	0-10	Current conditions
LSCW02 ^B	Elliott Bay W. Deep	47.61194	-122.39083	1991	180	0-10	Current conditions
LTCA02	Elliott Bay Central	47.61000	-122.37194	1991	130	0-2	Long-term
LTDF01 ^{B,F}	Elliott Bay Waterfront	47.60778	-122.34611	1988	35	0-2 & 0-10	Long-term + Current conditions
LTED04 ^W	Elliott Bay E. Central	47.60364	-122.35651	1992	90	0-2	Long-term
DWMHD1 ^C	Duwamish Head	47.60046	-122.39012	2025	20	0-10	Current conditions
LTGF01 ^{B,F}	Harbor Island	47.58984	-122.35239	2007	30	0-10	Current conditions
LSHZ08 ^C	Seacrest Park	47.58925	-122.37841	2007	25	0-10	Current conditions

*Some sampling sites are shared by multiple programs (e.g., benthos or water quality) and/or located near sampling sites for other programs (e.g., crab or fish tissue).

^B = Benthos sampling site

^C = Crab sampling site

^F = Fish sampling site

^W = Water quality sampling site

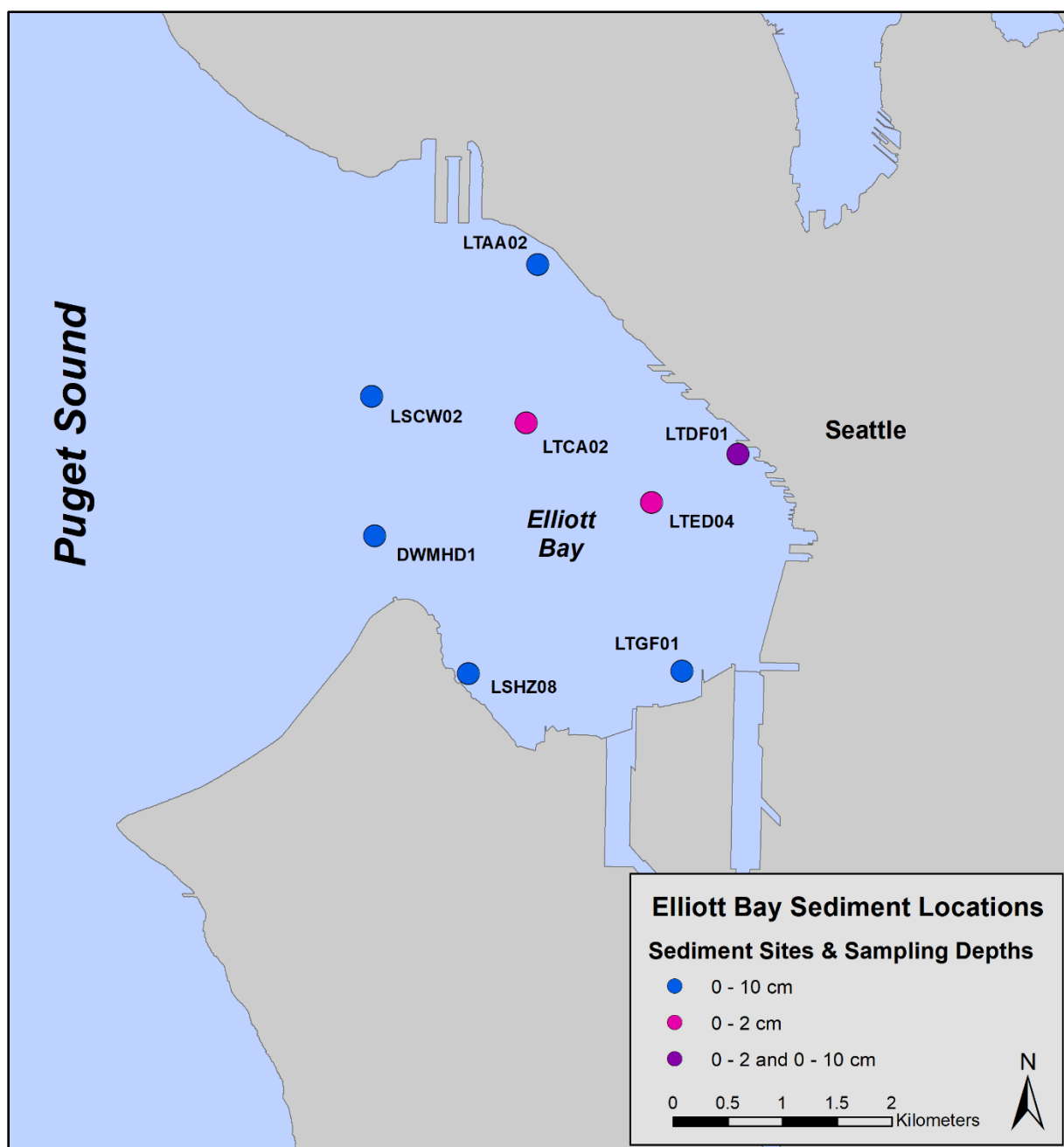


Figure 1. Elliott Bay sediment chemistry sampling locations and sampling depths.

4.1.2 Field parameters and laboratory analytes

Samples will be collected from either the top 0–2 cm and/or top 0–10 cm of sediment to assess long-term trends or characterize current conditions, respectively (Figure 1). Sampling procedures are described in Section 6. Sediment will be homogenized and split into laboratory containers in the field. The parameters associated with each sample will include a suite of metadata that will be documented in the field, the chemicals of concern listed within the marine Sediment Management Standards (SMS), conventional parameters, and additional nutrients, metals, and organics.

Additionally, if extra sampling material is available, it will be provided to laboratories at the University of Washington, Tacoma (UW Tacoma) for analysis of sediment microplastics and *Alexandrium* cysts to support other regional monitoring efforts.

Sample metadata will be documented in the field and will include the following parameters:

- Sample ID number
- Station name
- Station bottom depth
- Sediment depth (i.e., sampler penetration depth) for each successful deployment
- Sediment depth stratum sampled (i.e., 0–2 cm or 0–10 cm)
- Physical sediment characteristics
- Date and time of sample collection
- Condition and height of tide
- Initials of all sampling personnel

Analytical parameters will include⁵:

- **Conventionals:** particle size distribution (PSD) and total solids
- **Biogeochemical:** ammonia* total organic carbon (TOC), and total sulfide*
- **Metals:** aluminum*, arsenic, cadmium, chromium, copper, iron*, lead, mercury, selenium*, silver, and zinc
- **Organics:** polycyclic aromatic hydrocarbons (PAHs), phthalates, phenols, chlorinated semi-volatile organic compounds, polychlorinated biphenyls (PCBs), and miscellaneous polar and non-polar organics, butyltins*, chlorinated pesticides*, and polybrominated diphenyl ethers* (PBDEs). A list of all organic chemicals measured is available in Section 7.4
- **Misc.:** microplastics and *Alexandrium* cysts (analyzed by UW Tacoma)

4.1.3 Assumptions underlying design

Analysis of sediment samples are snapshots in time. One of the assumptions of the sampling design is that this snapshot represents conditions for the period sampled, though sediment is continually being deposited. However, environmental conditions can change year-round and there are time periods between sampling events that we are not capturing. Additionally, marine sediment chemistry can be patchy (variable within a site) and sample heterogeneity can occur though we assume our sample results accurately represent conditions at the site. We take steps to assure representativeness of samples (see Section 5.1.2) including compositing two or more grabs, but data users should be careful to not overstate conclusions from measurements.

4.1.4 Characteristics of existing data

Sediment data have been collected from Elliott Bay sites from as far as back as 1988 (Table 3). Data generated by the King County Environmental Lab (KCEL) can be accessed internally through LIMS, which also includes quality control (QC) data and data anomaly forms. Data quality is dependent on the quality assurance (QA) methods that were conducted at the time the sampling/analysis occurred. These are documented in the individual SAPs for each event. These data have been collected and analyzed using KCEL SOPs. Some methods have changed over time and are documented by KCEL in Customer Notification Memos or in SAPs. Reference methods are included as a downloadable field in LIMS. Older data, from the three long-term monitoring stations (LTDF01,

⁵ Parameters indicated with a “*” are not included in the SMS.

LTED04, and LTCA02) will be evaluated using the information available in LIMS and on method changes, prior to use in any long-term trend analysis.

Table 3. Elliott Bay ambient sediment monitoring station description and sampling history. X's indicate years when samples were collected. All samples collected from 0–2 cm.

Station	Description	Years Sampled												
		1988	1989	1990	1991	1992	1993	1995	1996	1998	2000	2002	2004	2007 - 2023*
LTAA02	Grain Terminal													X
LSCW02	Elliott Bay W. Deep				X	X	X	X	X	X	X	X	X	X
LTCA02	Elliott Bay Central				X	X	X	X	X	X	X	X	X	X
LTDF01	Elliott Bay Waterfront	X	X	X	X	X	X	X	X	X	X	X	X	X
LTED04	Elliott Bay E. Central					X	X	X	X	X	X	X	X	X
DWMHD1	Duwamish Head													
LTGF01	Harbor Island													X
LSHZ08	Seacrest Park													X

*Sampled every two years

5 Data Quality Objectives

The data quality objectives (DQOs) of the 2025 Elliott Bay sediment sampling event outlined below are to collect data of sufficient quantity and quality and to meet the program goals outlined in Section 2.0.

The quantity of sediment chemistry data to be collected is based on previous sampling events conducted under King County's marine ambient monitoring program as well as Ecology's marine Sediment Monitoring Program. One sediment chemistry sample will be collected from each of the eight stations located within Elliott Bay.

Program data will be assessed to determine whether the data collected are of sufficient quality to meet the study goals. The data quality issues of precision, accuracy, bias, representativeness, completeness, comparability, and sensitivity are described in the following subsections.

5.1 Measurement Quality Objectives (MQOs)

MQOs for the Routine Marine Sediment Monitoring Program include data quality indicators of precision, accuracy, sensitivity, bias, representativeness, completeness, and comparability. Details on specific quality control tests and acceptance criteria for analysis are available in Section 8. Samples outside of the allowable target ranges/criteria of tests used for measuring data quality may be flagged (i.e., qualifier

applied) or reanalyzed based on laboratory analysis review with other QC data and possible discussion with the program manager.

5.1.1 Targets for Precision, Accuracy, Sensitivity, and Bias

Precision. The measure of agreement among repeated measurements of the same property under identical or substantially similar conditions; calculated as either the range or as the standard deviation. May also be expressed as a percentage of the mean of the measurements, such as relative range or relative standard deviation (coefficient of variation).

Precision will be determined by measuring the deviation between laboratory duplicate and triplicate samples and matrix spike (MS) and matrix spike duplicates (MSD) and comparing that deviation to the allowable ranges noted in Section 8.2.

Accuracy. A measure of the overall agreement of a measurement to a known value; includes a combination of random error (precision) and systematic error (bias) components of both sampling and analytical operations.

Standard reference materials will be used for MS/MSD analysis of most parameters to determine how close to the known concentration the analysis is able to measure. Those values will be compared to allowable ranges noted in Section 8.2.

Sensitivity. The capability of a method or instrument to discriminate between measurement responses representing different levels of the variable of interest.

For most sediment chemistry analytical methods presented in Section 7, techniques are sensitive enough to allow comparison of sediment chemistry data to SQS. However, there may be some issues in meeting target detection limits for some trace organic parameters when concentrations are normalized to dry weight and to organic carbon. Refer to Section 8.2 for more details on how sensitivity is determined and reported for each of the analytical methods to be used for this program.

Bias. The systematic or persistent distortion of a measurement process that causes errors in one direction.

Laboratory instruments will be calibrated to reduce bias in sample results. Additionally, standard reference materials, method blanks, and MS/MSD analysis will be evaluated for sample bias by comparing them to allowable ranges noted in Section 8.2.

