East Waterway Operable Unit
Supplemental Remedial Investigation/ Feasibility Study
Final Data Report
Clam Surveys and Sampling of Clam Tissue and Sediment

For submittal to:

The US Environmental Protection Agency
Region 10
Seattle, WA

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Acronyms

Acronym	Definition
ACG	analytical concentration goal
ARI	Analytical Resources, Inc.
aRPD	apparent redox potential discontinuity
BBP	butyl benzyl phthalate
BEHP	bis(2-ethylhexyl) phthalate
BHC	benzene hexachloride
CFR	Code of Federal Regulations
CCV	continuing calibration verification
COC	chain of custody
COI	chemical of interest
CAS	Columbia Analytical Services, Inc.
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CSL	cleanup screening level
CVAA	cold vapor atomic absorption spectrophotometry
DCM	dichloromethane
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DMMP	Dredged Material Management Program
DRC	dynamic reaction cell
dw	dry weight
EPA	US Environmental Protection Agency
ERA	ecological risk assessment
EW	East Waterway
EWG	East Waterway Group
GC/ECD	gas chromatography/electron capture detection
GC/MS	gas chromatography/mass spectrometry
GFAA	graphite furnace atomic absorption spectrophotometry
HG-AFS	hydride generation-atomic fluorescence spectrometry
HHRA	human health risk assessment
HPAH	high-molecular-weight polycyclic aromatic hydrocarbon
HRGC/HRMS	high-resolution gas chromatography/high-resolution mass spectrometry

Acronym	Definition
ICP-AES	inductively coupled plasma-atomic emission spectrometry
ICP-MS	inductively coupled plasma-mass spectrometry
LAEL	lowest apparent effects threshold
2LAET	second lowest apparent effects threshold
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
LPAH	low-molecular-weight polycyclic aromatic hydrocarbon
MDL	method detection limit
ML	maximum level
MLLW	mean lower low water
MS	matrix spike
MSD	matrix spike duplicate
NOAA	National Oceanic and Atmospheric Administration
OC	organic carbon
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCP	pentachlorophenol
PSEP	Puget Sound Estuary Program
QA/QC	quality assurance/quality control
QAPP	quality assurance project plan
RL	reporting limit
RPD	relative percent difference
SDG	sample delivery group
SIM	selective ion monitoring
SL	screening level
SMS	Washington State Sediment Management Standards
SQS	sediment quality standard
SVOC	semivolatile organic compound
T-18	Terminal 18
TOC	total organic carbon
USCG	US Coast Guard
Windward	Windward Environmental LLC
ww	wet weight

1 Introduction

This data report presents the results of intertidal clam and geoduck habitat surveys and chemical analyses of tissue samples (geoduck and intertidal clam) and sediment samples (co-located with intertidal clam tissue) that were conducted as part of the supplemental remedial investigation (SRI) for the East Waterway (EW). The surveys, tissue and sediment sampling, and chemical analyses were conducted in accordance with the intertidal clam studies quality assurance project plan (QAPP) and addendum to the QAPP (Windward 2008c). Data from these studies will be used to support the ecological and human health risk assessments (ERA and HHRA, respectively) and the SRI and feasibility study for the EW. The following components of this study are described in this data report:

- Characterization of intertidal clam habitat
- Collection and chemical analysis of intertidal clam tissue and co-located sediment
- Characterization of subtidal benthic habitats and identification of potential geoduck beds
- Collection of geoduck tissue and co-located sediment and chemical analysis of geoduck tissue

The intertidal clam studies were designed to collect composite samples of intertidal clams and co-located sediment samples from EW intertidal areas where clams could potentially be harvested by people and wildlife. The intertidal clam tissue data will be used in the HHRA to estimate chemical exposures of people who could potentially consume clams collected from the EW and in the ERA to estimate chemical exposures of otters, which are wildlife receptors of concern that may consume clams as part of their diet. The co-located sediment chemistry data will be used to evaluate potential relationships between tissue chemical concentrations and sediment chemical concentrations. Geoduck tissue samples were collected for tissue analysis to support the evaluation of tribal shellfish consumption in the EW.

This report is organized into sections that address field and analytical methods, chemical analysis results, and references. The text is supported by the following appendices:

- Appendix A – Data Tables
- Appendix B – Data Management
- Appendix C – Data Validation Reports
- Appendix D - Laboratory Report forms
- Appendix E – Collection Forms and Field Notes
- Appendix F – Chain-of-Custody (COC) Forms

- Appendix G – Photographs of Benthic Habitat
- Appendix H –Clam Compositing Memorandum
- Appendix I – Geoduck Compositing Memorandum
- Appendix J Geoduck Aging Memorandum

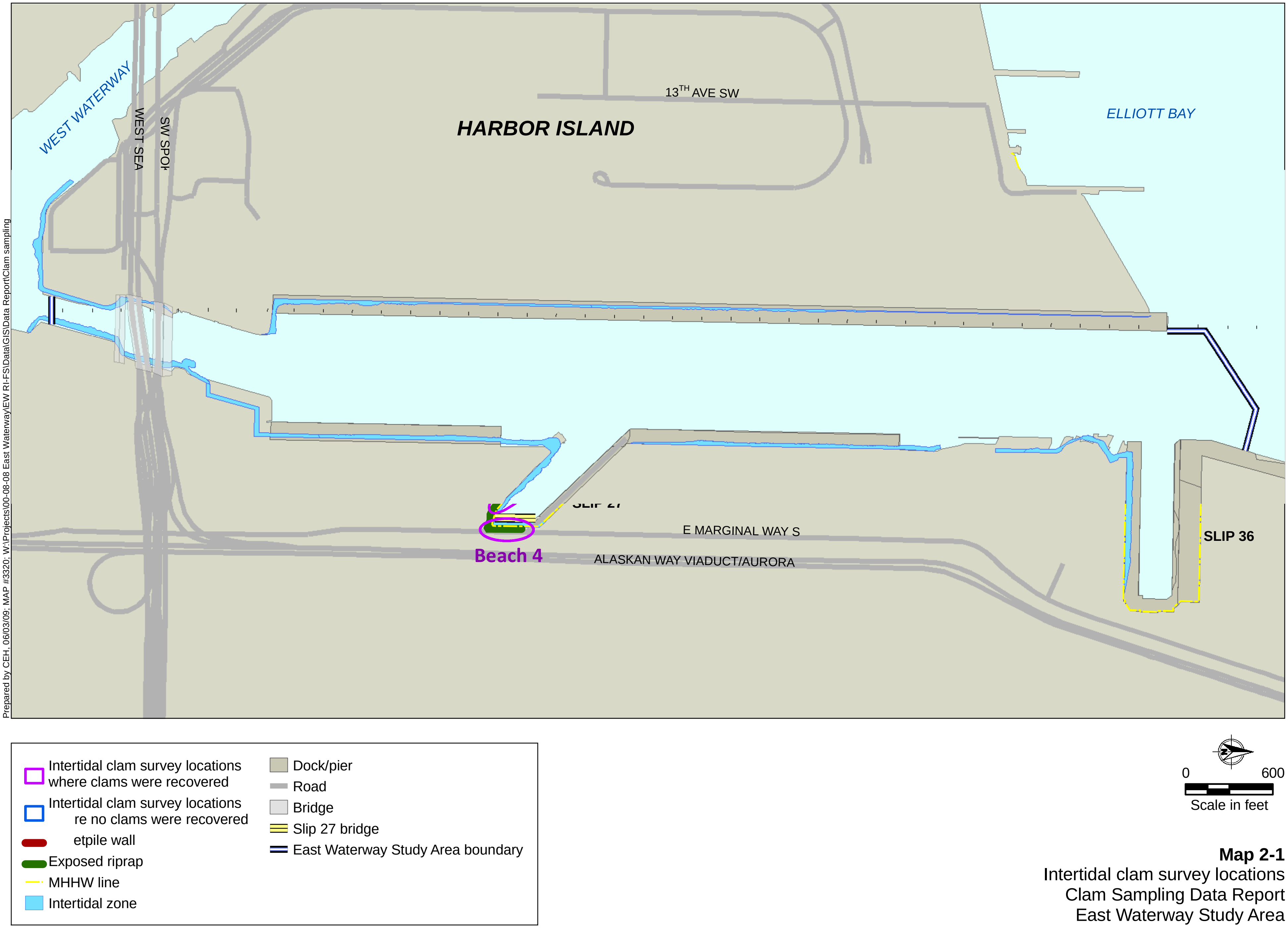
A subset of intertidal clam and geoduck samples will be analyzed for polychlorinated biphenyl (PCB) congeners and dioxin and furans). The PCB congener and dioxin and furan data are not available for inclusion in this report. The results from these analyses will be provided in a separate data report. Geoduck shell aging results will be provided in a separate data memo.

