Quality Assurance Project Plan

Surface Sediment and Fish Tissue Chemistry in Greater Elliott Bay (Seattle)

By
Thomas H. Gries

Environmental Assessment Program
Washington State Department of Ecology
Olympia, Washington 98504-7710

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For more information contact:

Carol Norsen
Environmental Assessment Program
P.O. Box 47600
Olympia, WA 98504-7600
E-mail: cnor461@ecy.wa.gov
Phone: 360-407-7486

Washington State Department of Ecology - www.ecy.wa.gov/

- Headquarters, Olympia 360-407-6000
- Northwest Regional Office, Bellevue 425-649-7000
- Southwest Regional Office, Olympia 360-407-6300
- Central Regional Office, Yakima 509-575-2490
- Eastern Regional Office, Spokane 509-329-3400

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February 2008

Approved by:

Signature[1]:	Date: January 2008
Brad Helland, Client, TCP[2], Northwest Regional Office	
Signature:	Date: January 2008
Gail Colburn, Supervisor, TCP, Northwest Regional Office	
Signature:	Date: January 2008
Bob Warren, Section Manager, TCP, Northwest Regional Office	
Signature:	Date: February 2008
Sandra Aasen/Maggie Dutch, Clients, Western Operations Section, EAP[3]	
Signature:	Date: January 2008
Tom Gries, Project Manager, Principal Investigator, and EIM[4] Data Engineer, Toxics Studies Unit, EAP	
Signature:	Date: January 2008
George Onwumere, Supervisor, Directed Studies Unit, EAP	
Signature:	Date: January 2008
Robert Cusimano, Manager, Western Operations Section, EAP	
Signature:	Date: February 2008
Stuart Magoon, Director, Manchester Environmental Laboratory, EAP	
Signature:	Date: February 2008
Bill Kammin, Ecology Quality Assurance Officer	

[1] Signatures are not available on the Internet version
[2] Toxics Cleanup Program, Washington State Department of Ecology
[3] Environmental Assessment Program, Washington State Department of Ecology
[4] Environmental Information Management System

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List of Acronyms and Abbreviations

Following are acronyms and abbreviations used frequently in this Quality Assurance Project Plan:

Ecology	Washington State Department of Ecology
EIM	Environmental Information Management database (Department of Ecology)
EPA	U.S. Environmental Protection Agency
GPS	Global Positioning System
MEL	Manchester Environmental Laboratory (Department of Ecology)
MSMP	Marine Sediment Monitoring Program (Department of Ecology)
MQO	Measurement quality objectives
NOAA	National Oceanic Atmospheric Administration
PAHs	Polynuclear aromatic hydrocarbon compounds
PCBs	Polychlorinated biphenyl compounds
PSAMP	Puget Sound Assessment and Monitoring Program
PSEP	Puget Sound Estuary Program
QA	Quality assurance
QC	Quality control
SMS	Sediment Management Standards
SRM	Standard Reference Material
TOC	Total organic carbon
WDFW	Washington Department of Fish and Wildlife

Abstract

This project is designed to assess sediment quality and, to a lesser extent, fish tissue quality in greater Elliott Bay, Seattle. Washington State Department of Ecology (Ecology) staff will collect samples of surface sediment from 30 locations. Washington Department of Fish and Wildlife (WDFW) staff will collect English sole caught in trawl samples from two areas. Most sampling will take place in Elliott Bay proper, but some will occur in waterways that border Harbor Island and in the Lower Duwamish Superfund cleanup site.

This project will focus on measuring levels of:

- Conventionals, trace metals, PAHs, PCBs, and dioxins/furans in samples of 0-10 cm deep sediment.
- Chlorinated dioxins and furans in samples of 0-3 cm deep sediment.
- Chlorinated dioxins and furans in English sole fish tissue samples.

Some sediment samples will be tested for various indicators of chemical and biological sediment quality by staff of Ecology's Marine Sediment Monitoring Program (MSMP).

Results from this project will augment MSMP findings. The results will also be used to estimate levels of contaminants in areas that might be deemed *local area background*. This will be the first sediment survey to collect data that will enable a comparison of 0-3 cm and 0-10 cm contaminant levels.

Results from this project will add to the very limited data available for levels of dioxins and furans in English sole tissue.

Each study conducted by Ecology must have an approved Quality Assurance Project Plan. This plan describes the objectives of the study and the procedures to be followed to achieve those objectives. After completion of the study, a final report describing the study results will be posted to the Internet.

Background

This project is driven by the needs of several programs:

1. The Aquatic Lands Cleanup Program (Washington State Department of Ecology or Ecology).
2. The Puget Sound Assessment and Monitoring Program (PSAMP, several agencies).
   - The Marine Sediment Monitoring Program (MSMP, Ecology).
   - Fish Component Contaminant Surveys (Washington Department of Fish and Wildlife or WDFW).
3. The Urban Water Cleanup and Protection Initiative (Ecology).

The focus of the first program is to measure indicators of chemical and biological sediment quality in surface sediment. This usually involves testing samples of *biologically active zone* sediment (top 0-10 cm) according to the Sediment Management Standards (SMS) rule and guidance (Ecology, 1995, 2003). Results are used for various purposes, including to:

- Determine the nature and extent of sediment contamination or biological effects.
- Estimate surface area-weighted average concentrations of contaminants.
- Describe *local area background* or *reference* sediment conditions.
- Monitor the effectiveness of a particular cleanup action.

The second program, PSAMP, measures changes in the condition or health of different natural resources in the region over space and time. Ecology's MSMP measures chemical and biological sediment quality in *recent* sediment (0-3 cm deep) throughout Puget Sound for comparison to previous results and to the SMS. WDFW staff measure contaminants in tissue samples of bottom and pelagic fish that are routinely collected from Puget Sound.

Finally, the goal of the Urban Waters Initiative is to strengthen efforts to find and control sources of pollution before pollutants enter urban waters (refer to legislation and fact sheets). The initiative focuses on three geographic areas:

- The Lower Duwamish Waterway (Seattle).
- Commencement Bay (Tacoma).
- The Spokane River (near Spokane).

Part of Ecology's response to this initiative will be to measure chemical and biological quality of surface sediment samples collected from these areas. Sediment samples from greater Elliott Bay, including samples from the Duwamish River, will be collected in the summer of 2007. Commencement Bay and urban Spokane River surface sediments will be sampled in 2008 and 2009, respectively. Sediment quality will be measured at the same locations five years later, following certain cleanup and source control actions, and results will be compared to the 2007-2009 results and the SMS. This will help determine whether Ecology's cumulative actions have had positive results.

Sediment quality in greater Elliott Bay, the 2007 study area, resembles the rest of Puget Sound in at least one respect. Sediments that are closest to urban and industrial centers tend to have the greatest levels of toxic chemicals and are most likely to show evidence of biological harm.

Results from previous sediment quality surveys in this study area reveal elevated levels of arsenic, copper, lead and zinc, PAHs, PCBs and other organic compounds. Some of these pollutants are elevated mainly where industrial wastewaters, municipal wastewaters, and stormwaters have been released or are still being discharged. Other pollutants are more ubiquitous in their distribution. There are far fewer results for indicators of biological sediment quality in Puget Sound. However, numerous sampling locations within greater Elliott Bay do show significant sediment toxicity or alteration in the benthic community (Long et al., 2000; Windward Environmental, 2005, 2007; Gries, 2007a).

Project Description

Problem identification

Sediment quality in the Puget Sound region is described by the SEDQUAL database compiled over the past two decades. The database contains thousands of results from testing the chemical and biological properties of sediment samples collected from the intertidal and subtidal zones of both urban and rural areas. The database for biological sediment quality is much less extensive, but does contain evidence of toxicity (as measured in laboratory tests), altered benthic communities, and accumulations of toxic chemicals in tissues of bottom-dwelling (benthic) organisms, shellfish, and fish species.

Limitations on the usability of these data include:

- There may not be enough 0-10 cm sediment chemistry results to define *local area background* conditions for regulatory purposes.
- Existing data may not clearly show that sustained cleanup and source control actions improve sediment quality on a bay-wide scale.
- Relatively little is known about the concentrations of chlorinated dioxins and furans[5] in surface sediment or fish tissue samples collected from Puget Sound.
- 0-3 cm and 0-10 cm sediment sample results cannot easily be compared or used for the same purpose.

Sediment cleanup programs often must address sites that contain large areas where toxic chemicals pose risk to human health or the environment. Some contaminants pose too much risk even when present at concentrations below *local area background*. This means that many sediment sites, when cleaned up to acceptable levels of risk, will return to *local area background* conditions that again pose too much risk. For this reason, sediment cleanup programs may set cleanup levels at or near *local area background* concentrations. This may be the case for contaminants such as arsenic, dioxins and furans, carcinogenic PAHs, and PCBs in the Lower Duwamish Waterway and other cleanup sites.

There are not enough data to define *local area background* concentrations for certain contaminants in surface sediment of areas identified in the Urban Water Initiative. This is because:

- Cleanup programs do not often test sediment samples from areas removed from sources of contamination.
- The MSMP does not test sediment from the *biologically active zone*.