5.1.2 Targets for Representativeness, Completeness, Comparability

Representativeness. A qualitative term that expresses “the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition.” (ANSI/ASQC 1995).

Chemistry test samples will be collected from stations with pre-selected coordinates to represent specific site locations. Sediment chemistry samples, from multiple grabs, will be homogenized to minimize variations in the chemical and physical composition of the sediments. Following the guidelines described for sampler decontamination, sample acceptability criteria, and sample processing (Section 6) will also help ensure that samples are representative.

Completeness. A measure of the amount of valid data needed to be obtained from a measurement system.

Adhering to standardized sampling and testing protocols will aid in providing a complete set of data for this study. The goal for completeness is 100%. If 100% completeness is not achieved, the study

team will evaluate whether the DQOs can still be achieved or if additional samples may need to be collected and analyzed.

Comparability. A qualitative term that expresses the measure of confidence that one data set can be compared to another and can be combined for the decision(s) to be made.

Samples from three sites will be collected from the top 0–2 cm to assess the most recently deposited sediments for consistency of depth with other samples previously collected from those sites. This will allow for the assessment of long-term trends at this subset of sites.

All other sites will be sampled from the top 0–10 cm of sediment for consistency with recommended methods for comparison to SMS. This will also make these data comparable with most other King County sediment sampling including the collections of sediments near wastewater treatment plant outfalls that are sampled to fulfill NPDES permit requirements.

The goal of comparability is achieved through using standard techniques to collect and analyze representative samples, along with standardized data validation and reporting procedures. By following the guidance of this SAP, the goal of comparability will be achieved.

5.1.3 Acceptance Criteria for Existing Data

Not Applicable

6 Field Procedures

Sediment chemistry sampling will be conducted in late May or early June of 2025 to be consistent with previous monitoring dates. All sampling will be performed according to guidelines recommended in Ecology's *Sediment Cleanup User's Manual (SCUM)* (Ecology, 2021). A checklist of supplies for sediment chemistry sampling is available in [Appendix B](#).

Sediment samples will be collected using two 0.1 m² modified, stainless steel van Veen grab samplers deployed in tandem via hydrowire and hydraulic winch from the King County research vessel *SoundGuardian*. Sediment will be collected from the contents of a minimum of two deployments of the dual grab samplers to obtain the volume needed for required analyses. Chemistry samples will be collected from the top 0–2 or 0–10 cm of sediment. Sediment chemistry samples will be stored on ice in coolers while in the field, and then transported to the KCEL at the end of each sampling day.

6.1 Sampling Site Positioning Methods

Reliable station positioning is crucial to be able to revisit established stations for future sampling events. Inaccuracies in station positioning when conducting sediment grab sampling in deep water can result from the action of currents and wind on the sampling vessel as well as current forces and viscous drag on the sampler and deployment line.

Station positioning for the 2025 Elliott Bay sediment sampling event will employ a combination of a differential global positioning system (DGPS) and positioning software to calculate the position of the van Veen grab samplers as they contact the seafloor.

For station positioning, the research vessel will employ a Trimble® DGPS. Prior to the sampling event, the prescribed station coordinates will be entered into the shipboard DGPS laptop computer. During the sampling event, the shipboard navigational system will utilize the differential data transmissions from regional Coast Guard base stations to automatically correct its GPS satellite data. The GPS antenna is boom-mounted above the sampler descent line to achieve a more accurate coordinate fix above the sampling point.

Upon contact of the grab samplers with the bottom, the coordinate data representing the sediment grab impact point will be electronically recorded in real time. Positioning information will include local time and date that a position is recorded, comments, and coordinate data in both latitude/longitude and NAD 83 State Plane formats.

Sample collection is expected to take place within a 6-meter radius of each station's prescribed position and samples will not be collected if the observed coordinates of the grab deployment are outside of this limit. If conditions such as a steep slope or rocky substrate preclude sample collection at a particular station, the station may be relocated after consultation with the program manager if relocation will not compromise the program goals. If the program manager is not available, the sampling team will use best professional judgement to collect a sample as close as possible, but outside of the 6-meter radius. Any station relocation will be documented and reported.

6.2 Field Measurement and Sampling Methods

Collection of marine sediments will follow standard operating procedures (SOP) outlined in King County SOP #2011v1 (King County, 2006).

6.2.1 Sample Deployment and Retrieval

Two 0.1 m², modified, stainless steel van Veen grab samplers will be deployed in tandem at each sampling station. The grab samplers will be lowered at a controlled speed of approximately 30 meters per minute until they approach the bottom, at which time the speed will be decreased to approximately 10 meters per minute to minimize potential bow wake activity and subsequent bottom disturbance.

After the grabs have tripped upon reaching the bottom, they will be raised slowly to allow gentle and complete closure of the sampler jaws to avoid sample disturbance and loss. Once clear of the bottom, the ascent speed will be increased to approximately 30 meters per minute. Care will be taken to ensure that minimal sample disturbance occurs when swinging the grabs on board.

Collection of undisturbed sediment requires that the grab samplers:

- create a minimal bow wake when descending;
- form a leak-proof seal upon closure of the jaws;
- are carefully retrieved to prevent excessive sample disturbance; and
- allow easy access to the sediment within the grab.

6.2.2 Sample Acceptability Criteria

When the grab samplers have been secured on board, the hinged top flaps will be opened, and the samples examined for acceptability. Acceptability criteria will include:

- the grabs are not overfilled to the point where there is evidence of sample loss around the access doors;
- overlying water is present, indicating minimal leakage;
- overlying water is not excessively turbid, indicating minimal sample disturbance; and
- a minimum acceptable sample penetration depth has been achieved.

Samples collected from the top 0–2 cm of sediment for chemistry analysis will require a minimum grab penetration depth of 4 cm. Samples collected from the top 0–10 cm of sediment for chemistry analysis will require a minimum grab penetration depth of 11 cm. Sampling coarser sediments at deeper depths can occasionally prove problematic when trying to obtain the required penetration depth. If multiple grab deployments at any station fail to recover the correct amount of sediment, subsequent grab deployments will be accepted with less than 11 cm, based on the discretion of the

lead sampler in consultation with the program manager. This situation will be documented on field notes.

Care will be taken to extract sediment for chemistry analysis from the most undisturbed center portion of each grab without collecting sediment that has touched the sides or bottom of the grab. Penetration depth will be determined by measuring the depth of sediment within each grab by sliding a ruler vertically along the inside of the grab's side wall after each successful cast. Penetration depth can also be calculated by measuring the space between the sediment's surface within the grab and the top of the grab, then subtracting this vertical distance from 17 cm, the total inside height of the grab. Overlying water within the grab will be carefully siphoned off the sediment surface for all acceptable samples.

Samples collected from the 0–2 and 0–10 cm depth stratum will require a minimum of two successful deployments of the tandem van Veen grab samplers. Sediment chemistry aliquots will be collected from one or both grabs from each successful deployment; if benthos samples are also collected from this location, three deployments will be needed, and benthos samples can be collected from the remaining grabs (King County, 2025b). The two or three grab deployments will result in enough sediment to composite material for all chemistry testing.

6.2.3 Handling Invasive Species

While collecting sediment samples, it is possible for grab samples to contain invasive species. To avoid the spread of invasive species to other areas, all sample material not contained for further analysis will be washed overboard, and sampling gear (i.e., van Veen grabs, steel bowls and spoons for compositing) will be rinsed on-site. Invasive species that can be identified by field staff will be humanely euthanized (i.e., placed on ice).

6.3 Sample Containers, Holding Times, and Storage Requirements

Prior to any subsampling, sediment aliquots will be collected for analysis of total sulfides. The sulfide samples will always be collected from the top 0–2 or 0–10 cm of sediment (depending on the site) in the first pair of grabs, using a stainless steel spoon and placed directly into the appropriate sample containers without homogenization. It is necessary to preserve total sulfide samples as soon as possible. After the four-ounce total sulfides container has been filled completely, 5 milliliters (ml) of 2N zinc acetate will be added to the top of the sediment prior to sealing the container.

The remaining top 0–2 cm or 0–10 cm of undisturbed sediment from the same grab will be collected and then placed in a stainless steel bowl. Sediment will be collected from the 0–2 cm or 0–10 cm depth stratum using a stainless steel spoon. When sufficient sediment for all analyses has been collected, the sediment in the stainless steel bowls will be thoroughly homogenized. After homogenization, sediment aliquots will be transferred to appropriate laboratory containers. Prior to homogenization, collected sediments will be stored covered with aluminum foil in coolers between grab deployments.

Head space will be left in all chemistry sample containers, with the exception of total sulfides, to allow for further mixing in the laboratory and expansion should the containers be stored frozen. All sample containers will be stored in insulated, ice-filled coolers while in the field. All sediment chemistry sample containers, storage conditions, and hold times are summarized in Table 4.

Additional sample material, if available, will be saved for analysis of microplastics and *Alexandrium* cysts by Julie Masura and Cheryl Greengrove's labs, respectively, at UW Tacoma. Two to four cups of sample material from the composited sediment will be placed in a plastic bag and transferred to a black plastic bag in a cooler with ice. Samples will remain refrigerated until collected by the UW Tacoma team.

Table 4. Sediment sample containers, storage conditions, and analytical hold times.

Analyte	Container	Preferred		Acceptable	
		Storage Conditions	Hold Time	Storage Conditions	Hold Time
Ammonia	4-oz. CWM PP	refrigerate at 4°C	7 days to analyze	N/A	N/A
Particle Size Distribution	16-oz. CWM PP	refrigerate at 4°C	6 months to analyze	N/A	N/A
Total Organic Carbon	4-oz. CWM PP	freeze at -18°C	6 months to analyze	refrigerate at 4°C	28 days to analyze
Total Solids (collect w/ TOC)	4-oz. CWM PP	freeze at -18°C	6 months to analyze	refrigerate at 4°C	14 days to analyze
Total Sulfide	4-oz. CWM PP No Headspace	refrigerate at 4°C w/ 2N Zn acetate	7 days to analyze	N/A	N/A
Mercury	8-oz. CWM PP	freeze at -18°C	1 year	N/A	N/A
Other Metals (Collect with Mercury)	8-oz. CWM PP	freeze at -18°C	2 years to analyze	refrigerate at 4°C	6 months to analyze
BNAs, Pesticides/PCBs, PBDEs, and Tributyltin	3 x 8-oz. glass**	freeze at -18°C	1 year to extract 40 days to analyze	refrigerate at 4°C	14 days to extract 40 days to analyze
Microplastics and <i>Alexandrium</i> *	1-quart plastic bag	Refrigerate in dark at 4°C (e.g., in black bag)	Several years	N/A	N/A

*Extra material provided to UW Tacoma for analysis.

** An archive jar (4 oz glass jar) will also be collected for each sample assuming sufficient sediment is available. The archives will be stored frozen at -18°C.

CWM PP – Clear, wide-mouth polypropylene, TOC = total organic carbon, BNAs = base/neutral/acid semivolatile organic compounds, PCBs = polychlorinated biphenyls, PBDES = polybrominated diphenyl ethers

6.4 Field Contingency Plan

If successive attempts to retrieve enough sample material have failed (i.e., grabs didn't penetrate deep enough to meet the minimum penetration depth of 4 or 11 cm), additional actions that could be taken include:

- Shifting the target grab location from within 6 m to within 10 m of the prescribed location.
- Accepting a grab with less than the prescribed depth of sediment.

All corrective actions listed above should be confirmed with the program manager before taken. Any corrective actions should be noted in the field sheets.

6.5 Sample IDs

Sample ID numbers (i.e., L-numbers) will be assigned to all samples so data from a single grab can be tracked. All sample containers will be labeled with the unique sample number (sample ID), project number, station name (locator), date of sample collection, preservation method, and analysis to be performed.

6.6 Field Documentation and Logbook Procedures

Sampling information and sample metadata will be documented using the methods noted below.