2 Habitat Surveys for Intertidal Clams and Geoducks

The intertidal clam and geoduck surveys were conducted to evaluate the extent, distribution, and quality of intertidal clam habitat, evaluate subtidal habitat for geoducks, and to identify locations from which to collect tissue and sediment samples for chemical analysis.

2.1 INTERTIDAL CLAM SURVEY

Eleven beaches were identified in the QAPP for the intertidal clam survey based on a field reconnaissance conducted in early June 2008 by Windward Environmental LLC (Windward) staff and a subsequent site visit in July 2008 by the US Environmental Protection Agency (EPA) and East Waterway Group (EWG) (Map 2-1). Each of these 11 beaches was visited during the intertidal clam sample collection events in July and August 2008. Observations of conditions, including apparent grain size/sediment texture; beach slope; degree of exposure to wind- or ship-generated wave action; presence of macroalgae, debris, or man-made structures; and the presence and type of clams and other organisms (e.g., worms, amphipods, crab) on or within the sediment were recorded (Appendix E). Intertidal clams were present at 9 of the 11 beaches (Map 2-1). The remaining two beaches – Beach 1 (US Coast Guard [USCG]) and Beach 2 (Jack Perry Memorial Park public access) – were composed of crushed rock that was unsuitable as intertidal clam habitat (Map 2-1). Although observations indicated that no clam habitat was available at Beaches 1 and 2 during the field reconnaissance and subsequent site visit, an attempt was made to collect samples from these beaches during the sampling event. No clams were found during the sampling event, which confirmed the previous determination of unsuitable habitat. Intertidal habitat characteristics varied by location within the EW and are summarized in Table 2-1.



Map 2-1
Intertidal clam survey locations
Clam Sampling Data Report
East Waterway Study Area

Table 2-1. Intertidal clam habitat characteristics based on reconnaissance and sampling event observations

Intertidal Location	Substrate Type and General Observations of Sediment Conditions	Were Clams Observed?	Clam Species Observed
Beach 1 (USCG)	Primarily placed material, including boulders, cobble and gravel; fine sediment only present below placed material; concrete and possible brick debris mixed in with boulders and gravel	no	none
Beach 2 (Jack Perry Memorial Park)	Primarily placed material, including riprap and crushed rock; subsurface sediment is anoxic with strong odor; minimal fine-grained sediment	no	none
Beach 3	Primarily sand with shell debris; boulders, gravel, and cobble along outside edges of beach; subsurface sediment is black and has an odor	yes	*Macoma* spp., Japanese littleneck (*Tapes japonica*), and butter clam (*Saxidomus giganteus*)
Beach 4 (Slip 27)	Primarily mixed course material of cobble, gravel, and sand; small area of mixed fine sand and mud; below 0.0-ft MLLW, top layer (0 to 2-in.) is silt and sand, below top layer is gravel with some fine sand; strong sulfur odor is present in the area below 0.0-ft MLLW; debris in the form of wood, rebar, and trash is scattered around beach	yes	*Macoma* spp. and Japanese littleneck (*Tapes japonica*)
Beach 5 (Slip 27)	Primarily placed riprap; a shelf of gravel, cobble, and sand below riprap	yes	*Macoma* spp.
Beach 6 (Slip 27)	Primarily a mix of boulders, cobble, and gravel extending to around 0.0-ft MLLW; below 0.0-ft MLLW is sand-mud substrate; shell debris mixed in with mud substrate and some asphalt pieces mixed with boulders	yes	*Macoma* spp. and butter clam (*Saxidomus giganteus*)
Beach 7	Primarily placed angular crushed rock and cobble; large pieces of asphalt and pipe debris are present; an interface between placed material and native material present at 2.0-ft MLLW; strong hydrogen sulfide odor was present in the subsurface sediment around -2.0-ft MLLW line	yes	*Macoma* spp. and Japanese littleneck (*Tapes japonica*)
Beach 8	Substrate is dense clay-sand with some large pieces of concrete under the Spokane Street Bridge and small patches of cobble; the central beach area is represented by sandy-gravel; the southern portion of the beach is silty-sand with some shell debris mixed in under the railroad bridge; some riprap is also present at the top portion of beach; a strong sulfur odor was present under the railroad bridge	yes	*Macoma* spp., butter clam (*Saxidomus giganteus*), Eastern soft-shell (*Mya* sp.), cockle (*Clinocardium nuttali*), and Japanese littleneck (*Tapes japonica*)
Beach 9	Placed riprap down to a sediment bench of primarily medium sand with an overlying silt layer; some areas still had remnants of filter fabric approximately 2 ft below the sediment	yes	*Macoma* spp. and Eastern soft-shell (*Mya* sp.)
Beach 10	Primarily riprap down to silty sand with some angular cobble	yes	Butter clam (*Saxidomus giganteus*), *Macoma* spp., cockle (*Clinocardium nuttali*), and Japanese littleneck (*Tapes japonica*)

Intertidal Location	Substrate Type and General Observations of Sediment Conditions	Were Clams Observed?	Clam Species Observed
Beach 11	Cement slabs and boulders down to the -2.0-ft MLLW elevation line; course black sand is below	yes	*Macoma* spp.

MLLW – mean lower low water

USCG – US Coast Guard

2.2 GEODUCK SURVEY

Two video surveys conducted in the EW in July and August 2008 were reviewed to select areas for potential geoduck tissue sampling in October 2008. On July 15 and 16, 2008, EPA made observations of subtidal geoduck habitat with a remotely operated video camera in shallow areas that were unlikely to be accessible by towed video equipment. This was followed by a towed video survey of the main waterway and slips conducted by Windward's contractor (Research Support Services) on August 15, 2008. Methods for the towed video survey are presented in the clam QAPP (Windward 2008d); no QAPP was prepared for the EPA survey. The video survey tracks for both types of video surveys are shown on Map 2-2.

During the video surveys, potential geoduck siphons (see example in Figure 2-1) were observed only at the Elliott Bay entrance to the EW in about 55 ft of water west of the channel center. One possible siphon "show" was also identified along the eastern shoreline, south of Slip 36, near the Jack Perry Memorial Park (Map 2-2). EPA's review of the survey tracks and video images resulted in a request to evaluate several other areas of the EW for the presence of geoducks. It was agreed that diver surveys would be conducted in October during the geoduck sampling effort and a concurrent rockfish collection effort, such that additional samples could be collected if geoduck were found to be present in other areas of the waterway. Areas of the EW that have been dredged within the past 2 years were not targeted because recently disturbed sediments are unlikely to support populations of geoduck.

Prepared by CEH, 06/03/09; MAP #3455; W:\Projects\00-08-08 East Waterway\EW RI-FS\Data\GIS\Data Report\Clam sampling

- Potential geoduck location[a]
- Towed video transect
- EPA remotely operated vehicle survey line
- Dock/pier
- Road
- Slip 27 bridge
- East Waterway Study Area boundary

Dredge Events (completion date)

- T-30 interim dredge (preliminary 2009, -51 MLLW)
- Stage 1a (completed 2006, -51 MLLW)
- Coast Guard dredge (completed 2005, -40 MLLW)
- Phase 1 removal action boundary (completed 2005, -51 MLLW)
- T-30 boundary (completed 2002, -51 MLLW)
- Stage 1 (completed 2000, -51 MLLW)

0 600
Scale in feet

Map 2-2
East Waterway video transects with potential geoduck observations
Clam Sampling Data Report
East Waterway Study Area

[a] These locations were identified as potential geoduck locations based on siphon shows except the location near Jack Perry Memorial Park, which was not positively identified as a siphon show.