The MSMP uses a stratified, random sampling design to identify areas of Puget Sound with relatively more or less *recent* sediment contamination. The program can also identify locations where certain sediment contaminants appear to be decreasing, increasing, or remaining

[5] Henceforth, simply “dioxins and furans”.

unchanged (Partridge et al., 2005). However, more frequent and intensive sampling of the areas listed in the Urban Waters Initiative may be required to show improvement in sediment quality.

Dioxins and furans can accumulate in the tissues of many organisms, including humans, cause cancers, and alter genetic material. However, little is known about levels of dioxins and furans in sediments or fish tissues of Puget Sound. This is partly because measuring these chemicals accurately is complex and costly. Therefore, to assess the health risks to humans and other species, regulators need more information on dioxins and furans in the Puget Sound ecosystem.

Finally, no studies have been specifically designed to compare levels of chemical contaminants in 0-3 cm and 0-10 cm surface sediment samples. Therefore, staff from one program cannot easily use the data collected by staff from other programs.

Goals

Project goals address the problems identified and the data needs inferred in the previous section. The following goals apply to greater Elliott Bay:

1. Help define *local area background* concentrations for certain sediment contaminants.
2. Add to MSMP results for contaminants in *recent* (0-3 cm) sediments.
3. Compare levels of contaminants found in 0-3 cm and 0-10 cm sediment samples.
4. Build a limited data set for the levels of dioxins and furans found in tissues of English sole.

Objectives

Specific project objectives are to obtain usable chemistry results for:

1. A suite of chemical contaminants in 0-10 cm sediment samples collected at approximately 8-10 locations in Elliott Bay that may represent *local area background* concentrations.
2. The same suite of chemical contaminants in enough additional 0-10 cm Elliott Bay sediment samples so that results can be compared to 0-3 cm sample results.
3. Dioxins and furans in archived 0-3 cm sediment samples collected from the 30 locations in greater Elliott Bay where the MSMP will measure other contaminants.
4. Dioxins and furans in samples of bottom fish (English sole) tissue collected from the two trawl areas.

Results of this project may help regulators define *local area background* concentrations and set cleanup levels for some contaminants in the Lower Duwamish Waterway cleanup site. Results will be used to describe *baseline* conditions in greater Elliott Bay, and explore relationships between contaminants present in *recent* sediment (0-3 cm) and sediment in the *biologically active zone* (0-10 cm). Finally, concentrations of dioxins and furans in fish tissue samples will begin to answer questions such as:

- What is the range of concentrations of dioxins and furans that might be expected in bottom fish of greater Elliott Bay?

- Do concentrations of dioxins and furans found in tissues of bottom fish collected from the Lower Duwamish Waterway differ from concentrations found in the same species collected along the Seattle waterfront?
- How do concentrations of dioxins and furans in whole body samples of bottom fish compare to concentrations in filet (muscle only) samples?
- What fraction of total toxicity equivalents (TEQ) found in tissue samples of bottom fish is due to dioxins and furans?[6]

[6] Other compounds contributing to total TEQ will be measured by PSAMP.

Organization and Schedule

Organization

Ecology and other personnel who will be involved in this project, along with a brief description of their roles and responsibilities, are listed in Table 1.

Table 1. Organization for Elliott Bay sediment and tissue chemistry studies.

Name	Role	Responsibilities
George Onwumere 360-407-6730	Directed Studies Unit Supervisor EAP	• Review project scope and budget. • Track progress. • Review and approve QA Project Plan and report.
Tom Gries 360-407-6327	Principal investigator Toxics Studies Unit EAP	• Prepare QA Project Plan and needed contracts. • Distribute samples with chain of custody. • Conduct QA review of data. • Enter, analyze, and interpret data. • Prepare report.
Brad Helland 425-649-7138	Ecology client TCP-NWRO	• Clarify scope of work, goals. • Review QA Project Plan and report. • Approve QA Project Plan.
Gail Colburn 425-649-7058	Unit supervisor TCP-NWRO	Approve QA Project Plan.
Bob Warren 425-649-7054	Section manager TCP-NWRO	Approve QA Project Plan.
Maggie Dutch 360-407-6021	Ecology client, EAP MSMP project manager	• Project manager for field sampling effort. • Approve QA Project Plan
Sandy Aasen 360-407-6980	Ecology client EAP	• Provide peer review of QA Project Plan and report. • Approve QA Project Plan
Robert Cusimano 360-407-6596	Section manager EAP	Approve QA Project Plan.
Jim West 360-902-2842	WDFW client	Provide peer review related to analyses of fish tissues.
Charlie Eaton Bio-Marine Enterprises 206-282-4945	*RV Kittiwake* Pilot/operator	• Provide precision navigation. • Ensure staff safety on vessel.
Various	Field crew	• Record field observations. • Help collect sediment samples.
Stuart Magoon 360-871-8801	MEL point of contact	• Act as point of MEL contact. • Provide sample containers. • Approve QA Project Plan
Various	MEL analysts	• Measure total solids, organic carbon, trace metals, and organic contaminants. • Review data quality.
Karin Feddersen 360-871-8829	MEL QA coordinator MEL point of contact	• Review QA Project Plan. • Review data quality. • Validate results for dioxins and furans.

Name	Role	Responsibilities
Various	Contract laboratory analysts	Analyze solids, grain size, dioxins and furans.
Bill Kammin 360-407-6964	Ecology QA officer	Review and approve QA Project Plan, and assist with review of data quality.
Tom Gries 360-407-6327	EIM data entry specialist	Enter sediment chemistry and toxicity data.

TCP – Toxics Cleanup Program, Washington State Department of Ecology
NWRO – Northwest Regional Office
EAP – Environmental Assessment Program, Washington State Department of Ecology
(See Page 5 for definitions of other acronyms used in Table 1)

Schedule

Ecology's MSMP staff will lead the sediment sampling effort planned for June 13-16, 2007. If the *RV Kittiwake* is not operable or if other conditions prevent sampling on these dates, sampling will likely occur during the following week.

WDFW will be responsible for conducting the 2007 PSAMP Fish Contaminant Surveys. Of importance to this study, WDFW staff will collect English sole (*Parophrys vetulus*) from two locations in greater Elliott Bay during mid-May. WDFW staff will provide Ecology with whole fish and prepared tissue samples.

Overall project data management and reporting will follow the schedule in Table 2.

Table 2. Project schedule for Elliott Bay sediment and fish tissue chemistry studies.

Environmental Information System (EIM) Data Set	
EIM Data Engineer	Tom Gries
EIM User Study ID	UWI_EB07
EIM Study Name	Elliott Bay sediment and tissue chemistry
EIM Completion Due	May 2008
Final Report	
Author Lead	Tom Gries
Schedule	
Draft Due to Supervisor	March 2008
Draft Due to Client/Peer Reviewer	April 2008
Draft Due to External Reviewer	April 2008
Final Report Due	May 2008

Quality Objectives

This section describes the general field and laboratory data quality objectives for this project that will ensure all data are (1) representative of environmental conditions, and (2) acceptable for the goals and objectives of the study.

The degree to which each sample represents the environment from which it is collected will be addressed by:

- Study design – choice of target sampling locations (Dutch et al., 1998; Ecology, 2003).
- Vessel position – accuracy of final sampling locations ≤ 3 meters from target locations.
- Sampling methods – consistent with the methods used previously at the study site and throughout Puget Sound (PSEP, 1997a; Dutch et al., 1998; Ecology, 2003).
- Sample acceptance criteria, handling, and storage – consistent with those described in *Sampling Procedures* section.

All sediment quality test results must be comparable to results from other cleanup site investigations. Results must be of acceptable quality and interpretable according to the SMS (Ecology, 1995). This means following accepted laboratory methods and protocols, testing required quality control (QC) samples, and having QC results meet specified control limits (PSEP, 1997b; Ecology 2003).

The QC samples and measurement quality objectives (MQOs) for sediment conventionals, trace metals, and organic contaminants that will be measured for this project are listed in Table 3. They are based on the QC samples and MQOs described in Ecology (2003) and PSEP (1986, 1997c, 1997d). QC sample results will be evaluated for analytical accuracy, bias, precision, and sensitivity. This project will not measure contaminants in field duplicates because:

- Field duplicates will be collected to assess how well subsamples of sediment are mixed together in the field.
- Field duplicates will not address small-scale spatial variability.
- Field duplicate results will not help achieve project goals and objectives.

The objective for completeness will be to obtain usable results for sediment and fish tissue chemistry for all sampling locations in greater Elliott Bay.

Quality objectives for data management will be for sediment chemistry data to be calculated, transcribed, entered, and transferred into one or more final databases without error. To evaluate this, 50% of the samples will be randomly selected for a complete audit/review. Raw laboratory results for each will be taken through the same calculations, formatting, and data entry processes. If any of the final results do not match those that have been entered into the EIM database, then the source of errors will be identified and corrected.

Table 3. Quality control samples and measurement quality objectives (MQOs) for Elliott Bay sediment and fish tissue chemistry studies.