- Field sheets generated by King County's Laboratory Information Management System (LIMS) will include information such as:
 1. sample ID number
 2. station name (locator)
 3. station bottom depth
 4. sediment depth (i.e., sampler penetration depth) for each successful deployment
 5. sediment depth stratum sampled (i.e., 0–2 cm or 0–10 cm)
 6. physical sediment characteristics
 7. date and time of sample collection
 8. condition and height of tide
 9. initials of all sampling personnel
- *SoundGuardian's* logbook will contain records of all shipboard activities, destinations, arrival and departure times, general weather and positioning information, and the names of shipboard personnel.
- *SoundGuardian's* cruise plan will list the prescribed stations to be sampled, along with their respective coordinates and other associated locating information.
- Electronic DGPS coordinate data will be electronically logged for each acceptable grab sample using both latitude/longitude and NAD 83 State Plane formats.
- COC documentation will consist of the Lab's standard field sheet and work order COC forms, which are used to track release and receipt of each sample from collection to arrival at the lab and for relinquishing samples to subcontract labs.

An example of a typical field sheet used by KCEL is included as Figure 2. This document also serves as chain of custody documentation. See Section 6.9 for additional chain of custody procedures.

The following field measurements and observations will be recorded on the appropriate field sheet/log for each sample:

- sample (bottom) depth—measured as total depth by vessel's fathometer;
- coordinates for individual grab samples;
- sediment depth (grab penetration depth)—measured by ruler inside the grab;
- sediment sampling range (0–2 cm);
- sediment type (a mnemonic code indicating color, gross grain size, odor, and debris – See [Appendix C](#));
- tide condition and height;
- collect date, start time, and sampling personnel; and
- general sample information such as sampling irregularities (e.g., inferior sample material due to the presence of rocks, debris, etc.).

Login:
Project:

Template

FSU TC: _____
LPM: _____

CHAIN OF CUSTODY

Relinquished by	Date	Time
Received by	Date	Time
Sample Numbers		[All]
Sample Number	PXXXXX-X	
QC Link		
Locator	TEMP	
Short Loc Desc	TEMPLOC	
Locator Desc	TEMPORARY LOCATOR	
Site	TEMP	
Comments		
Start Date/Time		
End Date/Time		
Time Span		
Sample Depth		
Dept, Matrix, Prod (Cont ID)		

Figure 2. King County Environmental Laboratory standard field sheet chain of custody form.

6.7 Equipment Decontamination

The grab samplers will be decontaminated between sampling stations by scrubbing with a brush and ambient sea water, followed by a thorough in situ rinsing. Prior to sampling, stainless steel bowls and spoons will be washed and scrubbed in detergent (as specified in KCEL SOP #2034v1, King County, 2007). The buckets and utensils will be rinsed with copious quantities of reverse osmosis water, allowed to dry in air, and covered in aluminum foil until used in the field. A separate stainless steel bowl and spoon (and spatula, if necessary) will be dedicated to each sampling station, precluding the need for decontamination of this equipment in the field.

6.8 Delivery of Samples to KCEL

All sample containers will be stored in an insulated cooler containing ice immediately after collection to maintain the samples at a temperature of approximately 4° Celsius until delivery to the laboratory. Sample containers from each station will be grouped and placed in plastic bags to facilitate sample receipt and login. At the end of each sampling day, all samples will be transported back to KCEL.

6.9 Chain of Custody (COC) Procedures

Chain of custody (COC) will commence at the time that each sample is collected. While in the field, all samples will be under direct possession and control of King County field staff. For chain of custody purposes, the research vessel will be considered a “controlled area.” Each day, all sample information will be recorded on a field sheet COC form (Figure 3). This form will be completed in the field and will accompany all samples during transport and delivery to the laboratory each day. Upon arrival at KCEL, the sample delivery person will relinquish all samples to the sample login person. The date and time of

LABORATORY WORK ORDER

Chain of Custody

**King County Department of Natural Resources
Water and Land Resources Division
Environmental Laboratory
322 West Ewing Street
Seattle, Washington 98119-1507**

Project Name:
Project Number:
Laboratory Project Manager:
Telephone Number:

[illegible]

7 Laboratory Analysis

The terms MDL and RDL, used in the following sediment chemistry analysis subsections, refer to method detection limit and reporting detection limit, respectively. The MDL is defined as the minimum

concentration of a chemical constituent that can be detected, while the RDL is defined as the minimum concentration of a chemical constituent that can be reliably quantified.

SW-846 (EPA, 2015) methods for metals, organic compounds, and some conventional analyses have eliminated the concept of the method detection limit discussed above and have replaced it with a lower limit of quantitation (LLOQ) concept. Details on how these quantitation limits are used to report data by KCEL are described in Section 7.1. Methods and the resulting detection and reporting limit goals are described in sections 7.2 through 7.4.

7.1 Analytical Methods and Detection Limit Requirements

The sensitivity of a particular analytical method is generally determined/defined by the reference method. The EPA reference methods used for this program belong mostly to the SW-846 compendium of analytical methods (including biogeochemical analyses TOC and total sulfide) and require that sensitivity be defined as a single limit called the “lower limit of quantitation” (LLOQ). With the exception of the metals Method 6020B and 7471B, the LLOQ can be no lower than the lowest concentration on the calibration curve and must be verified according to the requirements in each reference method. For metals Method 6020B and 7471B, the LLOQ may be lower than the lowest concentration on the calibration curve but must be verified within each analytical run by analyzing a standard at the level of the LLOQ and recovering the standard within 80%-120% of its true value ([Appendix D](#)).

For the metals (6020B, 7471B), conventionals, (9030B, 9060A), and chlorinated pesticides/PCBs (8081B (02/07) /8082A (02/07)) methods, sample results may not be reported below the LLOQ. In this case, the LLOQ value for each parameter is used as both the LIMS MDL and LIMS RDL (LIMS refers to the KCEL Laboratory Information Management System).

Sample results for BNAs (Method 8270E (06/18)), PBDEs (3550C (02/07)/8270E (06/18) NCI), and butyltins (Krone et al., 1989 and 8270E (06/18) SIM) may be reported at concentrations below the LLOQ if the qualitative peak identification requirements of the reference method are met. The LLOQs for BNA, PBDE, and butyltin parameters will be reported in the LIMS RDL field. The LIMS MDL may be lower than the LLOQ if the qualitative peak identification requirements of the reference method are fulfilled. Therefore, the LIMS MDL values for these parameters represent the lowest concentration at which a given compound meets the qualitative peak identification criteria specified in the reference method.

Any BNA, PBDE or butyltin parameters reported below the LLOQ (LIMS RDL) will be flagged “<QL, J,” because any result reported below the lower limit of quantitation (referred to as QL in LIMS) must be reported as an estimated value. See Section 8.4 for definitions of data qualifiers.

For the tests based on non-SW-846 reference methods, sensitivity is defined as the MDL, which is calculated by the 40 CFR Part 136, Appendix B, Revision 2 (2016) procedure. The value determined by this procedure may be increased to account for method variability, and will be reported in the LIMS MDL field. The LIMS RDL is calculated by multiplying the LIMS MDL by a factor between 2 and 10, depending on the parameter, and should be considered analogous to the Practical Quantitation Limit or (PQL).

Every effort will be made to achieve method LLOQs below the appropriate SMS chemical criteria (listed in [Appendix A](#)) for each parameter. The ability of the laboratory to attain detection limits that meet organic carbon-normalized chemical criteria, however, will depend upon the total solids and TOC content of each sample. Results for certain non-ionizing organic compounds are normalized to organic carbon for comparison to SMS chemical criteria. However, for sediment with a TOC content less than 0.5% (5,000 mg/Kg DW) or greater than 3.5% (35,000 mg/Kg DW), Ecology recommends comparing dry weight-normalized, non-ionic organic data to the Puget Sound Apparent Effects Thresholds (AETs). These values

are provided in Table 8-1 of SCUM (Ecology, 2021) and are considered to be equivalent to the organic carbon normalized benthic SMS values.

Every effort will be made to meet the MDL/RDL goals listed in the following sections of this SAP. However, the values for the LIMS MDLs and LIMS RDLs reported for individual samples may differ from the target detection limit goals reported below in Sections 7.2 thru 7.4. This may occur as a result of necessary analytical dilutions or reductions of extracted or digested sample amounts based on preliminary examination of the sample (including total solid and TOC values). When samples must be diluted for the analysis of one or more target analytes, LIMS MDLs and LIMS RDLs from the original, undiluted extract will be reported for all other parameters that did not require dilution. If it is determined that it will not be possible to meet the SMS criteria based upon TOC and total solids values, SW-846 method criteria, or KCEL Standard Operating Procedure criteria, the program manager will immediately be consulted.

LLOQs, MDLs, and RDLs are periodically evaluated and may change up or down. Any changes to the instrument LLOQ values will be documented in a Data Anomaly Form as a deviation from the SAP. If for any reason after analysis, a non-detected parameter's LLOQ/MDL was raised and is no longer less than or equal to the sediment quality criteria in [Appendix A](#) (e.g., required dilution due to matrix interferences or QC failures), the program manager will be contacted prior to data being moved to the LIMS database. This will allow a discussion on the implications of not meeting the limits and any other potential corrective actions that might be taken.

7.2 Conventionals/Biogeochemical

Conventional and biogeochemical sediment parameters will include ammonia, particle size distribution (PSD), total organic carbon (TOC), total solids, and total sulfide. The analytical methods and detection limits for conventional parameters are summarized in Table 5.

Table 5. Conventional/biogeochemical target analytes, methods, and detection limit goals.

Parameter	Method	MDL	RDL	Units
Ammonia	Kerouel & Aminot, 1997	0.02	0.1	mg/Kg wet wt.
PSD (gravel and sand)	ASTM D422	0.1	1.0	percent dry wt.
PSD (silt and clay)	ASTM D422	0.5	1.0	percent dry wt.
Total Solids	SM 2540-G	0.005	0.01	percent wet wt.
Parameter	Method	MDL/RDL/QL*		Units
Total Organic Carbon	EPA 9060; PSEP, 1996	500		mg/Kg wet wt.
Total Sulfide	EPA 9030B/SM 4500-S2-D	0.5		mg/Kg wet wt.

*QL refers to the Lower Limit of Quantitation (LLOQ) and is equal to the LIMS MDL and RDL for TOC and Total Sulfide.

Total solids will be analyzed on all samples to allow normalization of all other sediment chemistry data except PSD to dry weight. Total solids analysis will be performed according to the latest edition of Standard Methods (SM) 2540-G (APHA, 2023), which is a gravimetric determination. Results for total solids analyses are reported in units of percent on a wet weight basis.

TOC analysis will be performed on all samples to allow normalization of some organic parameters to organic carbon, if warranted. TOC analysis will be performed according to EPA Method 9060 (11/99), which is high-temperature combustion with infrared spectroscopy. Results for TOC analysis are reported in units of mg/Kg on a wet weight basis and/or percent on a wet weight basis. The MDL/RDL/QL value shown in Table 5 will be adjusted for individual samples, based on the amount of sample analyzed.

PSD analysis will be performed according to ASTM Method D422 (ASTM, 2002), which is a combination of sieve and hydrometer analyses. Results for PSD analysis are presented in units of percent on a dry weight basis, both for phi sizes and for the four broad classifications of clay, silt, sand, and gravel. Results for the clay and silt fractions are also summed to report a result for “percent fines.” The MDL and RDL values shown in Table 5 will be adjusted for individual samples, based on the amount of sample analyzed.

Ammonia and total sulfide, which are indicators of potential sediment toxicity, will be analyzed by Kerouel & Aminot, 1997 and SM 4500-S2-D (EPA 9030B), respectively. Ammonia analysis will involve a potassium chloride extraction followed by fluorometric analysis of the extract. Total sulfide will be analyzed by distillation following acidification and colorimetric analysis of the distillate. The MDL/RDL/QL value shown in Table 5 will be adjusted for individual samples, based on the amount of sample analyzed and any required dilutions.