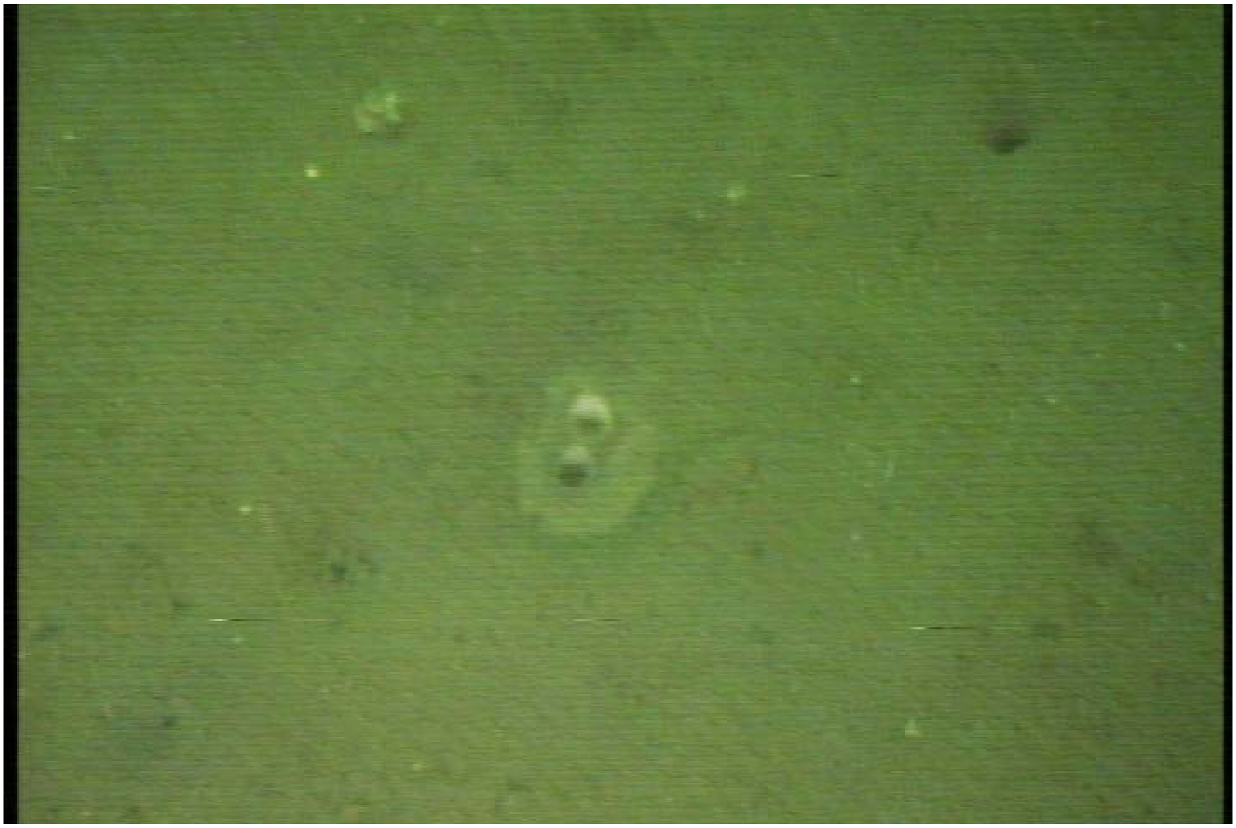


Figure 2-1. Geoduck siphon hole

The following six areas (Map 2-3) were selected for the diver survey of geoducks in October 2008:

- **Area 1 –** the western half of the channel at the mouth of the waterway where potential geoduck siphons had been observed during the towed video survey
- **Area 2 –** the eastern shoreline near Jack Perry Memorial Park, where the video survey recorded a potential geoduck show
- **Area 3 –** the deep, undredged area in the midchannel between Terminal 30 and Terminal 18 (T-18)
- **Area 4 –** the undredged area at the head of the waterway between Terminal 25 and the south end of T-18
- **Area 5 –** northern portion of T-18, dredged in 2000 with elevated PCB concentrations
- **Area 6 –** middle of the waterway, along T-18 pier face

Methods and results of the additional habitat characterization and sampling of geoducks and co-located sediment are discussed in Section 3.2 of this data report.

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Potential geoduck locations[a]
Diver observation/potential geoduck collection area
Dock/pier
Road
Slip 27 bridge
East Waterway Study Area boundary

Dredge Events (completion date)
T-30 interim dredge (preliminary 2009, -51 MLLW)
Stage 1a (completed 2006, -51 MLLW)
Coast Guard dredge (completed 2005, -40 MLLW)
Phase 1 removal action boundary (completed 2005, -51 MLLW)
T-30 boundary (completed 2002, -51 MLLW)
Stage 1 (completed 2000, -51 MLLW)

0 600
Scale in feet

Map 2-3
Geoduck diver survey areas
Clam Sampling Data Report
East Waterway Study Area

[a] These locations were identified as potential geoduck locations based on siphon shows except the location near Jack Perry Memorial Park, which was not positively identified as a siphon show.

3 Field Collection and Sample Processing Methods

This section describes the collection of intertidal clam tissue samples, sediment samples co-located with intertidal clams, and geoduck tissue, as well as sample processing methods. The field procedures are described in greater detail in the QAPP (Windward 2008c). Field deviations from the QAPP are also presented. Copies of field forms, notebooks, and laboratory forms are presented in Appendix E. Copies of completed COC forms used to track sample custody are presented in Appendix F.

3.1 Intertidal Clam Tissue and Sediment Collection and Sample Processing Methods

This section describes the collection of intertidal clam tissue samples and co-located sediment samples, as well as sample processing methods. Intertidal clam tissue samples and co-located sediment samples were collected at low tide from the EW from July 29 to August 1, 2008, at nine intertidal locations identified as having intertidal clam habitat based on the initial survey results (Beaches 3 though 11; Map 2-1). During this effort, the field crew attempted to collect clams at the remaining two beaches (Beaches 1 and 2), but clams were not found. The specific sampling date and coordinates for each beach area are presented in Table 3-1.

Table 3-1. Intertidal clam sampling location coordinates in the EW

Location	Collection Date	Intertidal Clam Sampling Location			
		North End (E End for Beaches 5 and 7)		South End (W End for Beaches 5 and 7)	
		Latitude	Longitude	Latitude	Longitude
Beach 1[a]	7/31/2008	47.58947	-122.34272	47.58942	-122.34265
Beach 2[a]	7/31/2008	47.58518	-122.34275	47.58833	-122.34273
Beach 3	7/30/2008	47.58747	-122.34262	47.58735	-122.34273
Beach 4	7/29/2008	47.57822	-122.34024	47.57795	-122.34036
Beach 5	7/29/2009	47.57837	-122.34125	47.57872	-122.34182
Beach 6	7/29/2008	47.57908	-122.34255	47.57895	-122.34270
Beach 7[b]	7/30/2008	47.57339	-122.34264	47.57337	-122.34268
Beach 8	7/30/2008	47.57187	-122.34460	47.57092	-122.34490
Beach 9	7/31/2008	47.57068	-122.34523	47.56973	-122.34568
Beach 10[b]	8/1/2008	47.57144	-122.34622	47.57112	-122.34630
Beach 11	8/1/2008	47.57368	-122.34550	47.57355	-122.34542

a Clam were not found at Beaches 1 and 2 during the sampling event.

b Coordinates are approximate for Beaches 7 and 10 because overhead structures blocked the GPS signal.

EW – East Waterway

GPS – global positioning system

At each beach, the entire area was canvassed for the presence of intertidal clams based on the observation of siphons, dimples, or siphon holes (clam "shows"). Two approaches were used for clam and sediment collection depending on clam density. The first approach, used at locations where intertidal clams were evident, involved placing 0.25-m^2 quadrats throughout the beach area and removing individual clams and sediment from the entire area of each quadrat. Representative tissue and sediment samples were collected from quadrats placed throughout the entire beach area at elevations including +2.0 ft, 0 ft, and -2.0 ft to avoid spatially biasing the characterization of the beach and potential exposure estimates.