Parameter	Initial calibration (correlation coefficient)	Continuing calibration (% recovery)	Lowest concentration of interest	Method blank		Laboratory Replicates per batch of ≤20 (%RPD or %RSD)		LCS or SRM[1] (% recovery limits)		Matrix spike (% recovery limits)[2]	
			MQO[3]	No.	MQO[4]	No.	MQO[5]	No.	MQO[4]	No.	MQO[4]
Total solids (% dry wt)	--	--	0.1	--	--	1 triplicate	< 20	--	--	--	--
Grain size (% dry wt)	--	--	1	1	< RL	1 triplicate	< 20	--	--	--	--
Total organic carbon (% dry wt)	≥ 0.995	90-110	0.1	1	< RL	1 triplicate	< 20	1/20	80-120	1/20	75-125
Trace metals (As, Cd, Cr, Cu, Pb, Ni, Se, Ag, Sn, Zn) (mg/Kg dry wt)	≥ 0.995	90-110	0.1-5.0 Table 5	1/20	<0.5 RL	1 duplicate	< 20	1/20	80-120	1/20	75-125
PAHs (µg/kg dry wt)	See Method	See Method	0.5-2.0 Table 5	1/20	<0.5 RL	1 duplicate	< 50	1/20	50-150	1/20	50-150
PCB Aroclors (µg/kg dry wt)	See Method	See Method	6-10	1/20	<0.5 RL	1 duplicate	< 50	1/20	50-150	1/20	50-150
Dioxins and furans (ng/Kg dry wt)	See Method	See Method	1.0-5.0 Table 5	1/20	<0.5 RL	1 duplicate	< 50	1/20	Varies[5]	--	--[6]
Dioxins and furans (tissue) (ng/Kg wet wt)	See Method	See Method	0.05-0.3 Table 5	1/20	<0.5 RL	1 duplicate	< 50	1/20	Varies[5]	--	--[6]
Lipids (% wet wt)	See Method	See Method	0.1	1/20	<0.5 RL	1 duplicate	< 50	1/20	65-135[5]	--	--

1. A laboratory control sample (LCS) is prepared by spiking a reagent blank with the analyte of interest to make a concentration similar to those expected in environmental samples. Analyses of LCS or standard reference material (SRM) samples often document laboratory performance.
2. A sample of the same matrix (sediment) spiked with the analyte of interest at levels appropriate for determining recovery efficiency.
3. See Ecology, 2003 (Table 5).
4. See Ecology, 2003 (Table 13).
5. The NIST-SRM #1944 (www-naweb.iaea.org/nahu/nmrm/nmrm2003/material/ni1944.htm) will be analyzed for this project.
6. Use of stable isotope-labeled internal standards will replace use of matrix spike samples.

Abbreviations used in Table 3:

dry wt. = dry weight of sediment.
RPD = relative percent difference (between duplicates).
RSD = relative standard deviation (between triplicates).
mg/Kg = milligrams of analyte per kilogram of matrix (dry sediment).
mg/L = milligrams of analyte per liter of water (porewater).
µg/kg = micrograms of analyte per kilogram of matrix (dry sediment).
ng/Kg = nanograms of analyte per kilogram of matrix (dry sediment).
wet wt. = wet weight of fish tissue.

Sampling Process Design (Experimental Design)

Sediment will be collected from locations chosen using a probability-based, random sampling design used by NOAA and Ecology to conduct PSAMP sediment monitoring (Long et al., 1996; Long et al., 2003). EPA has used this design (Schimmel et al., 1994) to monitor sediment quality and assess:

- Spatial patterns of sediment quality indicators over time, with a known level of confidence.
- Changes in sediment quality indicators over time, with a known level of confidence.
- Relationships between sediment quality indicators and ecological resources (contamination and benthic community health).
- Sediment quality in different regions of the country.

The sampling design has been applied by the MSMP to different sub-regions and strata of Puget Sound (Dutch et al., 1998). Thirty-four locations in greater Elliott Bay have been sampled, including 9 near Harbor Island or in the Lower Duwamish Waterway (Long et al., 2003).

The sampling design for this project is driven by Goal #2, and will therefore be based on the MSMP sampling design. 0-3 cm sediment will be collected from 30 of the 34 established sampling locations. Sampling will occur at 3-4 target locations in each of 9 sub-areas that represent 2 sampling strata: *harbor* and *urban*. These 30 locations are shown in Figure 1.

Samples of 0-10 cm sediment will also be collected from the same 30 sampling locations. Eighteen locations in Elliott Bay proper will be chosen at random for comparing sediment quality results from 0-3 cm and 0-10 cm samples. Results from as many as 10 of the 18 Elliott Bay locations will be used to estimate *local area background* concentrations for certain contaminants (see Figure 1). Selection of these 10 locations will be subjective, based on proximity to contamination sources and previous sediment quality results.

The WDFW will collect English sole from two trawl areas. The first area is along the Seattle waterfront, nearest sediment sampling location 188 (Figure 1). The second area starts near sediment sampling locations 203 and 204 (Figure 1). It runs SSE along the east side of Kellogg Island in the Lower Duwamish Waterway, and ends just south of the island. Both trawl areas are sampled periodically by the WDFW for the PSAMP Fish Toxics Component, with the goal of assessing temporal trends in fish tissue contamination and fish liver disease (WDFW, 2007a, 2007b).

Results of sediment quality testing conducted for this project will allow:

- Estimation of *baseline* (2007) concentrations for dioxins and furans in *recent* sediments of greater Elliott Bay (Goal #1, Objective #1).
- Estimation of *local area background* concentrations of arsenic, dioxins and furans, PAHs, and PCBs in *biologically active zone* sediment (Goal #2, Objective #2).
- Comparison of the sediment chemistry results for 0-3 cm and 0-10 cm samples (Goal #3, Objective #3).
- Reporting results for levels of dioxins and furans in tissues of English sole (Goal #4, Objective #4).

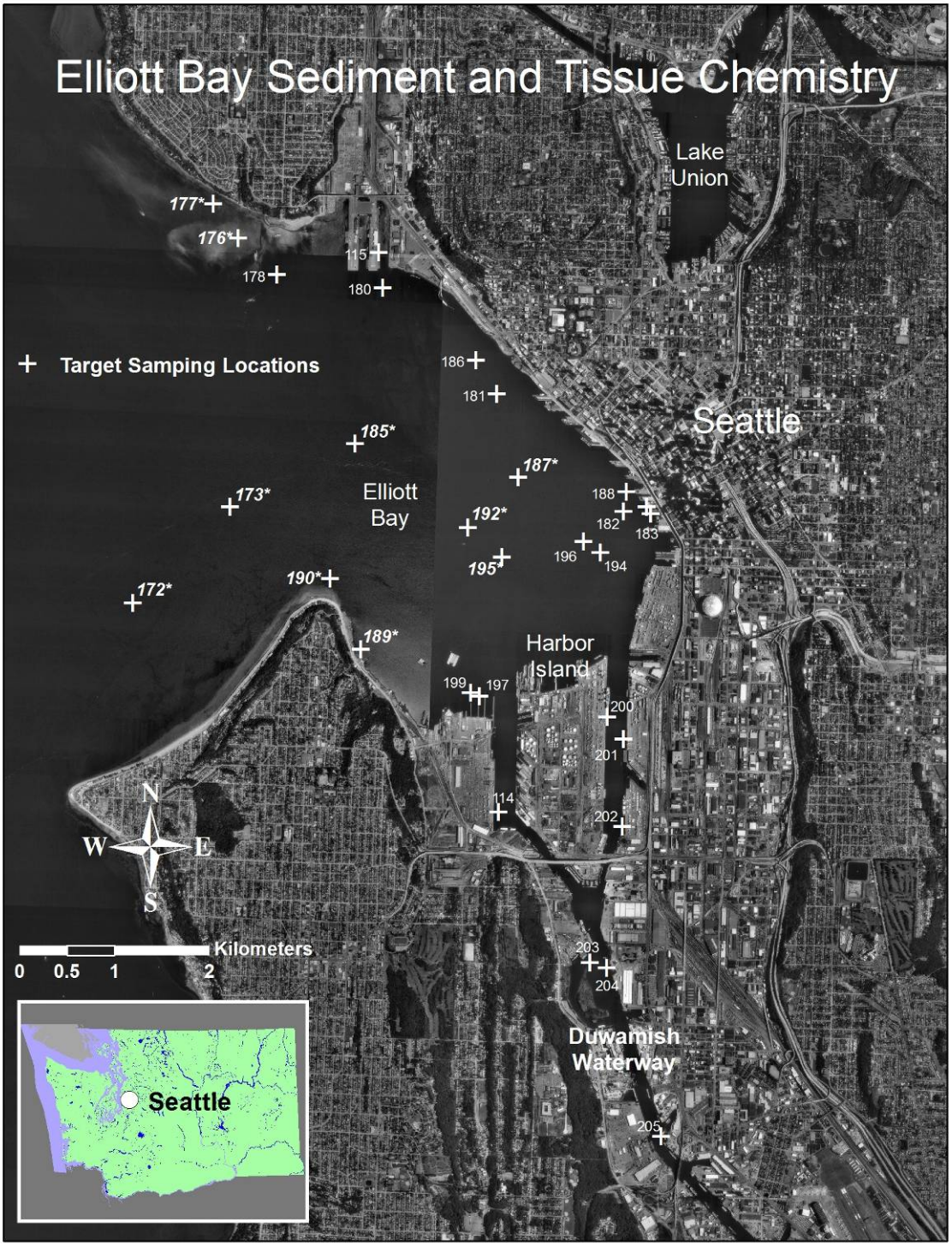

Figure 1. Target sampling locations for Elliott Bay sediment and tissue chemistry studies. Sediment sampling locations shown in ***bold italic*** font and with an asterisk may prove most useful in estimating *local area background* concentrations. Fish will be collected near sediment sampling location 188 (Trawl Area 1) and near locations 203-204 (Trawl Area 2).