7.3 Metals

Detection limits for the eleven target metals are summarized in Table 6. These LLOQs/LIMS MDLs/LIMS RDLs are presented on a wet-weight basis and are based on an initial sample weight of 1 (+/- 0.05) gram (g) and a final volume of 50 milliliters (ml) for ICPMS metals and 100 ml for mercury. Mercury will be analyzed by cold vapor atomic absorption spectroscopy (CVAA), following EPA Method 7471B (SW-846) and other metals will be analyzed by inductively coupled plasma mass spectroscopy (ICPMS) with a strong acid digestion, following EPA Method 3050B/6020B (SW-846).

Table 6. Trace metals target analytes and detection limit goals (mg/Kg wet weight).

Analyte	MDL/RDL/QL*		Analyte	MDL/RDL/QL*
Aluminum**	1.25		Lead	0.025
Arsenic	0.0125		Mercury	0.005
Cadmium	0.0125		Selenium	0.125
Chromium	0.050		Silver	0.010
Copper	0.050		Zinc	0.125
Iron	2.50			

*QL refers to the Lower Limit of Quantitation (LLOQ) and is equal to the LIMS MDL and RDL for the metals listed.

**Even though the sampling equipment is wrapped or covered with aluminum foil, any possible contribution of aluminum from the foil is considered insignificant in comparison to the level of aluminum in the sediment.

7.4 Organics

Organic parameters will include base/neutral/acid extractable semivolatile compounds (BNAs), chlorinated pesticides, polychlorinated biphenyls (PCBs), butyltins, and polybrominated diphenyl ethers (PBDEs). The analytical methods are described below and detection limits for the target trace organic compounds are summarized in Table 7 – Table 10 below (presented on a wet-weight basis).

Results for certain non-ionizing organic compounds are generally normalized to organic carbon for comparison to SMS marine chemical criteria. However, normalization to organic carbon can produce biased results when the organic carbon content of the sample is very low (Ecology, 1992). When the organic carbon content of a sample is near 0.1 or 0.2% (1,000 to 2,000 mg/Kg dw), even background concentrations of certain organic compounds can exceed the Sediment Quality Standards (SQS).

For sediment with a TOC content less than 0.5% (5,000 mg/Kg dw) or greater than 3.5%, Ecology recommends comparing dry weight-normalized, non-ionic organic data to the Puget Sound AET chemical

criteria (EPA, 1988; Ecology, 2021), which are considered to be equivalent to the SQS criteria. This comparison allows a more appropriate evaluation of sediment quality relative to organic compounds (Ecology, 1992, 2021). Historic TOC data show that some sampling sites will likely fall below the 0.5% or above the 3.5% normalization threshold.

For the samples with measured dry weight-normalized TOC concentrations between 0.5% and 3.5%, KCEL will normalize the appropriate trace organics data on an organic carbon basis.

For each reported parameter, every effort will be made to achieve analytical method LLOQs below the appropriate SQS listed in [Appendix A](#), Table A-1. However, the ability of the laboratory to attain detection limits which meet organic carbon-normalized chemical criteria will depend upon the total solids and TOC observed for each individual sample.

7.4.1 BNAs

The detection limit goals for the target BNA compounds are summarized in Table 7. These LIMS MDLs and RDLs are presented on a wet-weight basis and are based on a 30 g extraction concentrated to a final volume of 1.0 ml for analysis. The LIMS RDL is equal to the LLOQ, which in LIMS will be referred to as the QL (quantitation limit). The LIMS MDL can be at the LLOQ, and may be lower if the qualitative peak identification requirements of the method are met. Note that the detection limits can vary if the amount of sample extracted deviates from 30 g, or if dilutions are required due to elevated target analyte concentration(s) and/or interferences from high background levels of non-target organic compounds.

For the BNA extraction, samples are sonicated in 1:1 methylene chloride:acetone (3550C (02/07)) and then undergo a gel permeation chromatography (GPC) cleanup. BNA analysis will be performed according to EPA method 8270E (06/18), using analysis by gas chromatography/mass spectroscopy (GC/MS).

For most parameters listed in Table 7, the detection limits shown are achieved by operating the GC/MS in standard scan mode. However, to meet the detection limits for the parameters in Table 7 denoted with a “**”, additional sample analysis may be required by operation of the GC/MS in selected ion monitoring (SIM) scanning mode. Because sample analysis in SIM mode involves an additional GC/MS analytical run, SIM mode is reserved for analytes where standard scan mode is not likely to achieve quantitation limits (LLOQs) that are below the appropriate SQS criteria.

Table 7. BNA target analytes and detection limits (µg/Kg wet weight).

Analyte	MDL	RDL/QL*	Analyte	MDL	RDL/QL*
1,2,4-Trichlorobenzene	1.7	3.33	Chrysene	3.3	6.67
1,2-Dichlorobenzene	1.7	3.33	Dibenzo(a,h)anthracene	3.3	6.67
1,4-Dichlorobenzene	1.7	3.33	Dibenzofuran	3.3	6.67
2,4-Dimethylphenol**	6.67	6.67	Diethyl Phthalate	17	33.3
2-Methylnaphthalene	3.3	6.67	Dimethyl Phthalate**	6.7	16.7
2-Methylphenol	6.67	16.7	Di-N-Butyl Phthalate	6.67	6.67
3-,4-Methylphenol	16.7	33.3	Di-N-Octyl Phthalate	16.7	16.7
Acenaphthene	3.3	6.67	Fluoranthene	3.3	6.67
Acenaphthylene	3.3	6.67	Fluorene	3.3	6.67
Anthracene	3.3	6.67	Hexachlorobenzene**	1.7	3.33
Benzo(a)anthracene	3.3	6.67	Hexachlorobutadiene**	1.7	3.33

Analyte	MDL	RDL/QL*		Analyte	MDL	RDL/QL*
Benzo(a)pyrene	3.3	6.67		Indeno(1,2,3-Cd)Pyrene	3.3	6.67
Benzo(b,j,k)fluoranthene	5	10		Naphthalene	3.3	6.67
Benzo(g,h,i)perylene	3.3	6.67		N-Nitrosodiphenylamine**	6.67	6.67
Benzoic Acid**	167	167		Pentachlorophenol**	33	66.7
Benzyl Alcohol**	16.7	16.7		Phenanthrene	3.3	6.67
Benzyl Butyl Phthalate	6.67	6.67		Phenol	17	33.3
Bis(2-Ethylhexyl) Phthalate	6.67	6.67		Pyrene	3.3	6.67

*QL refers to the Lower Limit of Quantitation (LLOQ) and is equal to the LIMS RDL for the analytes listed.

** Selected ion monitoring (SIM) scanning mode may be used for these analytes and the detection limits for that method are reflected above.

SIM mode may be used for the following parameters:

- 2,4-Dimethylphenol
- Benzoic Acid
- Benzyl Alcohol
- Dimethyl Phthalate
- Hexachlorobenzene
- Hexachlorobutadiene
- N-Nitrosodiphenylamine
- Pentachlorophenol

7.4.2 Chlorinated Pesticides and PCBs

The detection limits for the target chlorinated pesticides and PCB Aroclors® are summarized in Table 8. For each pesticide target analyte and each Aroclor, the LIMS MDL and RDL are equal to the LLOQ, which in LIMS is referred to as the QL. These limits are presented on a wet-weight basis and are based on a 30 g extraction, which is concentrated to a final volume of 1.0 ml for analysis. These samples are extracted together in one extraction by sonication in 1:1 hexane:acetone (3550C (02/07)), and then undergo gel permeation chromatography. Before the cleanups are performed, the extract will be split in half. One portion will be vialled for chlorinated pesticides analysis. The other half of the extract is used for PCB Aroclors and undergo further cleanups of tetrabutylammonium (TBA), sulfuric acid, and silica gel. Note that the detection limits can vary if the amount of sample extracted deviates from 30 g, or if a dilution is required due to elevated target analyte concentration(s) and/or interferences from high background levels of non-target compounds. Chlorinated pesticide/PCB analysis will be performed according to EPA methods 8081B (02/07)/8082A (02/07), gas chromatography/electron capture detector (GC/ECD) with dual column confirmation.

Table 8. Chlorinated pesticide and PCB target analytes and sample detection limit goals (µg/Kg wet weight).

Analyte	MDL/RDL/QL*		Analyte	MDL/RDL/QL*
4,4'-DDD	0.167		Endosulfan II	0.167
4,4'-DDE	0.167		Endosulfan Sulfate	0.167
4,4'-DDT	0.167		Endrin	0.167
Aldrin	0.167		Endrin Aldehyde	0.167

Analyte	MDL/RDL/QL*		Analyte	MDL/RDL/QL*
Alpha-BHC	0.167		Gamma-BHC (Lindane)	0.167
Alpha-Chlordane	0.167		Trans-Chlordane	0.167
Beta-BHC	0.167		Heptachlor	0.167
Delta-BHC	0.167		Heptachlor Epoxide	0.167
Dieldrin	0.167		Methoxychlor	0.833
Endosulfan I	0.167		Toxaphene	16.7
Aroclor 1016	0.833		Aroclor 1248	0.833
Aroclor 1221	2.50		Aroclor 1254	0.833
Aroclor 1232	2.50		Aroclor 1260	0.833
Aroclor 1242	0.833			

*QL refers to the Lower Limit of Quantitation (LLOQ) and is equal to the LIMS MDL and RDL for the analytes listed.

7.4.3 Butyltins

Butyltin analysis will be performed according to Krone et al., 1989 and EPA method 8270E (06/18) SIM, which employs solvent extraction with tumbling and analysis by GC/MS in SIM mode. The detection limit goals for the target butyltin compounds are summarized in Table 9. The MDLs and RDLs are presented on a wet weight basis and are based on a 25 g extraction and a final volume of 5.0 mL for analysis. The MDLs and QLs for specific analytes requiring dilution (e.g., exceedance of analyte calibration range or matrix interferences) will be increased to reflect the dilution.

Table 9. Butyltin target analytes and sample detection limit goals (µg/Kg wet weight).

Parameter	MDL	RDL/QL*
Mono-n-Butyltin (as monobutyltin ion)	0.622	0.622
Di-n-Butyltin (as dibutyltin ion)	0.766	0.766
Tri-n-Butyltin (as tributyltin ion)	0.892	0.892
Tetra-n-Butyltin (as tetrabutyltin)	1	1

*QL refers to the Lower Limit of Quantitation (LLOQ) and is equal to the LIMS RDL.

7.4.4 PBDEs

The detection limits for target PBDE congeners are summarized in Table 10. These MDLs and RDLs are presented on a dry-weight basis (assumed 50% solids content) and are based on a 15 g extraction with gel permeation chromatography (GPC) and sulfuric acid cleanups, and concentration to a final volume of 1 mL for analysis. Note that the detection limits can vary if the sample deviates from 15 g, or if dilution is required due to elevated analyte concentration(s) and/or interference. PBDE analysis will be performed according to EPA methods 3550C (02/07)/8270E (06/18) negative chemical ionization (NCI), which employs solvent extraction with sonication and analysis by gas chromatography/mass spectroscopy (GC/MS) in NCI SIM mode.

Table 10. PBDE target analytes and sample detection limit goals (µg/Kg wet weight).

BDE congener	Congener #	MDL	RDL/QL*
2,2',4-TriBDE	17	0.013	0.0267
2,4,4'-TriBDE	28/33	0.013	0.0267
2,2',4,4'-TetraBDE	47	0.13	0.333
2,3',4,4'-TetraBDE	66	0.033	0.0667

BDE congener	Congener #	MDL	RDL/QL*
2,3',4',6-TetraBDE	71	0.013	0.0267
2,2'3,4,4'-PentaBDE	85	0.013	0.0267
2,2'4,4'5-PentaBDE	99	0.33	0.667
2,2',4,4'6-PentaBDE	100	0.033	0.0667
2,2',3,4,4',5'-HexaBDE	138	0.013	0.0267
2,2',4,4',5,5'-HexaBDE	153	0.013	0.0267
2,2',4,4',5',6-HexaBDE	154	0.013	0.0267
2,2',3,4,4',5',6-HeptaBDE	183	0.013	0.0267
2,3,3',4,4',5,6-HeptaBDE	190	0.013	0.0267
2,2',3,3',4,4',5,5',6,6'-DecaBDE	209	0.17	0.333

*QL refers to the Lower Limit of Quantitation (LLOQ) and is equal to the LIMS RDL.