Where no intertidal clams were evident (i.e., Beaches 4, 5, 6, 7, and 11), a second, more systematic approach was used. At these beaches, transects were laid out along intertidal elevations of +2.0 ft, 0 ft, and -2.0 ft. Five sampling points along each transect or 10% of each transect length (whichever was greater) was randomly selected along each transect, and a quadrat was placed at each of these points.

Sediment from the entire area within each quadrat was excavated to a depth of 30 cm (1 ft) below the sediment surface at each sampling point. Shovels were used to initiate the hole; in many cases, hand digging was required to retrieve intertidal clams without breaking shells. Following the collection of intertidal clams from a hole, an aliquot of sediment representing the top 30 cm from the excavation wall was sampled and placed in a large stainless steel bowl. The remaining sediment was screened through a 2-mm mesh screen; intertidal clams larger than (or equal to) approximately 4 cm were sorted by species and retained for potential analysis. Smaller (< 4 cm and retained on the sieve screen) intertidal clams, which could represent invertebrate exposures or possible subsistence consumption were also retained. The maximum level of effort was 2 hours for a small pocket beach and an entire low-tide cycle (± 2 hours on either side of the low tide) for a larger beach.

Large intertidal clams (≥ 4 cm) were separated by species, wrapped in clean foil (shiny side out), and double-bagged in plastic ziplock bags.[1] Samples were held on ice until transport to Windward for weighing, measuring, and species identification.

At each beach, all of the sediment collected from each quadrat where clams were collected was homogenized in a stainless steel bowl in the field to create one composite sediment sample. From this composite, 68 oz of sediment was removed. Homogenized sediment was placed in two 16-oz glass jars, two 8-oz glass jars, one 4-oz glass jar, and one 16-oz high-density polyethylene jar. These jars were stored on ice in the field and during transport to the laboratory.

The intertidal clams were transported on ice in coolers to the Windward laboratory, where each intertidal clam was identified to species and its weight (with shell), and shell length at the longest point was measured and recorded. Of the nine beaches with

[1] All clams were kept in their shells until processed at the laboratory (see Section 4-1).

intertidal clam habitat, five had adequate tissue per species, if composited,[2] to support a full suite of analyses (assuming that 200 grams of tissue were required and that the shell contributes 50% of the total body weight). *Macoma* spp. intertidal clams were encountered at all beaches where clams were found (i.e., Beaches 3 through11); however, these species are very small (< 4 cm) and only provided enough tissue for analysis at one beach. After consultation with the tribes and EPA, it was determined that *Macoma* spp. would not be used to represent tribal subsistence diets and thus were not analyzed. Instead, these clams were archived for potential future analysis. Littleneck clams were found at five beaches but collectively did not provide enough tissue for analysis of all chemicals of interest (COIs) as outlined in the QAPP (Windward 2008b). Butter clams were collected at four beaches and provided excess combined biomass in almost all cases (i.e., replicate analyses were possible). Cockles were found at two beaches where butter clams were also found with sufficient biomass to analyze all COIs, if composited.[1] Eastern soft-shell clams, the principal species of intertidal clams analyzed for the Lower Duwamish Waterway risk assessment, were found at only two of the southern-most beaches and with adequate tissue for analysis at only one beach (Beach 9).

The intertidal clam species and average intertidal clam weights at each EW sampling location are presented in Table 3-2. The species, weights, and lengths of individual intertidal clams are presented in Appendix E. After identification and measurement, intertidal clams were repackaged,[3] stored on ice, and delivered to Analytical Resources, Inc., (ARI), for sample processing and chemical analysis. The intertidal clams were frozen until a tissue compositing strategy was finalized by EPA.

Table 3-2. Intertidal clam species and weight for each EW beach

Sampling Location	Species	Weight (g ww with shell)	Number of Intertidal Clams
Beach 3	butter clam (*Saxidomus giganteus*)	389.6	9
	native littleneck clam (*Protothaca staminea*)	55.5	1
	Macoma spp.	32.7	7
Beach 4	Japanese littleneck clam (*Tapes japonica*)	1.7	1
	Macoma spp.	23	8
Beach 5	*Macoma* spp.	92.1	37
Beach 6	butter clam (*Saxidomus giganteus*)	1,178.4	17
	Macoma spp.	3.9	2
Beach 7	native littleneck clam (*Protothaca staminea*)	1.8	1

[2] Composites were composed of all individual clams of the same species from a single beach. When tissue volumes were adequate to allow the creation of replicate samples with the same species, the clams were divided into two groups representing similar size ranges, and each group was homogenized and analyzed separately.

[3] The procedures followed during repackaging at Windward were the same as those used in the field. Clams were stored in the refrigerator at Windward when not being processed.

Sampling Location	Species	Weight (g ww with shell)	Number of Intertidal Clams
	Macoma spp.	>3.8[a]	34
Beach 8	butter clam (*Saxidomus giganteus*)	2,258.5	30
	native littleneck clam (*Protothaca staminea*)	169.6	9
	Eastern soft-shell clam (*Mya* sp.)	43	1
	cockle clam (*Clinocardium nuttali*)	845.5	17
	Macoma spp.	63.1	23
Beach 9	Eastern soft-shell clam (*Mya* sp.)	595	15
	Macoma spp.	539.9	121
Beach 10	butter clam (*Saxidomus giganteus*)	1,183.5	13
	native littleneck clam (*Protothaca staminea*)	67.7	4
	cockle clam (*Clinocardium nuttali*)	480.5	13
	Macoma spp.	116.13	50
Beach 11	*Macoma* spp.	220.7	57

[a] Twenty-five clams in this group each weighed less than 0.1 g, which is below the accuracy of the field scale.

EW – East Waterway

ww – wet weight

A compositing approach was agreed upon by EWG, EPA, tribes, and stakeholders and documented in a memorandum to EPA (Windward 2008b) (Appendix I). Because of the variety of species collected at various locations and limitations in tissue mass, this memorandum considered the most appropriate approach for supporting the needs of the HHRA. Based on the memorandum, composite intertidal clam tissue samples were created using tissue from the following five beaches with sufficient tissue: Beaches 3, 6, 8, 9, and 10 (Table 3-3). In summary, of the 11 identified intertidal sediment areas, 9 beaches were found to have intertidal clams, and 5 beaches were found to contain sufficient clams to create intertidal clam samples. Composite sediment samples were collected at each of the 9 beaches, although chemical analyses were performed on only the 5 composite sediment samples from beaches with clam samples.

Table 3-3 Composite clam tissue

Location	Species	Total Number of Intertidal Clams	Number of Composites	Number of Intertidal Clams per Composite
Beach 3	butter clam (*Saxidomus giganteus*)	9	1	9
Beach 6	butter clam (*Saxidomus giganteus*)	17	2[a]	8 – 9
Beach 8	butter clam (*Saxidomus giganteus*)	30	2[a]	15
	native littleneck clam (*Protothaca staminea*)	9	1[b]	9
	cockle clam (*Clinocardium nuttali*)	17	1	17
Beach 9	Eastern soft-shell clam (*Mya* sp.)	15	1	15

Location	Species	Total Number of Intertidal Clams	Number of Composites	Number of Intertidal Clams per Composite
Beach 10	butter clam (*Saxidomus giganteus*)	13	2[a]	6 – 7
	native littleneck clam (*Protothaca staminea*)	4	1[b]	4
	cockle clam (*Clinocardium nuttali*)	13	1	13