Sampling Procedures

Vessel positioning

Vessel positioning protocols will be consistent with regional guidance (PSEP, 1998). Target sample stations will be located using a Leica MX420 differentially-corrected, 12-channel GPS receiver mounted on the boom of the *RV Kittiwake* and a Coast Guard beacon differential receiver on land. The GPS unit will receive radio broadcasts of GPS signals from satellites. The Coast Guard beacon receiver will acquire corrections to the GPS signals. Overall positioning accuracy is expected to be $\pm$ 1-2 meters and no worse than $\pm$ 3 meters.

Northing and easting coordinates will be updated every second and displayed directly on an onboard computer. The coordinates at the time the sampling device reaches the bottom and its doors close will be stored in real time using software for managing positioning data. Washington State Plane Coordinates, North (North American Datum 83), will be translated into degrees and decimal minutes and be used as the horizontal datum. The vertical datum will be the National Oceanic and Atmospheric Administration's mean lower low water (MLLW) datum. Vertical control will be provided by the ship's depth finder. Water depth measured by a calibrated winch cable will be corrected for tides when sampling is completed. Tidal elevation will be determined by using National Ocean Service tide gage readings for Elliott Bay locations, or using software-predicted tides levels.

To ensure the accuracy of the navigation system, a checkpoint will be located at a known point. This will be a feature such as a pier face, dock, piling, or similar structure that is accessible by the vessel. The vessel will be stationed at the check point at the beginning and end of each day. A GPS position reading will be taken, and the reading will be compared with the known land-survey coordinates. The two position readings should agree, within the limits of the survey vessel operational mobility, to within $\pm$ 2 meters.

Collecting sediment samples

MSMP staff and field crew will be responsible for collecting and handling of all surface sediment samples until they are returned to Ecology facilities for storage. Sampling methods will conform to those described in Ecology and EPA QA Project Plans and other documents (PSEP, 1997a; Dutch et al., 1998; Ecology, 1995, 2003).

The project manager for the MSMP field work, Maggie Dutch (or designee), will direct field sampling efforts. She will decide on the following and record those decisions in the field logbook:

- Sampling order for primary target locations (Table 6 and Appendix A).
- Need to sample an alternate location.
- Need to modify sampling procedure.
- Acceptability of each grab sample.

If a primary target location cannot be accessed, a suitable alternate target location will be chosen. Reasons for sampling an alternate location include physical obstruction (barge on location) and failure of the van Veen to penetrate the substrate after three attempts.

Samples of 0-3 cm and 0-10 cm surface sediment will be collected from the *RV Kittiwake* using a stainless steel double van Veen grab sampler (0.1 m^2 surface area each side). The field crew will deploy the van Veen as many as 6 times at each location. Representative subsampling of these grabs will result in the volume needed to:

- Measure grain size distribution, total organic carbon, trace metals, organic contaminants, toxicity, and the condition of the benthic community in 0-3 cm sediment.
- Measure concentrations of various contaminants in 0-10 sediment.
- Archive 0-3 cm and 0-10 cm sediment for potential repeat analysis.

The sampling procedure for each grab sample will be based on the one described in the final QA Project Plan for the MSMP (Dutch et al., 1998):

- Maneuver the vessel to be near coordinates of primary or alternate target sampling locations.
- Open the grab sampler jaws into the deployment position.
- Guide the sampler overboard until it is clear of the vessel.
- Position the sampling vessel such that the GPS receiver registers being within 1-2 meters of the target coordinates.
- Lower the sampler through the water column at approximately 1 foot or 0.3 meters per second to a depth approximately 1 meter above the bottom.
- Lower the sampler to the bottom if the GPS still registers within 1-2 meters of target coordinates *and* if the cable is very near vertical (otherwise reposition vessel and then do so).
- Record the date, time, GPS coordinates, and water depth when the sampler reaches bottom.
- Retrieve the sampler and raise it at approximately 1 foot or 0.3 m/s.
- Guide the sampler aboard the vessel and into the work stand on deck, using care to not to disturb surface sediment.
- Examine the sample using the following sediment acceptance criteria:
    - The penetration depth is at least 11 cm and not more than 17 cm (not overfilled or extruding out the top of the sampler).
    - There is minimal apparent loss of overlying water (sampler closed completely), and the overlying water that remains is not excessively turbid.
    - The sediment surface (after overlying water is removed) is relatively flat or undisturbed.

In addition to the field notes listed above, field crew members will record the following observations in the field log (Appendix B) after accepting a grab sample:

- Visual characteristics of surface sediment (e.g., cobble/debris/wood, colors, odors, oil/sheen, textures, biological structures).
- Characteristics of sediment with depth (e.g., change in color, redox layer).
- Maximum depth of penetration (to 0.5 cm).
- Overall quality of the sample.

Separate composite samples that represent 0-3 cm and 0-10 cm deep sediment at each location will be prepared as follows:

- The overlying water will be siphoned off of each grab.
- Subsamples of surface sediment will be collected using a pre-cleaned, stainless-steel spoon.
- Equal-volume subsamples of 0-10 cm sediment (one stainless-steel spoonful) will be taken from each van Veen quadrant not used to measure benthic community health.
- These subsamples will be placed in a separate stainless-steel bucket labeled "0-10 cm".
- Equal-volume subsamples of 0-3 cm sediment will be removed from each quadrant of each double van Veen sampler used to collect subsamples of 0-10 cm sediment.
- These subsamples will be placed in a pre-cleaned stainless-steel mixing bucket labeled "0-3 cm".
- The field project manager will determine whether large rocks, pieces of wood, shells, or organisms will be removed before mixing.
- The total volume of sediment in each bucket will be mixed using a stainless steel paint stirrer to attain uniform color and texture.

Sub-samples of the well-mixed sediment will be placed into appropriate sample containers, leaving 1 cm of headspace (to minimize breakage), and sealed with Teflon-lined lids. The number, size, and type of containers used for each analysis are listed in Table 4. A field duplicate will be created at 3 sampling locations from each bucket of well-mixed sediment. Finally, each container will be placed in a cooler with wet ice. Bubble wrap may be used to prevent or reduce breakage of glass containers that will be transported any substantial distance.

Collecting and preparing fish tissue samples

WDFW will use established field methods to collect, handle, and store fish (PSEP, 1990, 1997a; WDFW, 2007a, 2007b). WDFW staff will also follow recommended procedures (PSEP, 1990, 1997d) to prepare 6 composite samples of English sole tissue (skin-on filets) from each trawl area. Ecology will obtain archived subsamples of these tissues for analysis of dioxins and furans. Ecology will also use 30 English sole obtained from the WDFW to prepare 3 composite tissue samples (whole fish). These samples will be prepared following regional guidance (PSEP, 1997d) and Section 6.2.1.2 of the Ecology's Standard Operating Procedures (Sandvik, 2006; Appendix C).

Sample labeling, storage, and handling

Waterproof labels will be placed on all sample containers before starting field work. Labels will include sample code or number, date, time, MEL sample number, and analysis to be conducted. Samples will be assigned identifier codes consistent with the previous MSMP sampling event (Long et al., 2000). Field duplicates will be collected at 3 locations, and may be used as a QA sample for testing of various sediment parameters. Field duplicates will be numbered in a similar manner.

All field samples will be transferred to Ecology storage facilities. Samples will be held at 4°C or frozen at -18°C, depending on when testing will occur. Table 4 shows recommended storage conditions and holding times (PSEP, 1997b; Dutch et al., 1998; Ecology, 2003).

Table 4. Recommended sediment sample sizes and storage conditions for Elliott Bay sediment and fish tissue chemistry studies.

Parameter	Matrix	Laboratory	Number of Sediment Samples[1] (0-3 cm/0-10 cm) or Fish Samples	Minimum Quantity Required (wet wt.)	Containers	Holding Time	Storage Conditions
Total solids	Sediment	MEL	33 / **30**	50 grams	From other 8-oz containers	7 days 6 months	4°C -18°C
Grain size	Sediment	Contract	33 / **30**	150 grams	8-oz HDPE jars	6 months	4°C
Grain size archive	Sediment	Contract	33 / **30**	150 grams	8-oz HDPE jars	6 months	4°C
Total organic carbon	Sediment	MEL	33 / **30**	25 grams	2-oz glass jars	14 days 6 months	4°C -18°C
Trace metals[2]	Sediment	MEL	33 / **30**	50 grams	4-oz glass jars	6 months 2 years	4°C -18°C
PAHs (isotope dilution)	Sediment	MEL	33 / **30**	100 grams	8-oz glass jars	14 days 1 year 40 days	4°C -18°C after extraction
Total PCBs (Aroclors)	Sediment	MEL	33 / **30**	100 grams	8-oz glass jars	1 year 40 days	4°C, -18°C after extraction
Dioxins and furans	Sediment Extracts	Contract	**33 / 30**	100 grams	8-oz glass jars	1 year	-18°C
Dioxins and furans	Fish tissue (whole body); Extracts	Contract	**3**	30 grams	8-oz glass jars	1 year	-18°C
Dioxins and furans	Fish tissue (filet); Extracts	Contract	**12**	30 grams	8-oz glass jars	1 year	-18°C
Lipids	Fish tissue	Contract	**15**	100 grams	8-oz glass jars	1 year	-18°C
Sediment archive	Sediment	MEL Contract	33 / **30**	250 grams	8-oz glass jars	6 months - 2 years	-18°C

[1] Samples in **bold** font will be collected for this project, excluding field replicates. Samples in regular font will be tested for the MSMP and Urban Waters Initiative, and include field duplicates.