7.5 Sample Disposal

All sediment samples will be stored for two years prior to disposal, or the program manager will be contacted if samples need to be disposed of sooner due to storage capacity. Sample disposal will follow guidance in KCEL's guidance on Solid and Liquid Sample Disposal (SOP #1007 [King County, 2018b]).

8 Quality Control Procedures

8.1 Field Quality Control Procedures and Requirements

Special care will be taken during the sample collection process to ensure that quality data are collected. The following procedures will be implemented during data collection:

1. When collecting samples, the sample location will be recorded by the onboard global positioning system and checked against the prescribed coordinates from Table 2.
 - a. Field staff will confirm that each sample was collected within a 6-meter radius before compositing the sample.
2. Field measurements listed in Section 6.6 will be recorded on field sheets.
 - a. Measurements for parameters including sediment depth and sediment depth stratum sampled will be checked against the prescribed depths pre-printed on the field sheets to ensure the correct depth was sampled.
3. Prior to leaving a sampling location, field staff will review the field sheets and confirm that all entries are complete, correct, and consistent with no omissions.
4. At the end of the sampling day, field staff will also review all field sheets, chain of custody forms, and sample labels prior to exiting the vessel, to confirm that all field documentation is complete, correct, and consistent with no omissions.

Any necessary divergence from the prescribed coordinates, sampling depths, or other field parameters should be recorded in the field notes. These divergences should also be highlighted in the text of the QA1-level report prepared by KCEL (See Section 9).

8.2 Analytical QC Requirements

The quality control (QC) samples that will be analyzed in association with sediment chemistry samples are summarized in Table 11. The frequency of method blanks, duplicates, triplicates, and matrix spikes is one per QC batch (20 samples maximum). The frequency of SRM (standard reference material) or LCS (laboratory control sample) analysis is one per batch (20 samples maximum). LCS analysis is used in lieu

of SRM analysis for selected analytes when an SRM may not be readily available. Surrogates are analyzed with every organic sample.

Table 11. Marine sediment quality control samples.

Analyte	Method Blank	Spiked Blank	Duplicate/Triplicate	Matrix Spike (MS)	MS Duplicate	SRM/LCS	Surrogates
Ammonia	Yes	Yes	Triplicate	Yes	No	Yes	No
PSD	No	No	Triplicate	No	No	No	No
TOC	Yes	Yes	Triplicate	Yes	No	Yes	No
Total Solids	Yes	No	Triplicate	No	No	No	No
Total Sulfide	Yes	Yes	Triplicate	Yes	No	No	No
Mercury	Yes	Yes	Duplicate	Yes	Yes	Yes	No
Other Metals	Yes	Yes	Duplicate	Yes	No	Yes	No
BNAs	Yes	Yes	Duplicate	Yes	Yes	Yes	Yes
Butyltins	Yes	Yes	Duplicate	Yes	Yes	Yes	Yes
Chlorinated Pesticides	Yes	Yes	Duplicate	Yes	Yes	Yes	Yes
PCBs	Yes	Yes	Duplicate	Yes	Yes	No	Yes
PBDEs	Yes	Yes	Duplicate	Yes	Yes	Yes	Yes

PSD = particle size distribution; TOC = total organic carbon; BNAs = base/neutral/acid compounds; PCBs = polychlorinated biphenyls; PBDEs = polybrominated diphenyl ethers; SRM = standard reference material; LCS = laboratory control sample

Quality assurance (QA1) marine sediment chemistry acceptance criteria (Ecology, 2021) are shown in Table 12.

Some trace metal and organic analyses have empirically derived laboratory limits for various QC samples. Specific laboratory-derived acceptance limits for trace metal and organic analyses are included in [Appendix D](#) (Tables D1–D17).

QC results that exceed the acceptance limits will be evaluated to determine appropriate corrective actions. Samples will typically be reanalyzed if the unacceptable QC results indicate a systematic problem with the overall analysis. Unacceptable QC results caused by a particular sample or matrix will not require reanalysis unless an allowed method modification would improve the results.

Analytical results that do not meet QA1 acceptance criteria will be qualified and flagged according to Ecology guidance (Ecology, 2021).

Table 12. QA1 acceptance criteria for marine sediment chemistry samples.

Analyte	Method Blank	Spiked Blank	Duplicate/Triplicate	Matrix Spike	SRM/LCS	Surrogates
Ammonia	< MDL	80–120%	RSD $\leq$ 20%	75 - 125%	80–120%	N/A
PSD	N/A	N/A	RSD $\leq$ 20%	N/A	N/A	N/A
TOC	< 0.5 QL	80 - 120%	RSD $\leq$ 20%	70-130%	80 - 120%	N/A
Total Solids	< MDL	N/A	RSD $\leq$ 20%	N/A	N/A	N/A
Total Sulfide	< 0.5 QL	80 - 120%	RSD $\leq$ 20%	65 - 135%	N/A	N/A

Analyte	Method Blank	Spiked Blank	Duplicate/Triplicate	Matrix Spike	SRM/LCS	Surrogates
Metals (Including Mercury)	< 0.5 QL	85–115%	RPD $\leq$ 20%	75 - 125%	Varies by Analyte	N/A
BNAs	< 0.5 QL	Varies by Analyte	RPD $\leq$ 35%	Varies by Analyte	Varies by Analyte	Varies by Analyte
Butyltins	< MDL	Varies by Analyte	RPD $\leq$ 35%	Varies by Analyte	Varies by Analyte	Varies by Analyte
Chlorinated Pesticides	< 0.5 QL	Varies by Analyte	RPD $\leq$ 35%	Varies by Analyte	Varies by Analyte	Varies by Analyte
PCBs	< 0.5 QL	Varies by Analyte	RPD $\leq$ 35%	Varies by Analyte	N/A	Varies by Analyte
PBDEs	< 0.5 QL	Varies by Analyte	RPD $\leq$ 35%	Varies by Analyte	Varies by Analyte	40 – 160%

< MDL - Method Blank result should be less than the method detection limit; N/A = Not Applicable; < 0.5QL – Method Blank result should be less than one-half of the QL (Lower Limit of Quantitation, LLOQ), or lower in the case of BNA analyses; PSD = particle size distribution; TOC = total organic carbon; BNAs = base/neutral/acid compounds; PCBs = polychlorinated biphenyls; PBDEs = polybrominated diphenyl ethers; SRM = standard reference material; LCS = laboratory control sample; RPD = Relative Percent Difference; RSD = Relative Standard Deviation QC results for matrix spike, SRM/LCS, and surrogates are in percent recovery of analyte.

Evaluation of method blank results is based on the requirements for each reference method. Therefore, the value entered for the LIMS MDL for the method blank may differ from the LIMS MDL for the associated samples.

For metals and conventional methods (6020B, 7471B, 9030B, and 9060A), and chlorinated pesticides/PCBs (Method 8081B (02/07)/8082A (02/07)), method blank results must be reported to one half the LLOQ. In this case, the LIMS MDL value for the method blank is one half the value reported for the LIMS RDL (LLOQ or QL).

For BNAs (Method 8270E (06/18)) the method blanks must be evaluated to at least one half the LLOQ and lower if the LIMS MDL is less than one half of the LLOQ.

For ammonia and total solids, the method blanks are evaluated to the same wet-weight LIMS MDL value reported for the undiluted samples.

Any method blank result that is at or above the associated LIMS MDL value will be qualified with a B flag on the QC report. Method blank values that are below the associated LLOQ will also be qualified with a J flag and a <QL qualifier to indicate they are estimated values detected below the QL.

If the associated method blank had a reportable value, any associated sample result measured at or above the LIMS MDL value will be qualified with either a B or B3 flag based on the ratio of the sample result to the associated method blank result on a wet-weight basis according to the following scheme:

- If the associated method blank is $\geq$ the LIMS MDL value and the sample result is $\geq$ MDL but $\leq$ 5 times the blank result, on a wet-weight basis, a “B” flag is applied.
- If the associated method blank is $\geq$ the LIMS MDL value and the sample result is > 5 and ≤ 10 times the blank result, on a wet-weight basis, a “B3” flag is applied.
- If the associated method blank is $\geq$ the LIMS MDL value and the sample result is > 10 times the blank result, on a wet-weight basis, no flag will be applied (the level of sample contamination associated with the method blank is considered negligible relative to the sample result).

8.3 Corrective Action Procedures

Field measurements or analytical results can fall outside the quality control acceptance criteria. If samples fall outside of the quality control specifications, the following corrective actions can be taken:

- Data qualifiers can be applied (see Section 8.4).
- Samples may be reanalyzed.
- The program manager and laboratory staff can meet to discuss additional corrective actions.

Additional information such as data anomaly forms or sample notes on potential data quality issues will be stored in KCEL's Laboratory Information Management System (LIMS). A relevant summary of any data quality issues can be included by the program manager in an additional notes field on the publicly accessible Open Data platform.

8.4 LIMS Data Qualifiers

The following is a comprehensive list of LIMS laboratory data qualifier flags and the typical conditions under which they are applied.

- **B** or **B3** are applied to sample results when the parameter is detected at a concentration at or above the value for the LIMS MDL in the method blank and if the ratio of the sample to blank result, on a wet-weight basis, meets these rules:
 - A “**B**” flag is applied if the associated blank is $\geq$ the LIMS MDL value and the sample result is $\geq$ MDL but ≤ 5 times the blank result.
 - A “**B3**” flag is applied if the associated blank is $\geq$ the LIMS MDL value and the sample result is > 5 and ≤ 10 times the blank result.
- **J** is applied to a parameter result when the reported value is an estimated value. All values less than the LIMS RDL value will receive a J qualifier for SW-846 methods.
- **JG** is applied to a parameter result when the reported value is an estimated value with a probable low bias.
- **JL** is applied to a parameter result when the reported value is an estimated value with a probable high bias.
- **H** indicates that a holding time criterion was not met prior to completion of analysis.
- **SH** indicates that a sample handling criterion was not met in some manner prior to analysis. The sample may have been compromised during the sampling procedure or may not comply with storage conditions or preservation requirements.
- **R** is applied to a parameter result that has been rejected and deemed unusable for all purposes
- **<MDL** is applied to sample data when a target analyte is not detected. This qualifier will no longer pertain to SW-846 methods. For this SAP, this qualifier will only be used for total solids, ammonia, and PSD data.
- **<RDL** is applied to sample results when a target analyte is detected at a concentration greater than or equal to the associated LIMS MDL, but less than the associated LIMS RDL value. This qualifier will no longer pertain to SW-846 methods and has been replaced by the qualifier <QL. For this SAP, this qualifier will only be used for total solids, ammonia, and PSD data.
- **<QL** replaces the <MDL and <RDL qualifiers for SW-846 methods. It is applied when a target analyte is detected at a concentration less than the associated LLOQ (LIMS RDL value) or when a parameter is not detected.

9 Data Management Procedures

This section details program data recording and reporting requirements.

9.1 Data Recording Requirements

Proper data management, including of both field and laboratory measurements, is critical for maintaining a long-term dataset. Field measurements will be collected on field sheets and the information from the field sheets (noted in Section 6.6) will be transferred to LIMS. Table 13 includes the LIMS product names that will be used to specify the analyses to be completed.

Table 13. King County Environmental Laboratory's Laboratory Information Management System (LIMS) products and list types.