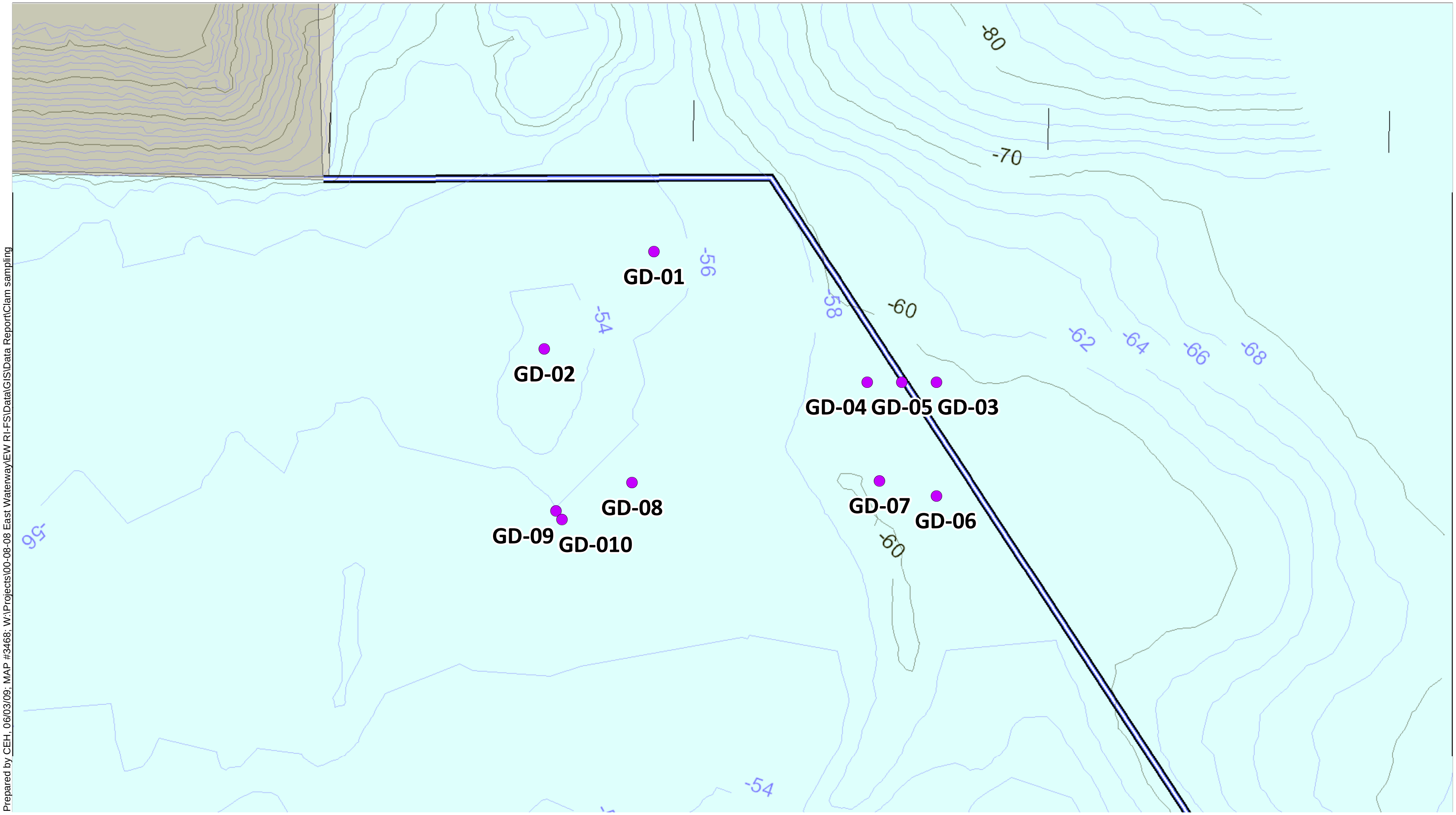
[a] Intertidal clams were sorted by size and separated into two composites. An effort was made to separate clams in a manner to include clams of equal size in each composite.

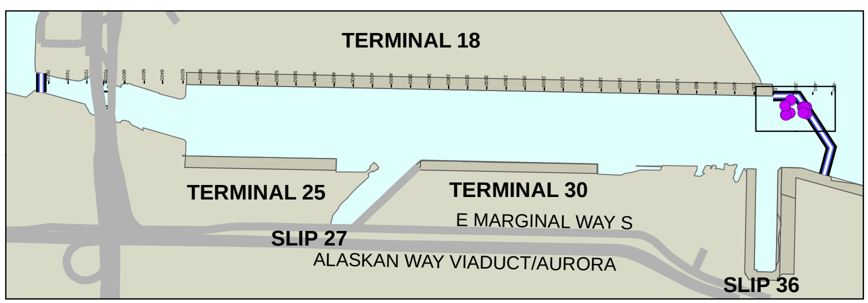
[b] Composite samples were analyzed for a subset of analytes because of low tissue mass (see Section 4.1).

3.2 SUBTIDAL GEODUCK COLLECTION AND SAMPLE PROCESSING METHODS

Geoduck tissue collection is described in detail in the addendum to the QAPP (Windward 2008a). Geoducks were collected by divers using a pressurized water nozzle that was inserted into the sediment adjacent to each intertidal clam. This hydraulic extraction method is similar to that used by commercial geoduck harvesters. Individual geoduck were placed in a mesh bag for transport to the surface where they were wrapped in foil, labeled with the sample location, bagged and placed on ice. Geoducks were found only in Area 1 (see Map 3-1). Geoduck sampling location coordinates are provided in Table 3-4, and the locations are shown on Map 3-1. Details on the compositing scheme for geoduck tissue are included in Appendix I. The geoduck weights and estimated ages for each sample are presented in Table 3-5.

Prepared by CEH, 06/03/09; MAP #3468; W:\Projects\00-08-08 East Waterway\EW RI-FS\Data\GIS\Data Report\Clam sampling





0 100
Scale in feet

Geoduck sampling location
Dock/pier
East Waterway Study Area boundary

Map 3-1
Geoduck sampling locations
Clam Sampling Data Report
East Waterway Study Area

Table 3-4. Geoduck sampling location coordinates in the EW

Location	Collection Date	Geoduck Sampling Location Coordinates	
		Latitude	Longitude
EW-S01-01	10/23/08	47.591008	122.345863
EW-S01-02	10/23/08	47.590837	122.34563
EW-S01-03	10/25/08	47.59146	122.34557
EW-S01-04	10/25/08	47.59135	122.345567
EW-S01-05	10/25/08	47.591405	122.345568
EW-S01-06	10/25/08	47.591464	122.345303
EW-S01-07	10/25/08	47.591373	122.345336
EW-S01-08	10/25/08	47.59098	122.34532
EW-S01-09	10/25/08	47.59086	122.34525
EW-S01-10	10/25/08	47.59087	122.34523

EW – East Waterway

Table 3-5. Geoduck tissue mass and estimated age

Sample	Whole Body Mass (in shell) (g)	Gutball Mass (g)	Edible Tissue Mass (g)	Estimated Age (years)
GD-01	280.08	32.27[a]	127.59	14
GD-02	655.15	64.39[a]	303.89	14
GD-03	588.60	57.93	248.42	14
GD-04	969.29	125.62	404.05	14
GD-05	557.45	62.75	223.78	13
GD-06	554.08	76.67	240.04	14
GD-07	788.26	69.37	319.24	16
GD-08	317.01	41.05	145.04	13
GD-09	312.66	32.28	136.72	14
GD-10	386.79	43.57	152.24	10

[a] These clams were not included in the gutball composite samples.

Sediment samples were subsequently collected by divers by means of shallow core sampling from the top 30 cm adjacent to geoduck collection locations. This sediment was collected prior to the collection of the geoduck at each location. Sediment samples were placed in appropriate sample containers, labeled, bagged, and placed on ice. The sediment samples and the geoduck samples were delivered to ARI. The geoduck sediment samples were not analyzed but instead were archived frozen for potential analysis once the tissue data had been reviewed. Geoduck samples were frozen whole until analysis.

Six of the individual geoduck edible meat samples were selected for analysis (GD-01, GD-02, GD-03, GD-04, GD-07, and GD10). The individual gutball samples did not have sufficient mass for the analysis of all chemicals of interest; therefore, the gutball samples were composited into three samples. Samples GD-03, GD-04, and GD-05 were composited as Composite 1; samples GD-06 and GD-07 were composited as Composite 2; and samples GD-08, GD-09, and GD-10 were composited as Composite 3. The compositing was based on combining samples that were collected in close proximity to one another (Windward 2009b). Details on the compositing scheme are presented in Appendix I.

Individual edible meat samples were homogenized following the removal of the gut ball and siphon skin (leathery outer layer) at ARI in accordance with the laboratory standard operating procedures. The skin was pulled off by hand from frozen tissue samples. The preparation was consistent with standard practices prior to human consumption and minimizes the loss of edible tissue associated with the removal of the siphon skin.