[2] The 10 trace metals to be measured are arsenic, cadmium, chromium, copper, lead, nickel, selenium, silver, tin, and zinc.

Decontamination

Decontamination of cleanup procedures will follow those used by MSMP staff (Dutch et al., 1998; Long et al., 2003). The van Veen sampler will be precleaned with phosphate-free Liquinox® detergent and rinsed with acetone and then on-site seawater before beginning sampling. The sampler will be cleaned between grabs collected at the same target location by rinsing it thoroughly with site water. Between sampling locations, the sampler and all associated sampling equipment will be cleaned using Liquinox® and acetone.

Waste management

Excess sediment and non-solvent decontamination rinses will be returned to the sampling location. All disposable sampling materials, such as gloves and paper towels, will be placed in a heavy-gauge, plastic garbage bag. The garbage bag will be removed from the study site at the end of each day and placed in a suitable solid waste disposal container.

Chain of custody

The general chain of custody expected for this project will be as follows:

- PSAMP project managers will initially track the status and fate of sediment and fish samples collected for this project.
- The principal investigator will take custody of the following samples when they are placed in storage at Ecology facilities:
  - 0-3 cm sediment samples that will be archived for analysis of dioxins and furans.
  - All 0-10 cm sediment samples.
  - English sole samples (whole fish and filets).
- Custody of samples will be transferred to a parcel shipping firm if sent to a contract laboratory.
- Custody will be transferred to analytical laboratory staff (including couriers).
- The principal investigator will track the status of samples until acceptable results are submitted as electronic or printed reports.

The contents of custody forms, sample custody transfer, and tracking of sample status described in Appendix D are consistent with regional guidance (PSEP, 1997b; Dutch et al., 1998; Ecology, 2003).

Shipping

Coolers with sediment samples for testing most sediment conventionals and contaminants will be transported to MEL by Ecology courier. Sediment and fish samples that will be tested by a contract laboratory will be transferred to its courier or to a shipping firm. If a shipping firm is used, the principal investigator will obtain a waybill to track progress of the shipment and status of samples. Upon receipt of coolers containing sediment or fish samples, laboratory staff will measure the inside temperature and note any coolers that are not 4°C ± 2°C.

Measurement Procedures

This project will measure conventionals and chemical contaminants in 18 of the 0-10 cm samples that will be collected from Elliott Bay. Analytes to be measured are listed in Table 5. The 0-10 cm samples collected from near Harbor Island or from the Lower Duwamish Waterway will not be tested. This project will also only measure levels of dioxins and furans in 30 samples of 0-3 cm sediment that will be archived frozen at -18^{o}C. Finally, all 15 fish tissue samples will be analyzed for dioxins, furans, and lipid content.

The analytical methods that will be used to measure the various analytes in samples of sediment and fish tissue are also listed Table 5. Results will be comparable to previous studies. To the greatest extent possible, test methods and reporting limits will mirror those used by the MSMP (Dutch et al., 1998; Long et al., 2003; Dutch, 2007) and required by sediment management programs (Ecology, 1995, 2003). These methods are based on regional guidelines:

- Conventional sediment parameters will be measured according to PSEP (1986).
- Most contaminants (trace metals, PAHs, PCBs) will also be measured according to PSEP (1997c, 1997d).
- Dioxins and furans in sediment samples will be measured using EPA method 1613B and following recent regional guidance (DMMP, 2007; Ecology, 2007).
- Lipids will be measured gravimetrically after homogenization with a tissue grinder and extraction with dichloromethane (Sloan et al., 2004).

MEL will measure the following parameters in 18 0-10 cm sediment samples:

- Total solids (including laboratory triplicates).
- Total organic carbon (including laboratory triplicates).
- SMS trace metals except mercury (sample holding time will have expired).
- PAHs (with isotope dilution).
- Total PCBs (as Aroclors).

Ecology will contract with accredited commercial laboratories to measure:

- Total solids and grain size distribution in 18 0-10 cm sediment samples.
- Dioxins and furans in 48 sediment samples (30 0-3 cm and 18 0-10 cm) and 3 standard reference materials[7].
- Dioxins and furans, total solids, and lipid content in 15 fish tissue samples and 1 standard reference material.

The parameters to be measured in each sediment sample are listed in Table 6.

[7] In addition to standard reference materials, contract laboratories will measure parameters in various other quality control samples (see Table 3).

Table 5. Measurement methods for sediment and fish tissue samples, Elliott Bay sediment and tissue chemistry studies.

Analyte or Test Protocol	Sample Number[1]	Expected Range of Results	Reporting Limits[2]	Sample Preparation Methods[3]	Sample Cleanup Methods[3]	Analytical (Instrumental) Method
Total solids (% of wet weight)	18	30 - 70	0.1	---	---	PSEP, EPA 160.3
Grain size (%)	18	<20% - >80% silt + clay	1.0	---	---	PSEP (1986) Plumb (1981)
Total organic carbon (% of dry weight)	18	<0.2% - 4.0%	0.1	---	---	PSEP (1986) (drying at 70°C), EPA 9060
Metals[4] (mg/Kg dry weight)	18	<0.1 - 500	0.1 except - 0.2 tin 0.5 chromium 0.5 selenium 5.0 zinc	PSEP EPA 3050B	PSEP EPA 3050B	EPA 200.8 (ICP/MS) or EPA 200.7 (ICP)
PAHs, regular analytes (µg/Kg dry weight)	18	<10 - >10,000	0.5-2.0	EPA 3545	EPA 3630	8270D with isotope dilution
Total PCBs (Aroclor) (µg/Kg dry weight)	18	<10 - 4,000	6-10	EPA 3545	EPA 3620 EPA 3665	EPA 8082
Dioxins/furans (ng/Kg dry weight)	51	<0.5 - ~1000	1.0-5.0	EPA 1613B	EPA 1613B	EPA 1613B
Dioxins/furans (tissue) (ng/Kg dry weight)	16	unknown	0.05-0.30	EPA 1613B	EPA 1613B	EPA 1613B
Lipids (% wet weight)	16	<0.5 - >8.0	0.1	Sloan et al., 2004	Sloan et al., 2004	Sloan et al., 2004

[1] Sample number includes 3 standard reference material samples for sediment dioxins and furans and one standard reference material sample for fish tissue. No field duplicates will be tested. Grain size, dioxins, and furans will be measured by contract laboratories in the number of samples indicated.

[2] Reporting limits for individual trace metals, PAHs, dioxins, and furans are from Dutch et al. (1998), Dutch (2007), DMMP (2007), and Ecology (2003; 2007).

[3] Sample preparation and cleanup methods for sediment conventional analyses are described in the analytical method.

[4] The 10 trace metals to be measured are: arsenic, cadmium, chromium, copper, lead, nickel, selenium, silver, tin, and zinc.

Table 6. Likely distribution of samples for testing and parameters to be measured in each (depth in cm).

Sampling Location	Target Latitude (NAD83)	Target Longitude (NAD83)	Total Solids	Grain Size	Total Organic Carbon	Metals	PAHs	PCBs	Dioxins & Furans
114	47.575445	-122.360705	--	--	--	--	--	--	0-3
115	47.628108	-122.379387	0-10	0-10	0-10	0-10	0-10	0-10	0-3,0-10
172	47.594400	-122.412662	0-10	0-10	0-10	0-10	0-10	0-10	0-3,0-10
173	47.603738	-122.399365	0-10	0-10	0-10	0-10	0-10	0-10	0-3,0-10
176	47.629177	-122.399123	0-10	0-10	0-10	0-10	0-10	0-10	0-3,0-10
177	47.632355	-122.402752	--	--	--	--	--	--	0-3
178	47.625798	-122.393563	0-10	0-10	0-10	0-10	0-10	0-10	0-3,0-10
180	47.624815	-122.378680	0-10	0-10	0-10	0-10	0-10	0-10	0-3,0-10
181	47.615033	-122.362302	0-10	0-10	0-10	0-10	0-10	0-10	0-3,0-10
182	47.604192	-122.344162	--	--	--	--	--	--	0-3
183	47.603998	-122.340390	0-10	0-10	0-10	0-10	0-10	0-10	0-3,0-10
184	47.604677	-122.340980	0-10	0-10	0-10	0-10	0-10	0-10	0-3,0-10
185	47.609983	-122.382022	0-10	0-10	0-10	0-10	0-10	0-10	0-3,0-10
186	47.618178	-122.365362	0-10	0-10	0-10	0-10	0-10	0-10	0-3,0-10
187	47.607187	-122.359027	0-10	0-10	0-10	0-10	0-10	0-10	0-3,0-10
188	47.606030	-122.343893	--	--	--	--	--	--	0-3
189	47.590513	-122.380505	0-10	0-10	0-10	0-10	0-10	0-10	0-3,0-10
190	47.597167	-122.385080	0-10	0-10	0-10	0-10	0-10	0-10	0-3,0-10
192	47.602277	-122.365957	0-10	0-10	0-10	0-10	0-10	0-10	0-3,0-10
194	47.600253	-122.347308	0-10	0-10	0-10	0-10	0-10	0-10	0-3,0-10
195	47.599578	-122.361033	0-10	0-10	0-10	0-10	0-10	0-10	0-3,0-10
196	47.601218	-122.349653	0-10	0-10	0-10	0-10	0-10	0-10	0-3,0-10
197	47.586377	-122.363738	--	--	--	--	--	--	0-3
199	47.586665	-122.365030	--	--	--	--	--	--	0-3
200	47.584643	-122.345792	--	--	--	--	--	--	0-3
201	47.582618	-122.343445	--	--	--	--	--	--	0-3
202	47.574327	-122.343328	--	--	--	--	--	--	0-3
203	47.561407	-122.347435	--	--	--	--	--	--	0-3
204	47.560923	-122.345088	--	--	--	--	--	--	0-3
205	47.545110	-122.336877	--	--	--	--	--	--	0-3