Parameter	LIMS Product
Ammonia	NH3-KCL
PSD	PSD
TOC	TOC-QL
Total Solids	TOTS
Total Sulfide	TOTSULFIDE-QL
Mercury by CVAA	HG-CVAA-M-QL
ICPMS Metals	AG-ICPMS-QL, AL-ICPMS-QL, AS-ICPMS-QL, CD-ICPMS-QL, CR-ICPMS-QL, CU-ICPMS-QL, FE-ICPMS-QL, PB-ICPMS-QL, SE-ICPMS-QL, ZN-ICPMS-QL
BNAs	BNASMS-QL, BNASMS-SIM-QL
PCBs	PCB-QL
PBDEs	PBDE-QL
Butyltins	TRIBUTYLtin-QL
CL Pesticides	CLPEST-QL

CVAA – Cold vapor atomic absorption spectroscopy.

ICPMS – Inductively coupled plasma mass spectroscopy.

CL Pesticides – Chlorinated pesticides

Following secondary review of the QC results by the program manager, and after any necessary corrective actions are taken, data will be uploaded to King County's Open Data platform and made accessible to the public. Finally, data will then be pulled from Open Data for summarization in reports and dashboards.

9.2 Laboratory Data Reporting Requirements

After any corrective actions (Section 8.3) are taken, data will be stored in the LIMS database and a summary of laboratory results will be reported in a QA1-level report which will include:

- a narrative discussing data quality in relation to study objectives and data criteria;
- all associated QC data (LIMS QC reports and batch reports);
- copies of field sheets and COC forms; and
- a comprehensive report containing all analytical and field data (including data qualifier flags summarized in Section 8.4) produced by KCEL.

All field records, custody documents, raw lab data, and narratives will be archived according to KCEL policy, for a minimum of 10 years from the date samples were collected. Interpretative reports and

memoranda, along with all chemistry data, benthic taxonomy data, and their respective data analysis program narratives and reports will be stored in program files, by the program manager, for a minimum of 10 years from the date samples were collected.

9.3 Third-party Data Upload Requirements

While not a legal requirement, the program manager will upload complete and reviewed data from the sampling event to Ecology's EIM database. This will be accomplished by using the EIM Special Report in King County's LIMSVIEW Database.

9.4 Model Information Management

Not Applicable

10 Data Quality and Usability Assessment

The program manager, in conjunction with the KCEL laboratory project manager, will conduct data review and verification. This effort will be supported by the QA1-level report, provided by the KCEL laboratory project manager, which will be used to determine if program objectives were met and how to handle data if they are not met. Any data that are excluded from future data analysis due to secondary review of the data will be noted within that deliverable (e.g., reports and data dashboards).

10.1 Data Review, Verification, and Validation

Data review is the in-house (King County) examination to ensure that the data have been recorded, transmitted, and processed correctly, including checking for data entry, transcription, calculation, reduction, and transformation errors. Each data package from KCEL is peer-reviewed for these types of errors by each analytical unit before it is loaded into LIMS.

Sample data download from LIMS by the program manager will be dry weight and organic carbon normalized for appropriate parameters. These data transformations will allow data to be compared to marine sediment quality standards. These transformed data will undergo additional review to ensure there is a complete list of sample information available, such as sample matrices, sample collection and analysis dates, lab sample numbers, etc., and ensure there are no calculation (transformation) errors. The program manager will also conduct a completeness check to determine if there are any deficiencies, such as data missing or integrity lost (e.g., due to corruption or loss in storage or processing).

Data verification is a systematic process for evaluating performance and compliance of a set of data when compared to a set of standards to ascertain the data's completeness, correctness, and consistency using methods and criteria defined in the SAP. The QA1-level report will be used for the evaluation of:

- Field and analytical procedures
- Data quality objectives (Section 5)
- MQOs (Section 5)
- Reporting limits (Section 7)
- Data qualifiers

If the specified criteria are met, data should be usable for program objectives. If these criteria are not met, the program manager will work with KCEL staff to determine whether data are still usable and sufficient to meet the program objectives. Data that do not meet the criteria noted in this SAP will be qualified and may be excluded from further analysis at the discretion of the program manager.

The program manager will add notes to any data that have been manipulated after being downloaded from LIMS. This way, information about the sample data is translated to future data users. This is

especially important for data available to the public who may not have easy access to full laboratory QC information as is the case for data provided on the Open Data platform. Examples of information that should be provided include: missing data due to the loss of a sample, whether samples were re-run in triplicate due to anomalous results, etc.

10.2 Treatment for Non-detects

Non-detects in sediment chemistry data are common, especially for those parameters that occur at low concentrations such as chlorinated pesticides. In data summaries and on the web, values will be flagged as non-detect. For graphical representations of the data, the non-detects will be censored at the reporting limit (quantitation limit), and represented with a different symbol (e.g., open symbol) than detected values. Summary statistics for parameters with non-detect values will be estimated using techniques such as regression on order statistics (ROS) or Kaplan-Meier censoring techniques (Helsel, 2012).

For data being compared to SMS (Ecology, 2013), the rules for how to treat non-detects noted in those standards will be followed. For example, when summing concentrations (e.g., Total PCB Aroclors), only detected values will be used, and if all compounds are non-detects, the highest reporting limit of the parameters being summed (quantitation limit) will be used as the total value. Sums that only consist of a reporting limit will be indicated and treated as a non-detect for analysis purposes.

10.3 Data Analysis Approach

Prior to any data analysis, the following steps will be completed:

- 1) Any data with an “R” (rejected) flag will be removed from the dataset
- 2) Data that have been flagged with a “B” (blank contamination) qualifier, will be evaluated by comparing the detected concentration to the concentration detected in the method blank. If the detected concentration is $> 10\times$ the concentration of the method blank concentration, the value may be used. If $< 10\times$ the method blank concentration, the value can be excluded from the dataset or treated as a non-detect.
- 3) Samples with “SH” (sample handling criterion not met) or “J” (estimated value) qualifiers, will be assessed for usability.
- 4) Field or laboratory duplicates (when samples have been reanalyzed), may be averaged and reported as a single value.

In all cases, what data were removed or how they were treated prior to further data analysis will be detailed in any deliverable.

Sediment chemistry data will be evaluated by comparing results to SMS criteria (from Chapter 173-204 WAC and Ecology, 2021 [Table A-1]; see [Appendix A](#)). Sediment data for some organic compounds are typically normalized to organic carbon content for comparison to SMS criteria. Normalization to organic carbon can produce biased results when the organic carbon content of the sample is very low or extremely high. Therefore, if the organic carbon content at any station is below 0.5% or above 3.5% dry weight, then dry weight-normalized results for non-ionizable organic compounds will be compared to AETs (EPA, 1988; Ecology, 2021), rather than SMS criteria. Historically some stations in Elliott Bay have had TOC values below 0.5% or above 3.5%, while others have been in-between.

Concentrations of SMS and non-SMS chemicals will be compared to results from previous King County and regional monitoring data. Summary statistics (e.g., minimum, maximum, mean, median, standard deviation) of long-term and current-conditions sites, will be computed for all variables. ROS or Kaplan-Meier (Helsel, 2012) estimation techniques will be used when non-detects are present.

Trends will be calculated for the three long-term monitoring sites for each site and parameter combination where no more than 50% of the data are non-detects. The cenken function in the NADA package in R, or an equivalent function, will be used to calculate Kendall's tau correlation coefficients and associated trend lines for censored data. This function substitutes non-detects using maximum likelihood estimation.

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12 Glossary

12.1 Acronyms

AET	Apparent Effects Thresholds
BNA	base/neutral/acid semivolatile organic compound
COC	chain of custody
CSO	combined sewer overflow
CVAA	cold vapor atomic absorption spectroscopy
CWM PP	clear, wide-mouth polypropylene
DGPS	differential global positioning system
DQO	data quality objective
dw	dry weight
e.g.	for example
EIM	Environmental Information Management
EPA	Environmental Protection Agency
GC/ECD	gas chromatography/electron capture detector
GC/MS	gas chromatography/mass spectroscopy
GPC	gel permeation chromatography
ICPMS	inductively coupled plasma mass spectroscopy
i.e.	in other words

KC	King County
KCEL	King County Environmental Laboratory
LCS	laboratory control sample
LIMS	Laboratory Information Management System
LLOQ	lower limit of quantitation
MDL	method detection limit
MQOs	measurement quality objective
MS	matrix spike or mass spectroscopy
MSD	matrix spike duplicate
NCI	negative chemical ionization
PAH	polycyclic aromatic hydrocarbon
PBDE	polybrominated diphenyl ether
PCB	polychlorinated biphenyl
PFD	personal flotation device
PSD	particle size distribution
PSEP	Puget Sound Estuary Program
QA	quality assurance
QC	quality control
QL	quantitation limit
RDL	reporting detection limit
ROS	regression on order statistics
RPD	relative percent difference
RSD	relative standard deviation
SAP	sampling and analysis plan
SIM	selected ion monitoring
SMS	Sediment Management Standards
SOP	standard operating procedure
SQS	sediment quality standards
SRM	standard reference material
TBD	to be determined
TOC	total organic carbon
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WTD	Wastewater Treatment Division
ww	wet weight

12.2 Units of Measurement

cm	centimeter
kg	kilogram
km	kilometer
m	meter
mg	milligram

mg/kg	milligram per kilogram (parts per million)
ml	milliliters
µg	microgram
µg/kg	microgram per kilogram (parts per billion)

12.3 Quality Control Glossary

<MDL	Qualifier that is applied when a target analyte is not detected. This qualifier will no longer pertain to SW-846 methods. For this SAP, this qualifier will only be used for total solids, ammonia, and PSD data.
<QL	Qualifier that replaces the <MDL and <RDL qualifiers for SW-846 methods. It is applied when a target analyte is detected at a concentration less than the associated LLOQ (LIMS RDL value) or when a parameter is not detected.
<RDL	Qualifier that is applied when a target analyte is detected at a concentration greater than or equal to the associated LIMS MDL, but less than the associated LIMS RDL value. This qualifier will no longer pertain to SW-846 methods and has been replaced by the qualifier <QL. For this SAP, this qualifier will only be used for total solids, ammonia, and PSD data.
Accuracy	A measure of the overall agreement of a measurement to a known value; affected by a combination of random error (precision) and systematic error (bias) components of both sampling and analytical operations.
B	Qualifier applied to data if the associated method blank is $\geq$ the LIMS MDL value and the sample result is $\geq$ MDL but $\leq$ 5 times the blank result, on a wet-weight basis
B3	Qualifier applied to data if the associated method blank is $\geq$ the LIMS MDL value and the sample result is > 5 and ≤ 10 times the blank result, on a wet-weight basis.
Bias	The systematic or persistent distortion of a measurement process that causes errors in one direction of its true value.
Blank	Analyte-free sample that is used to detect contamination during sample handling, preparation, and/or analysis. Can be in a form of method blank, calibration blank, field blank, etc.
Calibration	Laboratory process to establish the relationship between the response of the system used for quantifying a parameter and the concentration of that parameter.