Geoduck shells were retained for age analysis. The age analysis was done by Bethany Stevick at the University of Washington aging lab. Geoduck age estimation is performed by examining the internal annuli (rings) found within the umbo region of the shell and counting the annuli from the growing edge toward the umbo. Ages are estimates and approximately +/- 1 year. Details on the geoduck shell age analysis are presented in Appendix J.

3.3 SAMPLE IDENTIFICATION SCHEME

Each sample location (e.g. beach for intertidal clams) was assigned a unique alpha-numeric location identification (ID) number. The first two characters of the location ID were "EW" to identify the East Waterway project area. The sampling locations for the overall project were divided into intertidal and subtidal groups, as indicated by a single character following the project area: B for an intertidal beach; S for a subtidal location. The specific location was indicated by a two-digit number that follows the intertidal/subtidal notation (beaches were numbered 01 to 11); subtidal sampling location was numbered separately).

The next characters indicated the sample medium collected at a location, SS for surface sediment, JL for Japanese littleneck clam (*Tapes japonica*) tissue, NL, native littleneck clam (*Protothaca staminea*) tissue, CN for cockle clam (*Clinocardium nuttali*) tissue, MY for Eastern soft-shell clam (*Mya arenaria)* tissue, MA for *Macoma* spp. clam tissue, BC for butter clam (*Saxidomus giganteus*) tissue, BN for bent-nose clam (*Macoma nasuta*) tissue, or GD for geoduck (*Panopea abrupta*) tissue. When more than one sample of a specific medium was collected at a given location, a two-digit numeric suffix greater than -01 was added (the first collected samples at each location were all labeled -01). Sample names for surface sediment samples also contained the depth of collection (e.g., -030 to indicate the sediment was collected from 0 to 30 cm). The homogenized geoduck samples were identified as either “EM” –for edible meat or “GB-comp” for gutball composite. Examples of sample naming conventions for the clam studies follow:

- EW-B01-BC-01 (East Waterway, Beach 1, butter clam tissue, first bag of clams)
- EW-B01-BC-02 (East Waterway, Beach 1, butter clam tissue, second bag of clams)
- EW-B01-SS-030 (East Waterway, Beach 1, surface sediment, collected from 0 to 30 cm)
- EW-S01-GD-01 (East Waterway, subtidal Location 1, first geoduck)

Once intertidal clams had been composited, a unique sample identifier was assigned to the composite sample. The three geoduck gutball tissue samples were composites from multiple individual geoducks, so an additional qualifier was added to those samples (comp1, comp2, or comp3).

3.4 FIELD DEVIATIONS FROM THE QAPP

Field sampling was conducted according to the QAPP (Windward 2008d) with one exception. Sediment from Beach 9 was collected as two samples from separate areas (9a and 9b) to represent the distinct difference in the distribution of intertidal clams in those two areas: Eastern soft-shell clam at the south end, and *Macoma* spp. on the north end). Because intertidal clams were composited according to species, the intent of this field deviation was to more accurately associate each co-located sediment sample with the corresponding intertidal clam species.

4 Laboratory Methods

The methods and procedures used to chemically analyze the tissue and sediment samples are described briefly in this section and in detail in the clam QAPP (Windward 2008d). This section also summarizes any laboratory deviations from the QAPP. Analytical testing adhered to the most recent Puget Sound Estuary Program (PSEP) and EPA quality assurance/quality control (QA/QC) guidelines and analysis protocols (PSEP 1997; EPA 2002).

Tissue (intertidal clam and geoduck) and sediment (co-located with intertidal clams) samples were hand-delivered to ARI, where they were homogenized into composite samples according to the compositing scheme that was approved by EPA (Appendix I). Samples were analyzed for total metals, including mercury, inorganic arsenic (tissue samples only), butyltins, semivolatile organic compounds (SVOCs), PCB Aroclors, organochlorine pesticides, total solids. Tissue samples were also analyzed for lipids and sediment samples were also analyzed for grain size and TOC. Two of the clam samples (EW-B08-NL-03-comp1 and EW-B10-NL-03-comp1) were analyzed only for a partial analyte list (Appendix I). A subset of samples were analyzed for PCB congeners and dioxins/furans by Analytical Perspectives. The results of the PCB congener and dioxins/furans analyses will be included in a separate data report. The laboratories performing the analyses are listed in Table 4-1.

Intertidal clam composite tissue samples and geoduck tissue samples were also reanalyzed to achieve lower reporting limits for PAHs at Columbia Analytical Services, Inc. (CAS), and bis(2-ethylhexyl) phthalate (BEHP) and pentachlorophenol (PCP) at ARI. Frozen archived composite clam tissue subsamples that were at Brooks Rand Labs following metals analysis and at CAS following PCB Aroclor analysis were shipped via overnight delivery to ARI. The remaining volume of the subsamples for each composite intertidal clam sample was then combined. A fresh subsample of each intertidal clam composite tissue sample was then transferred to CAS via overnight delivery for the low-level PAH analyses, and the remainder of the sample was used for low-level BEHP and PCP analyses at ARI.

Table 4-1. Chemical analyses by analytical laboratory

ARI	Brooks Rand Labs	CAS	Analytical Perspectives
Sample homogenization and compositing PCB Aroclors[a] Organochlorine pesticides SVOCs (including PAHs and phthalates) Total metals, including mercury[b] Butyltins Lipids (tissue samples only) Total solids Grain size (sediment samples only) Low-level BEHP and PCP	Inorganic arsenic Total arsenic [b]	PCB Aroclors[a] Low-level PAHs	PCB congeners[c] Dioxins and furans[c]

a PCB Aroclors were analyzed in geoduck tissue and co-located clam sediment by ARI and in intertidal clam tissue by CAS.

b Total arsenic was analyzed in intertidal clam and geoduck tissue by Brooks Rand Labs and in co-located clam sediment by ARI.

c PCB congener and dioxins/furans analysis will be conducted on a subset of samples and reported in an addendum to this data report.

ARI – Analytical Resources, Inc.
BEHP – bis(2-ethylhexyl) phthalate
CAS – Columbia Analytical Services, Inc.
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
PCP – pentachlorophenol
SVOC – semivolatile organic compound

The QAPP specified EPA Method 8270 for the analysis of SVOCs including PAHs, BEHP, and PCP. The resulting reporting limits greatly exceed the analytical concentration goals (ACGs) based on human health (Section 5.1.10). Additional analyses of all the tissue samples were conducted using more sensitive methods (EPA

Method 8270-SIM for PAHs and BEHP and EPA Method 8041 for PCP) to obtain lower reporting limits. The results of these analyses are provided in this data report.

4.1 Clam Tissue Analytical Methods

All tissue samples were homogenized at ARI according to their laboratory standard operating procedures, following agreement between EWG and EPA as to how intertidal clam tissues and geoduck gutball tissues should be composited (Appendices I and J). Frozen subsamples of homogenized intertidal clam tissue samples were sent to CAS for the analysis of PCBs as Aroclors and low-level PAHs. Frozen subsamples of homogenized intertidal clam composite tissue samples and geoduck tissue samples were sent to Brooks Rand Labs for analysis of total and inorganic arsenic. Table 4-2 presents the laboratory analytical methods and sample handling requirements for tissue samples.

Table 4-2. Laboratory analytical methods and sample handling requirements for tissue samples

Parameter	Method	Reference	Sample Holding Time[a]	Preservative
PCBs as Aroclors	GC/ECD	EPA 8082	1 year to extract, 40 days to analyze	freeze/-20°C
Organochlorine pesticides[b]	GC/ECD[d]	EPA 8081A	1 year to extract, 40 days to analyze	freeze/-20°C
SVOCs, including phthalates and PAHs[c]	GC/MS	EPA 8270D	1 year to extract, 40 days to analyze	freeze/-20°C
Low-level PAHs	GC/MS-SIM	EPA 8270C-SIM	1 year to extract, 40 days to analyze	freeze/-20°C
Low-level BEHP	GC/MS-SIM	EPA 8270D-SIM	1 year to extract, 40 days to analyze	freeze/-20°C
Low-level PCP	GC/ECD	EPA 8041	1 year to extract, 40 days to analyze	freeze/-20°C
Arsenic (inorganic)	HG-AFS	EPA 1632	6 months[d]	freeze/-20°C
Total arsenic	ICP-MS with DRC	EPA 1638	6 months[d]	freeze/-20°C
Total mercury	CVAA	EPA 7471A	6 months	freeze/-20°C
Other total metals[e]	ICP-MS and ICP-AES	EPA 200.8 and EPA 6010B	6 months	freeze/-20°C
Tributyltin, dibutyltin, monobutyltin (as ions)	GC/MS-SIM	Krone et al. (1989)	1 year to extract, 40 days to analyze	freeze/-20°C
Lipids	DCM: acetone extraction gravimetric	NOAA (1993)	1 year	freeze/-20°C
Total solids	freeze-dried or oven-dried	PSEP (1986) or EPA 160.2	6 months	freeze/-20°C

[a] All samples will be archived frozen at the laboratory until the Windward project manager or QA/QC officer authorizes their disposal.