Quality Control Procedures

Field

Field logs will be reviewed to assess how well each sample may represent the local sampling environment. In particular, the review will determine if:

- Field samples are collected at a time of year similar to previous MSMP sampling events.
- Sampling locations are no more than three meters from the target sampling locations identified in this QA Project Plan.
- Regional sampling protocols and sample acceptance guidelines, detailed in the *Sampling Procedures* section, are followed.
- Samples are handled appropriately and stored as specified in Table 4.

No field blanks will be prepared for this project. Field duplicates will be collected at three sediment sampling locations but will not be analyzed for this project.

Laboratory

QC samples that will be collected in the field, or prepared and analyzed in the laboratory, are listed in Table 3. QC samples for most sediment contaminants will include method blanks, laboratory replicates, laboratory control samples, certified or standard reference materials, and matrix spikes. QC samples required for total solids, grain size, and total organic carbon samples will be limited.

Field duplicates will be collected at three sediment sampling locations, but will not be tested. Experience has shown contaminant levels differ little between two or more field replicates prepared to assess effectiveness of mixing (not spatial variability). In addition, measuring contaminants in field duplicates will contribute little to achieving the goals of this project.

Accuracy of results for sediment conventionals will be evaluated using recoveries of known amounts of the analyte from a certified reference material or spiked matrix. Precision will be evaluated using results from laboratory replicates. Sensitivity will be assessed using reporting limits, and bias will be addressed by examining recovery of analytes from various QC samples.

If sample results exceed control limits, then reasonable corrective actions will be taken by the laboratory. If such actions do not yield acceptable results, the laboratory will discuss the need for additional corrective actions with the principal investigator. Potential corrective actions for the conventionals listed are reanalysis or assignment of appropriate data qualifiers.

The total fund for all goods and services associated with this project was originally $69,000. Approximately $10,300 of this fund was diverted to cover costs of conducting another study (Gries, 2007b). Table 7 estimates the number of samples of each type and the unit analytical costs. The total cost of the project is nearly equal to the fund balance.

Table 7. Summary of estimated analytical costs for Elliott Bay sediment and fish tissue chemistry studies (fiscal year 2008).

Analysis	Laboratory	No. of Samples	No. of QA Samples[1]	Total No. of Samples	Unit Cost ($)	Subtotal ($)
Total solids	MEL[2]	18	--	18	10	180
Total solids	Contract	18	--	18	10	180
Grain size	Contract	18	--	18	86	1,548
Organic carbon	MEL[2]	18	--	18	39	702
Metals[3]	MEL[2]	18	--	18	159	2,862
PAHs, regular list isotope dilution	MEL[2]	18	--	18	375	6750
Total PCBs (Aroclors)	MEL[2]	18	--	18	100	1,800
Dioxins/furans (sediment)	Contract	48	3	51	575	29,325
Dioxins/furans (tissue)	Contract	15	1	16	575	9,200
Dioxins/furans SRMs	Contract					1,500
Lipids	Contract	15	1	16	82	1,312
Data validation (dioxins/furans)	MEL					3,000
Miscellaneous (equipment, shipping)						300
					Total	58,659

[1] Standard references materials (SRMs) will be tested for dioxins and furans (only). Other QC sample costs are included in unit costs.

[2] Cost includes a 50% discount rate.

[3] Metals that will be analyzed include arsenic, cadmium, chromium, copper, lead, nickel, selenium, silver, tin, and zinc. Mercury will not be measured because of expired holding times.

Data Management Procedures

Field notes will be taken during all sampling activities. Notes will include date, time, meteorological observations, vessel position at time of sampling, and meter wheel water depth. Observable characteristics of all sediment samples will also be recorded. These will include grab sampler penetration depth, surface sediment physical features, organisms present, sediment color, odors, presence of sheen, and apparent depth of oxic sediment. Field notes will be recorded using a form similar to the one provided in Appendix B.

Results of laboratory analyses will be submitted to the principal investigator as follows:

- MEL will submit a printed report (with a QA summary) that presents percent solids, total organic carbon, trace metal, PAH, and PCB results for sediment test and QA samples. Output from MEL's Laboratory Information Management System will also be submitted electronically for transfer into Ecology's EIM database.
- Deliverables from contract laboratories will include all test and QA sample results for total solids, grain size, dioxins, furans, and lipids. A printed report of results will be accompanied by an electronic deliverable in an EIM format.

All sediment quality data generated for this project will be evaluated relative to the MQOs listed in Tables 3-5. Acceptable results will be used to prepare the final report, will be entered into Ecology's EIM database, and will be made available to the public via Ecology's web site.

Audits and Reports

Manchester Environmental Laboratory (MEL) participates in routine performance and system audits of various analytical procedures. Audit results are available upon request. The Laboratory Accreditation Unit of Ecology's Environmental Assessment Program accredits all contract laboratories that conduct environmental analyses for the agency, and the accreditation process includes performance testing and periodic lab assessments. No additional audits are envisioned.

The principal investigator will track the status of samples being analyzed by MEL and the contract chemistry lab, being particularly alert to any significant QA problems as they arise. He may visit the contract toxicity lab to observe or troubleshoot the initiation of toxicity tests. Finally, the principal investigator will keep Ecology managers apprised of the status of field work, sample analyses, data analysis, and report preparation for the study.

The scope of the study is such that no interim reports are anticipated.

The principal investigator will prepare an initial draft report describing results of this study. The first draft is targeted for completion in March 2008, and will include the following elements:

- Abstract.
- Background, problem statement, study goals, and objectives.
- Description of the study design, with site maps showing past sediment quality data and results from this study.
- Description of field and laboratory methods.
- Summary of the sampling event (e.g., date, time, location, and depth).
- Data quality highlighting exceptions to the QA Project Plans, difficulties encountered in the field, and problems associated with lab tests.
- Compilation of, and summary of, all test results.
- One or more maps showing sediment quality results.
- Analysis of sediment quality results that will:
  - Estimate *local area background* levels of arsenic, dioxins, furans, PAHs and PCBs using results for up to 10 of the 0-10 cm sediment samples (Goal #1, Objective #1).
  - Statistically summarize levels of dioxins and furans in 30 samples of 0-3 cm sediment (Goal #2, Objective #2).
  - Statistically compare the contaminant chemistry of samples of 0-3 cm and 0-10 cm sediment (Goal #3, Objective #3).
  - Summarize and compare results for levels of dioxins and furans in the fish tissue samples.
- Conclusions and recommendations.
- References.
- Appendices (QA Project Plan, final sampling locations, field notes, raw data tables).

The draft report will undergo peer review by Ecology staff, and a final report will be prepared by May 31, 2008 (Table 2).

Upon completion of the project, all project data will be entered into Ecology's EIM system. Public access to electronic versions of the data and reports generated from this project will be available via Ecology's internet homepage (www.ecy.wa.gov).

Data Verification and Validation

Data verification and validation is a two-step process:

1. Data are reviewed for errors, omissions, and compliance with quality control (QC) acceptance criteria.
2. The data package is carefully examined to determine whether measurement quality objectives (MQOs) have been met.

The principal investigator will assess representativeness of results by reviewing field notes about where and how each surface sediment sample was collected. He will then assess the comparability of sample results to other studies. This will be accomplished by comparing the methods and protocols described in case narratives prepared by MEL and contract laboratories with the ones listed in this QA Project Plan (Tables 3 and 4).

MEL and contract laboratory staff involved in analyzing conventional parameters and sediment contaminants will review all results and prepare a case narrative. The case narrative will include a QC report that describes:

- Methods and protocols used, especially any deviating from the QA Project Plan.
- Results of initial and ongoing instrument calibrations and QC samples (method blanks, field and lab replicates, laboratory control samples, spiked samples), especially those not meeting QC acceptance criteria (control limits or performance standards).
- Intermediate calculations (e.g., accounting for sample dilution).
- Completeness (no omissions) and accuracy (calculation/transcription errors).
- Assignment of data qualifiers.