Comparability	A qualitative term that expresses the measure of confidence that one data set can be compared to another and can be combined for the decision(s) to be made.
Completeness	A measure of the amount of valid data needed to be obtained from a measurement system.
Data Quality Objectives (DQO)	Series of steps that guide the collection and analysis of environmental data. Include quantitative and qualitative statements that define the appropriate type of data needed and tolerable levels of error to ensure that data meet the program goals.
Data review	By-parameter examination to ensure that the data have been recorded, transmitted, and processed correctly, including checking for data entry, transcription, calculation, reduction, and transformation errors.
Data verification	Detailed review of a dataset for errors, omissions, and assessment of measurement quality objectives.
Duplicate sample	Two samples treated the same. Can be a field or lab duplicate. A field duplicate sample consists of a second aliquot of the collected sample placed in separate sample containers. A lab duplicate consists of two aliquots of the same sample processed in parallel to show method reproducibility.
H	Qualifier that indicates that a holding time criterion was not met prior to completion of analysis.
J	Qualifier that is applied to a parameter result when the reported value is an estimated value. All values less than the LIMS RDL value will receive a J qualifier for SW-846 methods.
JG	Qualifier that is applied to a parameter result when the reported value is an estimated value with a probable low bias.
JL	Qualifier that is applied to a parameter result when the reported value is an estimated value with a probable high bias.
Laboratory Control Sample (LCS)	A laboratory control sample (LCS) is a sample of known analyte concentration(s) that is obtained from an outside source or prepared in the lab from a separate source of analyte(s) relative to the calibration standards. The LCS analysis should follow the entire analytical process. Analysis of a LCS is used as an indicator of method accuracy and long-term analytical precision.
Matrix Spike (MS)	A matrix spike is a second sample aliquot fortified with a known concentration of a target analyte(s). The spiked

	sample is processed through the entire analytical procedure. Analysis of the matrix spike is used as an indicator of sample matrix effect on the recovery of target analyte(s).
Measurement Quality Objectives (MQOs)	Specify how good the data quality must be to meet the objectives of the program. They are often obtained from the participating laboratories, and/or the analytical methods used.
Method	A body of procedures and techniques for performing an activity systematically presented in the order in which they are to be executed.
Method blank	A method blank is an aliquot of a clean reference matrix such as purified sodium sulfate for soil/sediment samples which is processed through the entire analytical procedure. If no suitable reference matrix is available, the method blank will include only the reagents. Analysis of the method blank is used to evaluate the levels of contamination that might be associated with the processing and analysis of samples.
Method detection limit (MDL)	The minimum concentration where the analyte can be reliably distinguished from the blank (a false positive rate of $\leq 1\%$).
Open Data	Web interface for sharing King County datasets with the public. https://data.kingcounty.gov/
Parameter	A unique measurable factor. Often used interchangeably with analyte or method.
Precision	The measure of agreement among repeated measurements of the same property under identical or substantially similar conditions; calculated as either the range or as the standard deviation. A measure of the overall agreement of a measurement to a known value; includes a combination of random error (precision) and systematic error (bias) components of both sampling and analytical operations.
Quality Assurance (QA)	An integrated system of activities involving planning, implementation, assessment, documentation, reporting, and quality improvement to ensure that a process, item or service is of the type and quality needed and expected by the customer.
Quality Control (QC)	The application of method and statistically-based procedures to evaluate and control the accuracy and precision of analyses relative to established standards. Quality Control is an element of quality assurance.

	Analysis of QC samples are common quality control activities.
R	Qualifier that is applied to a parameter result that has been rejected and deemed unusable for all purposes
Relative Percent Difference (RPD)	Absolute difference of two measurements, divided by the mean of the measurements, multiplied by 100.
Relative Standard Deviation (RSD)	The standard deviation expressed as a percentage of the mean. Also termed coefficient of variation.
Replicate Sample	Two or more samples taken at the same time and place using identical protocols. Replicates are used to estimate the amount of variability of a material sample.
Reporting Detection Limit (RDL)	The minimum concentration of an analyte that can be reliably measured. This is the lowest concentration where the analyte has been shown to meet specified precision and accuracy limits.
Representativeness	A qualitative term that expresses “the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition.” (ANSI/ASQC 1995).
Sampling and Analysis Plan (SAP)	A written document that details the history of the sampling project or program, the goals of that project/program, where sampling will occur, standardized methods for sample collection and analysis, and how data will be reviewed and used. This document helps ensure accurate and reliable results for the project or program.
Sensitivity	The capability of a method or instrument to discriminate between measurement responses representing different levels of the variable of interest.
SH	Qualifier that indicates that a sample handling criterion was not met in some manner prior to analysis. The sample may have been compromised during the sampling procedure or may not comply with storage conditions or preservation requirements.
Spike Blank	A spike blank is an aliquot of clean reference matrix used for the method blank, such as reverse osmosis water for water samples and purified sodium sulfate for soil/sediment samples, to which a known concentration of target analyte(s) has been added. If no suitable reference matrix is available, the spike blank will include only the reagents. The spiked aliquot is processed through the entire analytical procedure. Analysis of the spike blank is used as an indicator of method accuracy.

Spiked Sample	A sample to which a known amount of analyte added to. When it's added to an environmental sample, the sample is called a matrix spike.
Standard	A solution or material, of which the concentration and purity of the target analyte or property are known. In chemical measurements, standard often describes a solution of analytes used to calibrate an instrument.
Standard Operating Procedure (SOP)	A written document that details the method for an operation, analysis or action with thoroughly described techniques and steps and that is officially approved as the method for performing such tasks.
Surrogate	A surrogate is a known concentration of non-target analyte which is added to each sample (both standard and QC samples) prior to extraction. Surrogate recovery is used as an indication of method or matrix bias for target analytes. The surrogate is selected to behave in a similar manner to the target analytes.

Appendix A – Metals and Organics Sediment Quality Criteria

Table A-1. Washington State Department of Ecology marine sediment chemical criteria (Ecology SCUM, 2021 Appendix A Table A-1).

Analyte	SMS Marine Sediment ^a		Marine Sediment AETs ^b	
	SQS/SCO	CSL/SIZmax	SCO	CSL/SIZmax
Metals	mg/kg dw		mg/kg dw	
Arsenic	57	93	57	93
Cadmium	5.1	6.7	5.1	6.7
Chromium	260	270	260	270
Copper	390	390	390	390
Lead	450	530	450	530
Mercury	0.41	0.59	0.41	0.59
Silver	6.1	6.1	6.1	6.1
Zinc	410	960	410	960
Organic Chemicals	µg/kg dw (except *)		µg/kg dw	
2,4-Dimethylphenol	29	29	29	29
2-Methylphenol	63	63	63	63
4-Methylphenol	670	670	670	670
Benzoic acid	650	650	650	650
Benzyl alcohol	57	73	57	73
Dibenzofuran	15*	58*	540	540
Phenol	420	1200	420	1200
N-nitrosodiphenylamine	11*	11*	28	40
Phthalates	mg/kg OC		µg/kg dw	
Bis(2-Ethylhexyl)phthalate	47	78	1300	1900
Butylbenzyl phthalate	4.9	64	63	900
Diethyl phthalate	61	110	200	>1200
Dimethyl phthalate	53	53	71	160
Di-n-butyl phthalate	220	1700	1400	1400
Di-n-octyl phthalate	58	4500	6200	6200
PCBs	mg/kg OC		µg/kg dw	
Total Aroclors	12	65	130	1000
Polycyclic Aromatic Hydrocarbons	mg/kg OC		µg/kg dw	
Total LPAH	370	780	5200	5200

Analyte	SMS Marine Sediment ^a		Marine Sediment AETs ^b	
	SQS/SCO	CSL/SIZmax	SCO	CSL/SIZmax
Naphthalene	99	170	2100	2100
Acenaphthylene	66	66	1300	1300
Acenaphthene	16	57	500	500
Fluorene	23	79	540	540
Phenanthrene	100	480	1500	1500
Anthracene	220	1200	960	960
2-Methylnaphthalene	38	64	670	670
Total HPAH	960	5300	12000	17000
Fluoranthene	160	1200	1700	2500
Pyrene	1000	1400	2600	3300
Benz[a]anthracene	110	270	1300	1600
Chrysene	110	460	1400	2800
Total benzofluoranthenes	230	450	3200	3600
Benzo[a]pyrene	99	210	1600	1600
Indeno[1,2,3-c,d]pyrene	34	88	600	690
Dibenzo[a,h]anthracene	12	33	230	230
Benzo[g,h,i]perylene	31	78	670	720
Chlorinated Organics	mg/kg OC		µg/kg dw	
1,2,4-Trichlorobenzene	0.81	1.8	31	51
1,2-Dichlorobenzene	2.3	2.3	35	50
1,4-Dichlorobenzene	3.1	9	110	110
Hexachlorobenzene	0.38	2.3	22	70
Hexachlorobutadiene	3.9	6.2	11	120
Pentachlorophenol	360**	690**	360	690

^a Marine SMS values are dry weight normalized for metals and polar organics and normalized to total organic carbon for nonpolar organics.

^b Dry weight normalized AETs are recommended when total organic carbon is outside the recommended range of 0.5 – 3.5% for organic carbon normalization.

* mg/kg OC

** Pentachlorophenol is in µg/kg dry weight

Appendix B - Sediment Chemistry Sampling Supplies

Table B-1. Elliott Bay sediment chemistry sampling supply checklist.

Check Off		Equipment	QTY.	Used for	Comments
Setup	Loaded				
GENERAL GEAR:					
		Dunnage (plywood)		Deck protection	
		SS VanVeen grabs	1		
		Sed. table	1		
		Dust pan/Shovel		To scrape off sed. table	
		Sed. depth ruler		To measure grab penetration	
		SAPs copy/COC forms			One COC form per sampling day
		Waypoints loaded to PC			
		Field sheets/Labels			Pre-label all jars
		Field observation form			
		Space pens, clip board			
		Ice chests, ice ea. day			
		SAMPLE MIXING/SPLITTING:			
		Zinc Acetate- 2N		Plus Transfer Pipets	-
		SS bowls	1/sta		-
		SS spatulas/spoons	1/sta		-
		Grab drain tubing			
		Sed. Type key			
		Nitrile gloves			
		Aluminum foil			On SoundGuardian
		Brushes		for washing grabs	
		SAMPLE CONTAINERS:			
		4 oz. (125 ml) wide-mo. PP	1/sta	TOTS/TOC	3/4 full only
		4 oz. (125 ml) wide-mo. PP	1/sta	NH3	3/4 full only
		4 oz. (125 ml) wide-mo. PP	1/sta	TOTSULFIDE	No Headspace- Zn Acetate
		16 oz. (500 ml) wide-mo. PP	1/sta	PSD	Collect 2nd jar for QC every 20 samples
		8 oz. (250 ml) wide-mo. Glass	2/sta	Organics	Less than 3/4 full only
		4 oz. (125 ml) wide-mo. PP	1/sta	individual elements ICPMS + Hg	3/4 full only
		4 oz. (125 ml) wide-mo. Glass	1/sta	Extra for PCB or dioxin/furan congener	Less than 3/4 full only

Note: Lead sampler must debrief previous crew & brief new crew each morning.

Appendix C – Sediment Type Code

When sediments are collected, field personnel include a description of the sediment type using a five-character format (XXXXX).

Principal Fraction (X___)

- 1 – Clay (<0.0039 mm)
- 2 – Silt/Mud (0.0039-0.063 mm)
- 3 – Sand (0.063 – 2 mm)
- 4 – Gravel (2 – 16 mm)
- 5 – Pebble/Cobble (16 - 256 mm)
- 6 – Boulders (>256 mm)

Secondary Fraction (_X___)

- 0 – None
- 1 – Clay (<0.0039 mm)
- 2 – Silt/Mud (0.0039-0.063 mm)
- 3 – Sand (0.063 – 2 mm)
- 4 – Gravel (2 – 16 mm)
- 5 – Pebble/Cobble (16 - 256 mm)
- 6 – Boulders (>256 mm)

Predominant Sample Debris (__X__)

- N – None
- W – Wood Chips
- M – Metal Fragments
- T – Tube Worms
- P – Plants
- S – Shells
- C – Coal
- D – Manmade Debris/Other

Predominant Sample Color (___X_)

- 1 – Black
- 2 – Brown
- 3 – Grey
- 4 – Green
- 5 – Tan

Sample Odor (___X)

- 0 – Odorless
- 1 – Natural, Non-Specific
- 2 – Solvent/Petroleum Slight
- 3 – Solvent/Petroleum Moderate
- 4 – Solvent/Petroleum Strong
- 5 – Solvent/Petroleum Overwhelming
- 6 – Hydrogen Sulfide Slight
- 7 – Hydrogen Sulfide Moderate
- 8 – Hydrogen Sulfide Strong
- 9 – Hydrogen Sulfide Overwhelming

Appendix D - Metals and Organics Performance – Based QC Limit Goals

Table D-1. Laboratory QC limits for soil metals – LCS recoveries (ERA SOIL)

Parameter	Lower Limit (%)	Upper Limit (%)
Aluminum	48	152
Arsenic	80	120
Cadmium	80	120
Chromium	80	120
Copper	80	120
Iron	63	138
Lead	80	120
Mercury	74	126
Selenium	79	121
Silver	80	120
Zinc	80	120

QC Limits are laboratory performance based limits and may change as recovery windows are evaluated and updated annually.