[b] Target pesticides include 4,4'-DDT, 4,4'-DDE, 4,4'-DDD, 2,4'-DDT, 2,4'-DDE, 2,4'-DDD, aldrin, alpha-BHC, beta-BHC, delta-BHC, gamma-BHC, oxychlordane, alpha- and gamma-chlordane, cis- and trans-nonachlor, dieldrin, endosulfan, endosulfan sulfate, endrin, heptachlor, heptachlor epoxide, hexachlorobenzene, methoxychlor, mirex, and toxaphene.

[c] Target PAHs include: anthracene, pyrene, dibenzofuran, benzo(g,h,i)perylene, indeno(1,2,3-cd)pyrene, benzo(b)fluoranthene, fluoranthene, benzo(k)fluoranthene, acenaphthylene, chrysene, benzo(a)pyrene, dibenz(a,h)anthracene, benzo(a)anthracene, acenaphthene, phenanthrene, fluorene, 1-methylnaphthalene, naphthalene, and 2-methylnaphthalene. Perylene was also included in the low-level PAH analysis by CAS.

[d] Tissue samples were frozen to extend the maximum holding time to 1 year.

[e] Antimony, arsenic, cadmium, chromium, cobalt, copper, lead, molybdenum, nickel, selenium, silver, thallium, vanadium, and zinc.

BEHP – bis(2-ethylhexyl) phthalate

BHC – benzene hexachloride

CAS – Columbia Analytical Services, Inc.

CVAA – cold vapor atomic absorption spectrophotometry

DCM – dichloromethane

DDD – dichlorodiphenyldichloroethane

DDE – dichlorodiphenyldichloroethylene

DDT – dichlorodiphenyltrichloroethane

DRC – Dynamic Reaction Cell

EPA – US Environmental Protection Agency

GC/ECD – gas chromatography/electron capture detection

GC/MS – gas chromatography/mass spectrometry

HRGC/HRMS – high-resolution gas chromatography/high-resolution mass spectrometry

HG-AFS – hydride generation-atomic fluorescence spectrometry

ICP-AES – inductively coupled plasma-atomic emission spectrometry

ICP-MS – inductively coupled plasma-mass spectrometry

NOAA – National Oceanic and Atmospheric Administration

PAH – polycyclic aromatic hydrocarbon

PCP – pentachlorophenol

PSEP – Puget Sound Estuary Program

QA/QC – quality assurance/quality control

SIM – selective ion monitoring

SVOC – semivolatile organic compound

4.2 Co-Located Sediment Analytical Methods

Co-located sediment samples collected from the site were hand delivered to ARI immediately following collection or were transported to the Windward office and stored in the Windward refrigerator until they were hand-delivered to ARI. Composite sediment samples that were co-located with intertidal clam samples were analyzed by the methods presented in Table 4-3. Sediment samples co-located with geoduck have not been analyzed and are archived frozen at ARI for potential future analyses.

Table 4-3. Laboratory analytical methods and sample handling requirements for sediment samples

Parameter	Method	Reference	Sample Holding Time[a]	Preservative
PCBs as Aroclors	GC/ECD	EPA 8082A	14 days to extract, 40 days to analyze[b]	cool/4°C
Organochlorine pesticides[c]	GC/ECD	EPA 8081A	14 days to extract, 40 days to analyze[b]	cool/4°C
SVOCs, including phthalates and PAHs[d]	GC/MS	EPA 8270D	14 days to extract, 40 days to analyze[b]	cool/4°C
Selected SVOCs	GC/MS-SIM	EPA 8270-SIM	14 days to extract, 40 days to analyze[b]	cool/4°C
Tributyltin, dibutyltin, monobutyltin (as ions)	GC/MS-SIM	Krone et al. (1989)	14 days to extract, 40 days to analyze[b]	cool/4°C
Other total metals[e]	ICP-MS and ICP-AES	EPA 200.8 and EPA 6010B	1 year	cool/4°C
Total mercury	CVAA	EPA 7471A	28 days[f]	cool/4°C

Parameter	Method	Reference	Sample Holding Time[a]	Preservative
Grain size	sieve/pipette	PSEP (1986)	none	none
TOC	combustion	Plumb (1981)	28 daysf	cool/4°C
Percent solids	oven-dried	PSEP (1986)	7 days[f]	cool/4°C

[a] All samples will be archived frozen at the laboratory until the Windward project manager or QA/QC officer authorizes their disposal.

[b] Sediment was frozen to increase the holding time to 1 year to extraction. Aqueous rinsate blanks have a maximum holding time of 7 days to extract and 40 days to analyze and were stored at 4°C.

[c] Target pesticides include 4,4'-DDT, 4,4'-DDE, 4,4'-DDD, 2,4'-DDT, 2,4'-DDE, 2,4'-DDD, aldrin, alpha-BHC, beta-BHC, delta-BHC, gamma-BHC, oxychlordane, alpha- and gamma-chlordane, cis- and trans-nonachlor, dieldrin, endosulfan, endosulfan sulfate, endrin, heptachlor, heptachlor epoxide, hexachlorobenzene, methoxychlor, mirex, and toxaphene.

[d] Target PAHs include anthracene, pyrene, dibenzofuran, benzo(g,h,i)perylene, indeno(1,2,3-cd)pyrene, benzo(b)fluoranthene, fluoranthene, benzo(k)fluoranthene, acenaphthylene, chrysene, benzo(a)pyrene, dibenz(a,h)anthracene, benzo(a)anthracene, acenaphthene, phenanthrene, fluorene, 1-methylnaphthalene, naphthalene, and 2-methylnaphthalene.

[e] Antimony, arsenic, cadmium, chromium, cobalt, copper, lead, molybdenum, nickel, selenium, silver, thallium, vanadium, and zinc.

[f] Sediment was frozen to extend the maximum holding time to 6 months.

BHC – benzene hexachloride

CVAA – cold vapor atomic absorption spectrophotometry

DDD – dichlorodiphenyldichloroethane

DDE – dichlorodiphenyldichloroethylene

DDT – dichlorodiphenyltrichloroethane

EPA – US Environmental Protection Agency

GC/ECD – gas chromatography/electron capture detection

GC/MS – gas chromatography/mass spectrometry

GFAA – graphite furnace atomic absorption spectrophotometry

ICP-AES – inductively coupled plasma-atomic emission spectrometry

ICP-MS – inductively coupled plasma-mass spectrometry

PAH – polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

PSEP – Puget Sound Estuary Program

SIM – selective ion monitoring

SVOC – semivolatile organic compound

TOC – total organic carbon

4.3 Laboratory Deviations from the QAPP

The laboratories followed the methods and procedures described in the QAPP with the following exceptions:

- The QAPP (Windward 2008d) specified that total metals would be analyzed by ARI using inductively coupled plasma-atomic emission spectrometry (ICP-AES), inductively coupled plasma-mass spectrometry (ICP-MS), or graphite furnace atomic absorption (GFAA) per EPA Methods 6010B, 6020, or 7000 series, respectively, within 6 months of sample collection. Total metals were analyzed by ARI using EPA 6010B and EPA 200.8, which is equivalent to EPA 6020.
- In consultation with the EPA QA office, total arsenic was also analyzed on the clam and geoduck tissue samples by Brooks Rand Labs using Dynamic Reaction Cell (DRC) with ICP-MS per EPA Method 1638, in addition to total arsenic analysis by ARI as specified in the QAPP (Windward 2008d). This

laboratory and test method was selected to minimize potential matrix interferences in the tissue samples and to ensure comparability by having a single laboratory generate both the total and inorganic arsenic results. The total arsenic results from both laboratories were similar; the results from Brooks Rand Labs are presented in this data report and the project database.