The case narrative will highlight all results not meeting acceptance criteria (outside control limits), corrective actions that have been taken (assignment of qualifier codes or reanalysis) and any further actions needed (reject results). The narrative and QC report will include a summary of results and the complete data package.

The contract laboratory analyzing samples for dioxins and furans will submit a *Level IV* data package to MEL. The data package will provide enough information for MEL quality assurance staff to validate results for these parameters.

The principal investigator, with possible assistance from Ecology's QA Officer, will review all case narratives, QC reports, data summaries, and raw lab data. Most importantly, he will:

- Verify that laboratories have complied with the MQOs presented in Table 3 (chemical analysis).
- Summarize data verification and validation efforts in the final study report.

Data Quality (Usability) Assessment

After reviewing, verifying, and validating the laboratory data, the principal investigator will determine whether the data are usable relative to the primary study goal: regulatory characterization of sediment toxicity. Specifically, he will assess:

- How representative the data are of environmental conditions.
- How comparable the data are to results from other regional studies.
- How interpretable the data are by the Sediment Management Standards (SMS) requirements and guidelines.
- Whether or not sufficient data were collected (number and quality) to address the goals and objectives of the study.

Representativeness will be assessed by a careful review of field notes with respect to several factors:

- Timing of sample collection
- The proximity of final sampling coordinates to targets locations.
- The extent to which sample acceptance criteria were adhered to or observed.

Results for any sediment sample collected more than 3 meters from target coordinates, or not meeting all sample acceptance criteria, will be scrutinized for possible exclusion from analyses.

To evaluate data comparability, the principal investigator will review the final analytical methods and standard operating procedures used, as well as the QC summaries or exception reports submitted by each laboratory. Where possible, he will compare analytical results from this study to results from similar studies and locations. Reasons that certain results may not be deemed usable include the following:

- Methods or standard operating procedures differed from those listed in this QA Project Plan such that they cannot be considered adequately comparable.
- QC reports indicated conventional parameter results had a severe bias or were highly qualified for some other reason.
- Detection limits or reporting limits were not as specified in Tables 3 and 6.

Results are likely to be rejected if that is the recommendation made by the analytical laboratory.

References

DMMP, 2007. Supplemental Information on Polychlorinated Dioxins and Furans (PCDD/F) for Use in Preparing a Quality Assurance Project Plan (QAPP). Prepared by the U.S. Corps of Engineers, Seattle District, for the Dredged Material Management Program. May 2007.

Dutch, M., E. Long, W. Kammin, and S. Redman, 1998. Final Quality Assurance Project & Implementation Plan: Measures of Bioeffects Associated with Toxicants in Puget Sound: Survey of Sediment Contamination, Toxicity, and Benthic Macroinfaunal Community Structure. Prepared as a Component of the Puget Sound Ambient Monitoring Program, Marine Sediment Monitoring Program, Washington State Department of Ecology, Olympia, WA. March 1998.

Dutch, M., 2007. Personal communication regarding analytical methods and reporting limits for chemical analysis of sediment samples collected for the Marine Sediment Monitoring Program. Washington State Department of Ecology, Olympia, WA.

Ecology, 1995. Chapter 173-204. Sediment Management Standards. www.ecy.wa.gov/biblio/wac173204.html

Ecology, 2003. Sediment Sampling and Analysis Plan Appendix. Washington State Department of Ecology, Olympia, WA. Publication No. 03-09-043. www.ecy.wa.gov/biblio/0309043.html

Ecology, 2007. DRAFT requirements for data packages from contract labs for analyses of PCB congeners by 1668A and dioxins and furans by 1613B. Environmental Assessment Program, Washington State Department of Ecology, Olympia, WA.

Gries, T., 2007a. Using Sediment Profile Imaging (SPI) to Evaluate Sediment Quality at Two Cleanup Sites in Puget Sound: Part I - Lower Duwamish Waterway. Washington State Department of Ecology, Olympia, WA. July 2007. Publication No. 07-03-025. www.ecy.wa.gov/biblio/0703025.html

Gries, T., 2007b. Quality Assurance Project Plan: Assessment of Toxicity Near Post Point (Bellingham Bay). Washington State Department of Ecology, Olympia, WA. Publication No. 07-03-113. www.ecy.wa.gov/biblio/0703113.html

Long, E.R., A. Robertson, D.A. Wolfe, J. Hameedi, and G.M. Sloane, 1996. Estimates of the spatial extent of sediment toxicity in major U.S. estuaries. Environmental Science and Technology 30: 3585-3592.

Long, E.R., J. Hameedi, A. Robertson, M. Dutch, S. Aasen, K. Welch, S. Magoon, R.S. Carr, T. Johnson, J. Biedenbach, K.J. Scott, C. Mueller, and J.W. Anderson, 2000. Sediment Quality in Puget Sound, Year 2 - Central Puget Sound. NOAA NOS NCCOS CCMA Technical Memo No. 147. Washington State Department of Ecology Publication No. 00-03-055. www.ecy.wa.gov/biblio/0003055.html

Long, E.R., M. Dutch, S. Aasen, K. Welch, and M.J. Hameedi, 2003. Chemical contamination, acute toxicity in laboratory tests, and benthic impacts in sediments of Puget Sound: A summary of results of the joint 1997-1999 Ecology/NOAA survey. Washington State Department of Ecology Publication No. 03-03-049. www.ecy.wa.gov/biblio/0303049.html

Partridge, V., K. Welch, S. Aasen, and M. Dutch, 2005. Temporal Monitoring of Puget Sound Sediments: Results of the Puget Sound Ambient Monitoring Program, 1989-2000. Washington State Department of Ecology, Olympia, WA. Publication 05-03-016. www.ecy.wa.gov/biblio/0503016.html

PSEP (Puget Sound Estuary Program), 1986. Recommended Protocols for Measuring Conventional Sediment Variables in Puget Sound. Prepared for U.S. Environmental Protection Agency Region 10, Office of Puget Sound, Seattle, WA and Puget Sound Water Quality Authority, Olympia, WA by Tetra Tech, Inc., Bellevue, WA, 43 pp.

PSEP (Puget Sound Estuary Program), 1990. Recommended Guidelines for Sampling Soft-Bottom Demersal Fishes by Beach Seine and Trawl in Puget Sound. Prepared by the U.S. Environmental Protection Agency Region 10, Office of Puget Sound, Seattle, WA, and the Puget Sound Water Quality Authority, Olympia, WA by Tetra Tech, Inc., Bellevue, WA, 56 pp.

PSEP (Puget Sound Estuary Program), 1997a. Recommended Guidelines for Sampling Marine Sediment, Water Column, and Tissue in Puget Sound. Prepared for U.S. Environmental Protection Agency Region 10, Seattle, WA and Puget Sound Water Quality Authority, Olympia, WA by King County Environmental Lab, Seattle, WA, 51 pp.

PSEP (Puget Sound Estuary Program), 1997b. Recommended Quality Assurance and Quality Control Guidelines for the Collection of Environmental Data in Puget Sound. Prepared for U.S. Environmental Protection Agency Region 10, Seattle, WA and Puget Sound Water Quality Authority, Olympia, WA by King County Environmental Lab, Seattle, WA, 32 pp. + appendices.

PSEP (Puget Sound Estuary Program), 1997c. Recommended Guidelines for Measuring Metals in Puget Sound Marine Water, Sediment and Tissue Samples. Prepared for U.S. Environmental Protection Agency Region 10, Seattle, WA and Puget Sound Water Quality Authority, Olympia, WA by King County Environmental Lab, Seattle, WA, 43 pp. + appendices.

PSEP (Puget Sound Estuary Program), 1997d. Recommended Guidelines for Measuring Organic Compounds in Puget Sound Water, Sediment and Tissue Samples. Prepared for U.S. Environmental Protection Agency Region 10, Seattle, WA and Puget Sound Water Quality Authority, Olympia, WA by King County Environmental Lab, Seattle, WA, 30 pp. + appendices.

PSEP (Puget Sound Estuary Program), 1998. Recommended Protocols for Station Positioning in Puget Sound. Prepared for U.S. Environmental Protection Agency Region 10, Office of Puget Sound, Seattle, WA and Puget Sound Water Quality Authority, Olympia, WA by Tetra Tech, Inc., Bellevue, WA, 25 pp. + appendices.

Sandvik, P., 2006. Standard Operating Procedures for Resecting Finfish Whole Body, Body Parts or Tissue Samples, Version 1.0. Washington State Department of Ecology, Olympia, WA. www.ecy.wa.gov/programs/eap/qa/docs/ECY_EAP_SOP_FishTissueProcessing_v1_0.pdf

Schimmel, S.C., B.D. Malzian, D.E. Campbell, C.J. Strobel, S.J. Benyi, J.S. Rosen, H.W. Buffum, and N.I. Rubenstein, 1994. Statistical Summary, EMAP Estuaries, Virginian Province - 1991. U.S. Environmental Protection Agency, Publication EPA/620/R-94/005.