Table D-2. Laboratory QC limits for sediment metals – SRM recoveries (PACS-3)

Parameter	Lower Limit (%)	Upper Limit (%)
Aluminum	80	120
Arsenic	80	120
Cadmium	80	120
Chromium	80	120
Copper	80	120
Iron	80	120
Lead	80	120
Mercury	80	120
Zinc	80	120

QC Limits are laboratory performance based limits and may change as recovery windows are evaluated and updated annually.

* Selenium and silver are not certified in PACS-3

Table D-3. Laboratory QC limits for sediment BNAs – matrix spike recoveries.

Parameter	Lower Limit (%)	Upper Limit (%)	Parameter	Lower Limit (%)	Upper Limit (%)
1,2,4-Trichlorobenzene	50	150	Chrysene	50	150
1,2-Dichlorobenzene	50	150	Di-N-Butyl Phthalate	50	150
1,4-Dichlorobenzene	50	150	Di-N-Octyl Phthalate	50	150
2,4-Dimethylphenol	50	150	Dibenzo(a,h)anthracene	50	150
2-Methylnaphthalene	50	150	Dibenzofuran	50	150
2-Methylphenol	50	150	Diethyl Phthalate	50	150
3-,4-Methylphenol	50	150	Dimethyl Phthalate	50	150
Acenaphthene	50	150	Fluoranthene	50	150
Acenaphthylene	50	150	Fluorene	50	150
Anthracene	50	150	Hexachlorobenzene	50	150
Benzo(a)anthracene	50	150	Hexachlorobutadiene	50	150
Benzo(a)pyrene	50	150	Indeno(1,2,3-Cd)Pyrene	50	150
Benzo(b,j,k)fluoranthene	50	150	N-Nitrosodiphenylamine	50	150
Benzo(g,h,i)perylene	50	150	Naphthalene	50	150
Benzoic Acid	50	150	Pentachlorophenol	50	150
Benzyl Alcohol	50	150	Phenanthrene	50	150
Benzyl Butyl Phthalate	50	150	Phenol	50	150
Bis(2-Ethylhexyl)Phthalate	50	150	Pyrene	50	150

QC Limits are laboratory performance based limits and may change as recovery windows are evaluated and updated annually.

Table D-4. Laboratory QC limits for sediment BNAs – blank spike recoveries.

Parameter	Lower Limit (%)	Upper Limit (%)	Parameter	Lower Limit (%)	Upper Limit (%)
1,2,4-Trichlorobenzene	50	150	Chrysene	50	150
1,2-Dichlorobenzene	50	150	Di-N-Butyl Phthalate	50	150
1,4-Dichlorobenzene	50	150	Di-N-Octyl Phthalate	50	150
2,4-Dimethylphenol	50	150	Dibenzo(a,h)anthracene	50	150
2-Methylnaphthalene	50	150	Dibenzofuran	50	150
2-Methylphenol	50	150	Diethyl Phthalate	50	150
3-,4-Methylphenol	50	150	Dimethyl Phthalate	50	150
Acenaphthene	50	150	Fluoranthene	50	150
Acenaphthylene	50	150	Fluorene	50	150
Anthracene	50	150	Hexachlorobenzene	50	150
Benzo(a)anthracene	50	150	Hexachlorobutadiene	50	150
Benzo(a)pyrene	50	150	Indeno(1,2,3-Cd)Pyrene	50	150
Benzo(b,j,k)fluoranthene	50	150	N-Nitrosodiphenylamine	50	150
Benzo(g,h,i)perylene	50	150	Naphthalene	50	150
Benzoic Acid	50	150	Pentachlorophenol	50	150
Benzyl Alcohol	50	150	Phenanthrene	50	150
Benzyl Butyl Phthalate	50	150	Phenol	50	150
Bis(2-Ethylhexyl)Phthalate	50	150	Pyrene	50	150

QC Limits are laboratory performance based limits and may change as recovery windows are evaluated and updated annually.

Table D-5. Laboratory QC limits for sediment BNAs – surrogate recoveries.

Parameter	Lower Limit (%)	Upper Limit (%)
2,4,6-Tribromophenol	40	150
2-Fluorophenol	40	150
d5-Phenol	40	150
d5-Nitrobenzene	40	150

QC Limits are laboratory performance based limits and may change as recovery windows are evaluated and updated annually.

Table D-6. Laboratory QC limits for sediment BNAs – SRM recoveries.

Parameter	Lower Limit (%)	Upper Limit (%)
Benzo(a)anthracene	40	150
Benzo(a)pyrene	40	150
Benzo(b,j,k)fluoranthene	40	150
Benzo(g,h,i)perylene	40	150
Chrysene	40	150
Dibenzo(a,h)anthracene	40	150
Fluoranthene	40	150
Indeno(1,2,3-Cd)Pyrene	40	150
Phenanthrene	40	150
Pyrene	40	150

QC Limits are laboratory performance based limits and may change as recovery windows are evaluated and updated annually.

Table D-7. Laboratory QC limits for sediment chlorinated pesticides and PCBs – matrix spike recoveries.

Parameter	Lower Limit (%)	Upper Limit (%)
4,4'-DDD	64	112
4,4'-DDE	68	115
4,4'-DDT	55	123
Aldrin	52	117
Alpha-BHC	57	109
Alpha-Chlordane	66	111
Beta-BHC	64	110
Delta-BHC	63	118
Dieldrin	65	116
Endosulfan I	20	125
Endosulfan II	30	117
Endosulfan Sulfate	44	120
Endrin	65	141
Endrin Aldehyde	20	100
Gamma-BHC (Lindane)	58	115
Trans-Chlordane	56	125
Heptachlor	62	117
Heptachlor Epoxide	64	108
Methoxychlor	61	125
Aroclor 1242	51	100
Aroclor 1260	35	108

QC Limits are laboratory performance based limits and may change as recovery windows are evaluated and updated annually.

Table D-8. Laboratory QC limits for sediment chlorinated pesticides and PCBs – blank spike recoveries.

Parameter	Lower Limit (%)	Upper Limit (%)
4,4'-DDD	68	118
4,4'-DDE	67	111
4,4'-DDT	71	117
Aldrin	33	100
Alpha-BHC	22	100
Alpha-Chlordane	60	112
Beta-BHC	49	107
Delta-BHC	62	105
Dieldrin	64	113
Endosulfan I	30	103
Endosulfan II	43	111
Endosulfan Sulfate	56	114
Endrin	65	115
Endrin Aldehyde	22	100
Gamma-BHC (Lindane)	33	101
Trans-Chlordane	55	113
Heptachlor	34	100
Heptachlor Epoxide	52	110
Methoxychlor	66	119
Aroclor 1242	38	100
Aroclor 1260	70	109

QC Limits are laboratory performance based limits and may change as recovery windows are evaluated and updated annually.

Table D-9. Laboratory QC limits for sediment chlorinated pesticides– SRM and surrogate recoveries.

Parameter	Lower Limit (%)	Upper Limit (%)
Alpha-Chlordane	69	136
Decachlorobiphenyl	47	122
2,4,5,6-Tetrachloro-m-xylene	20	134

QC Limits are laboratory performance based limits and may change as recovery windows are evaluated and updated annually.

Table D-10. Laboratory QC limits for sediment PCBs – surrogate recoveries.

Parameter	Lower Limit (%)	Upper Limit (%)
Decachlorobiphenyl	51	115
2,4,5,6-Tetrachloro-m-xylene	22	113

QC Limits are laboratory performance based limits and may change as recovery windows are evaluated and updated annually.

Table D-11. Laboratory QC limits for sediment butyltins – butyltin matrix spike recoveries.

Tri-n-butyltin (as tributyltin)	Lower Limit (%)	Upper Limit (%)
Mono-n-Butyltin (as monobutyltin ion)	50	150
Di-n-Butyltin (as dibutyltin ion)	50	150
Tri-n-Butyltin (as tributyltin ion)	50	150
Tetra-n-Butyltin (as tetrabutyltin)	50	150

QC Limits are laboratory performance based limits and may change as recovery windows are evaluated and updated annually.

Table D-12. Laboratory QC limits for sediment butyltins – butyltin spike blank recoveries.

Tri-n-butyltin (as tributyltin)	Lower Limit (%)	Upper Limit (%)
Mono-n-Butyltin (as monobutyltin ion)	50	150
Di-n-Butyltin (as dibutyltin ion)	50	150
Tri-n-Butyltin (as tributyltin ion)	50	150
Tetra-n-Butyltin (as tetrabutyltin)	50	150

QC Limits are laboratory performance based limits and may change as recovery windows are evaluated and updated annually.

Table D-13. Laboratory QC limits for sediment butyltins – butyltin SRM recoveries.

Tri-n-butyltin (as tributyltin)	Lower Limit (%)	Upper Limit (%)
Mono-n-Butyltin (as monobutyltin ion)	40	150
Di-n-Butyltin (as dibutyltin ion)	40	150
Tri-n-Butyltin (as tributyltin ion)	40	150

QC Limits are laboratory performance based limits and may change as recovery windows are evaluated and updated annually.

Table D-14. Laboratory QC limits for sediment butyltins – butyltin surrogate recoveries.

Tri-n-butyltin (as tributyltin)	Lower Limit (%)	Upper Limit (%)
Triphenyltin	49	133
Tripropyltin	40	136

QC Limits are laboratory performance based limits and may change as recovery windows are evaluated and updated annually.

Table D-15. Laboratory QC limits for sediment PBDEs - PBDE spike blank recoveries.

Parameter	Lower Limit (%)	Upper Limit (%)	Parameter	Lower Limit (%)	Upper Limit (%)
PBDE-17	42	122	PBDE-100	38	122
PBDE-28	30	136	PBDE-138	32	144
PBDE-47	47	139	PBDE-153	39	130
PBDE-66	50	155	PBDE-154	41	119
PBDE-71	41	128	PBDE-183	45	118
PBDE-85	40	128	PBDE-190	10	143
PBDE-99	41	136	PBDE-209	10	108

QC Limits are laboratory performance based limits and may change as recovery windows are evaluated and updated annually.

Table D-16. Laboratory QC limits for sediment PBDEs - PBDE matrix spike recoveries

Parameter	Lower Limit (%)	Upper Limit (%)	Parameter	Lower Limit (%)	Upper Limit (%)
PBDE-17	49	131	PBDE-100	42	134
PBDE-28	51	137	PBDE-138	40	161
PBDE-47	48	140	PBDE-153	54	120
PBDE-66	72	132	PBDE-154	44	134
PBDE-71	53	130	PBDE-183	52	125
PBDE-85	55	132	PBDE-190	40	129
PBDE-99	51	131	PBDE-209	10	111

QC Limits are laboratory performance based limits and may change as recovery windows are evaluated and updated annually.

Table D-17. Laboratory QC limits for sediment PBDEs – PBDE LCS recoveries

Parameter	Lower Limit (%)	Upper Limit (%)	Parameter	Lower Limit (%)	Upper Limit (%)
PBDE-17	60	200	PBDE-138	44	170
PBDE-28	48	153	PBDE-153	37	168
PBDE-47	57	186	PBDE-154	54	160
PBDE-85	40	176	PBDE-183	45	171
PBDE-99	43	179	PBDE-209	90	200
PBDE-100	53	148			

QC Limits are laboratory performance based limits and may change as recovery windows are evaluated and updated annually.