Sloan, C.A., D.W. Brown, R.W. Pearce, R.H. Boyer, J.L. Bolton, D.G. Burrows, D.P. Herman, and M.M. Krahn, 2004. Extraction, cleanup, and gas chromatography/mass spectrometry analysis of sediments and tissues for organic contaminants. U.S. Department of Commerce, NOAA Technical Memorandum, NMFS-NWFSC-59, 47 pp. www.nwfsc.noaa.gov/publications/displayallinfo.cfm?docmetadataid=4330

WDFW, 2007a. 2007 PSAMP Groundfish Contaminant Survey: Sampling Plan (TRWL0705). Prepared for the Puget Sound Assessment and Monitoring Program, Fish Component. Prepared by the Washington Department of Fish and Wildlife. Spring 2007.

WDFW, 2007b. 2007 PSAMP Groundfish Contaminant Survey: Sampling Summary (TRWL0705). Prepared for the Puget Sound Assessment and Monitoring Program, Fish Component. Prepared by the Washington Department of Fish and Wildlife. Fall 2007.

Windward Environmental, LLC, 2005. Lower Duwamish Waterway Remedial Investigation. Data Report: Round 2 Surface Sediment Sampling for Chemical Analyses and Toxicity Testing. Map Folio – Final. Prepared for the US EPA and the Washington State Department of Ecology. December 2005.

Windward Environmental, LLC, 2007. Lower Duwamish Waterway Remedial Investigation. Phase 2 Remedial Investigation Report, Appendix A: Baseline Ecological Risk Assessment Final Lower Duwamish Waterway. Prepared for the US EPA and the Washington State Department of Ecology. July 2007.

Appendices

Appendix A – Sampling Locations: Target Coordinates

Table A-1. Coordinates for target sampling locations, Elliott Bay sediment and fish tissue chemistry studies.

Sampling Location Code	Target Latitude (NAD 1983)	Target Longitude (NAD 1983)		Sampling Location Code	Target Latitude (NAD 1983)	Target Longitude (NAD 1983)
114	47.575445	-122.360705		188	47.606030	-122.343893
115	47.628108	-122.379387		189	47.590513	-122.380505
172	47.594400	-122.412662		190	47.597167	-122.385080
173	47.603738	-122.399365		192	47.602277	-122.365957
176	47.629177	-122.399123		194	47.600253	-122.347308
177	47.632355	-122.402752		195	47.599578	-122.361033
178	47.625798	-122.393563		196	47.601218	-122.349653
180	47.624815	-122.378680		197	47.586377	-122.363738
181	47.615033	-122.362302		199	47.586665	-122.365030
182	47.604192	-122.344162		200	47.584643	-122.345792
183	47.603998	-122.340390		201	47.582618	-122.343445
184	47.604677	-122.340980		202	47.574327	-122.343328
185	47.609983	-122.382022		203	47.561407	-122.347435
186	47.618178	-122.365362		204	47.560923	-122.345088
187	47.607187	-122.359027		205	47.545110	-122.336877

Appendix B – Example Field Log

WASHINGTON STATE DEPARTMENT OF ECOLOGY
PUGET SOUND SEDIMENT MONITORING — SPATIAL COMPONENT

JUNE 2007 FIELD LOG

SAMPLE No.: _____ **MEL Lab ID: _____**

☐CHEM SPLIT SPLIT SAMPLE No.: _____ SPLIT MEL Lab ID: _____

CREW: ☐Sandra Aasen ☐Maggie Dutch ☐Valerie Partridge ☐Kathy Welch
Other:_____

WEATHER: ☐Clear ☐Cloudy ☐Fog ☐Overcast ☐Continuous layer of clouds ☐Rain ☐Windy ☐Thunderstorm

SEA STATE: ☐Calm ☐Choppy ☐Rough ☐Strong Current

GRAB USED: ☐Weighted ☐Unweighted

LOCATION: _____

TARGET DGPS LAT: _____ **LONG:** _____
☐TARGET MOVED 100m

SAMPLING DATE: _____/_____/2007

TIME OF: 1ST GRAB: _____AM/PM LAST GRAB: _____ AM/PM

STRATUM: ☐Basin ☐Harbor ☐Passage ☐Rural ☐Urban

STATION DESCRIPTION:
_____
_____

STATION STATUS: ☐ Target and Sampled ☐ Not Needed ☐ Not Sampled ☐ Not Targeted ☐ Other Sample ☐ Physically Inaccessible ☐Alternate for Station No. _____

STATION FAIL REASON: ☐ Abandoned ☐ Washed ☐ Poor Closure ☐ Disturbed Surface ☐ Shallow Penetration ☐ Rocky Bottom ☐ Algal Mats

GRAB INFORMATION (GRAB NO. 1)

GRAB ACCEPTIBILITY: No. Taken: _____ No. Rejected: _____

REASON FOR REJECT: ☐Abandoned ☐Washed ☐Poor Closure ☐Disturbed Surface ☐Shallow penetration

☐Rocky Bottom ☐Algal Mats

Meter Wheel Depth: _____ m Surface Salinity: _____ ppt
Temp: _____ºC

Penetration Depth: _____cm RPD: _____cm
☐Sheen Observed

SEDIMENT TYPE: ☐Cobble ☐Gravel ☐Sand ☐Silt-Clay

MATERIAL IN/ON SEDIMENT: ☐Wood Fragments ☐Shell Fragments ☐Plant Fragments ☐Macroalgae

SEDIMENT COLOR: ☐Olive ☐Gray ☐Brown ☐Black **–OVER–**

☐Olive ☐Gray ☐Brown ☐Black

SEDIMENT ODOR: ☐H_2S ☐Petroleum ☐Other: _____

☐Slight ☐Moderate ☐Strong ☐None

PARAMETERS SAMPLED: ☐ Grain Size ☐ Chemistry & TOC ☐ Bioassay

☐ Infauna ☐ Foraminiferans ☐ Other Tests: _____

COMMENTS:

_____

_____

_____

_____

SUBSEQUENT GRAB INFORMATION (if different from first) (GRAB NO. ____)

REASON FOR REJECT: ☐Abandoned ☐Washed ☐Poor Closure ☐Disturbed Surface ☐Shallow penetration ☐Rocky bottom ☐Algal Mats

METER WHEEL DEPTH: _____ m

Surface Salinity: _____ ppt Temp: _____ºC

Penetration Depth: _____cm RPD: _____cm ☐ Sheen Observed

SEDIMENT TYPE: ☐ Cobble ☐ Gravel ☐ Sand ☐ Silt-Clay

MATERIAL IN/ON SEDIMENT: ☐ Wood Fragments ☐ Shell Fragments ☐ Plant Fragments ☐ Macroalgae

SEDIMENT COLOR: ☐ Olive ☐ Gray ☐ Brown ☐ Black **–OVER–**
☐ Olive ☐ Gray ☐ Brown ☐ Black

SEDIMENT ODOR: ☐ H_2S ☐ Petroleum ☐ Other: _____
☐ Slight ☐ Moderate ☐ Strong ☐ None

PARAMETERS SAMPLED: ☐ Infauna ☐ Chemistry & TOC ☐ Grain Size

☐ Bioassay ☐ Foraminiferans ☐ Other Tests: _____

FAUNA OBSERVED :

_____
_____
_____
_____
_____

COMMENTS:

_____
_____
_____
_____
_____

RECORDED BY:

Appendix C – Methods for Preparing Fish Tissue Samples

Sandvik, P., 2006. Standard Operating Procedures for Resecting Finfish Whole Body, Body Parts or Tissue Samples. Version 1.0, Section 6.2.1.2: Whole Fish. Washington State Department of Ecology, Olympia, WA.
www.ecy.wa.gov/programs/eap/qa/docs/ECY_EAP_SOP_FishTissueProcessing_v1_0.pdf

Appendix D – Chain of Custody

The following provides details on the overall chain-of-custody requirements for this project.

Custody forms

- Sample label information will be compared to field logs and corrected if it does not match.
- Sample label information will be copied to custody forms.
- Samples will be placed on ice in a cooler.
- Information on custody forms will be compared to contents of the cooler.
- Final custody forms will include:
  - Project name and number.
  - Unique sample numbers.
  - Sample collection dates.
  - Special notations on sample characteristics or problems.
  - Types of analysis to be conducted.
  - Dates and times of sample transfer of custody.
  - Name of shipping firm and waybill number (if any).

Process for transferring custody of samples and tracking their status

- All persons will take custody and sign a form only if the samples being received are properly secured and will not be left unattended.
- The principal investigator will ensure proper transfer of custody to any shipping firm and obtain a waybill for each shipment.
- The principal investigator will ensure that each laboratory has accepted delivery of samples at the specified time.
- Laboratory staff will:
  - Ensure custody forms are signed upon receipt of samples.
  - Record observations or questions about sample integrity on custody forms.
  - Contact the principal investigator upon receipt of samples if any shipment differs from information on its custody form.
  - Retain copies of all custody forms.
  - Include the custody forms as an appendix to data and QA/QC reports.

Requirements for contract laboratories

Upon receipt and taking custody of samples, contract laboratories will assign a unique identifier to each sample and ensure that each sample is tracked through all stages of preparation and analysis. At a minimum, the tracking record will contain the test method being used, name or initials of persons conducting the analysis, and dates samples were extracted, otherwise prepared, and tested.