- All samples were analyzed for total metals and inorganic arsenic within the laboratories' standard holding times of one year for frozen tissues, which is consistent with PSEP guidance (PSEP 1997), rather than the 6 month holding time that was listed in the QAPP (Windward 2008d).
- PCBs as Aroclors were analyzed in clam tissue samples at CAS, per EPA agreement (e-mail from R. Sanga, 1/2/09) instead of ARI as specified in the QAPP (Windward 2008d).
- Butyltins were analyzed using gas chromatography/mass spectrometry with selective ion monitoring. The QAPP (Windward 2008d) listed butyltin analysis using gas chromatography/flame photometric detection in error. The quality of the data is not affected by this deviation.
- Additional analyses were conducted for low-level PAHs and two SVOC compounds (PCP and BEHP) that were not specified in the QAPP. EPA approved the additional analyses prior to analysis. The results of these analyses will replace results for these analytes from the initial analysis conducted using EPA 8270 because of the increased sensitivity of the low-level analyses.

5 Results of Chemical Analyses

This section presents the results of the chemical analyses and data validation of the intertidal clam tissue samples, intertidal clam co-located sediment samples, and geoduck tissue samples. Co-located geoduck sediment samples were not analyzed but were instead archived frozen for potential future analyses. Complete data tables and raw laboratory data are presented in Appendices A and D, respectively. A detailed discussion of the approach used in averaging laboratory replicates is presented in Appendix B. Methods for calculating concentrations of total PCBs, total polycyclic aromatic hydrocarbons (PAHs), and total dichlorodiphenyltrichloroethanes (DDTs) are also presented in Appendix B. The number of significant figures shown for each concentration was as reported by the analytical laboratories.

QA review of the sediment and tissue chemistry data was conducted in accordance with the QA/QC requirements and technical specifications of the methods, and the national functional guidance for organic and inorganic data review (EPA 1999, 2004) as outlined in the QAPP.

EcoChem, Inc., conducted the data review and summary validation. The results of the data validation are discussed in Section 5.2, and presented in full in Appendix C.

Explanations of data qualifiers for specific analytes and sample groups are provided in Section 5.2. A detailed discussion of each qualified sample is provided in Appendix C.

5.1 TISSUE AND SEDIMENT RESULTS

All 12 of the intertidal clam composite tissue samples collected from the five beaches of the EW were analyzed for arsenic and inorganic arsenic. Ten intertidal clam composite tissue samples and nine geoduck tissue samples were analyzed for metals, butyltins, SVOCs, PCBs as Aroclors, organochlorine pesticides, percent lipids, and total solids. Five co-located composite sediment samples from the five beaches were analyzed for metals, butyltins, SVOCs, PCBs as Aroclors, organochlorine pesticides, total organic carbon (TOC), total solids, and grain size. Table 5-1 presents the samples and analyses conducted for each intertidal clam composite sample.

5.1.1 Metals

This section presents results from the metal analyses for intertidal clam composite tissue, intertidal clam co-located composite sediment, and geoduck tissue samples.[4]

[4] The geoduck sediment samples have not been analyzed.

Table 5-1. Analyses conducted on each clam composite sample

Analyte Group	EW-B03-BC-03-comp1	EW-B06-BC-01-comp1	EW-B06-BC-01-comp2	EW-B08-BC-01-comp1	EW-B08-BC-01-comp2	EW-B08-CN-02-comp1	EW-B08-NL-03-comp1	EW-B09-MY-M-comp1	EW-B10-BC-01-comp1	EW-B10-BC-01-comp2	EW-B10-CN-05-comp1	EW-B10-NL-06-comp1
Conventionals	X	X	X	X	X	X		X	X	X	X	
Total and inorganic arsenic	X	X	X	X	X	X	X	X	X	X	X	X
Total metals	X	X	X	X	X	X		X	X	X	X	
Organometals	X	X	X	X	X	X		X	X	X	X	
PAHs	X	X	X	X	X	X		X	X	X	X	
PCB Aroclors	X	X	X	X	X	X	X	X	X	X	X	
Pesticides	X	X	X	X	X	X		X	X	X	X	
Phthalates	X	X	X	X	X	X		X	X	X	X	
Other SVOCs	X	X	X	X	X	X		X	X	X	X	
Low-level PAHs	X	X	X	X	X	X	X[a]	X	X	X	X	-
Low-level BEHP	X	X	X	X	X	X	-	X	X	X	X	-
Low-level PCP	X	X	X	X	X	X	-	X	X	X	X	-

[a] This sample was not analyzed for SVOCs during the first round of analysis at ARI because of insufficient sample volume. All remaining sample volume at Brooks Rand Labs and ARI following metals and PCB Aroclor analyses, respectively, was transferred to CAS for low level PAH analysis.

ARI – Analytical Resources, Inc.

BEHP – bis(2-ethylhexyl) phthalate

Columbia Analytical Services, Inc.

PAH – polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

PCP – pentachlorophenol

SVOC – semivolatile organic compound

5.1.1.1 *Intertidal clam tissue*

Table 5-2 presents a summary of the metals analyzed in intertidal clam composite tissue samples, including the number of detections, the range of detected metals concentrations, and the range of RLs. Results for detected metals in each individual intertidal clam composite tissue sample are presented in Table 5-3 (see Appendix A, Table A-1, for all results, including non-detected metals). Twelve of the metals (arsenic, inorganic arsenic, cadmium, chromium, cobalt, copper, mercury, molybdenum, nickel, selenium, vanadium, and zinc) were detected in all samples. Three other metals (antimony, lead, and silver) were each detected in seven to eight samples. Thallium was not detected in any of the samples. The highest concentrations of metals were detected at the following beaches: Beach 3 (antimony and nickel), Beach 6 (cadmium, lead, molybdenum, and zinc), Beach 8 (copper, mercury, and molybdenum), Beach 9 (inorganic arsenic, cobalt, and vanadium), and Beach 10 (arsenic, cadmium, chromium, selenium, and silver) (Table 5-3).

Table 5-2. Summary of metals data for intertidal clam composite tissue samples

Analyte	Detection Frequency	Detected Concentration (mg/kg ww)		Reporting Limit (mg/kg ww)
		Minimum	Maximum	Min – Max
Antimony	8/10	0.009	0.061	0.008
Arsenic	12/12	0.916 J	2.83 J	na
Arsenic (inorganic)	12/12	0.074 J	0.443	na
Cadmium	10/10	0.04	0.11	na
Chromium	10/10	0.3	1.0	na
Cobalt	10/10	0.12	0.36	na
Copper	10/10	1.52	9.67	na
Lead	7/10	0.4	1.2	0.4
Mercury	10/10	0.01	0.03	na
Molybdenum	10/10	0.3	0.6 J	na
Nickel	10/10	0.6	1.2	na
Selenium	10/10	0.27	0.52	na
Silver	7/10	0.11 J	0.26 J	0.06
Thallium	0/10	nd	nd	0.004 – 0.008
Vanadium	10/10	0.25	0.82	na
Zinc	10/10	13.3	20.9	na

J – estimated concentration

na – not applicable

nd – not detected

ww – wet weight

Table 5-3. Concentrations of detected metals in individual intertidal clam composite tissue samples

Analyte	Concentration (mg/kg ww)											
	EW-B03-BC-03-comp1	EW-B06-BC-01-comp1	EW-B06-BC-01-comp2	EW-B08-BC-01-comp1	EW-B08-BC-01-comp2	EW-B08-CN-02-comp1	EW-B08-NL-03-comp1	EW-B09-MY-M-comp1	EW-B10-BC-01-comp1	EW-B10-BC-01-comp2	EW-B10-CN-05-comp1	EW-B10-NL-06-comp1
Antimony	0.061	0.012	0.010	0.013	0.008 U	0.008 U	na	0.009	0.012	0.011	0.017	na
Arsenic	2.18 J	2.01 J	1.83 J	2.48	2.04	0.916 J	2.70 J	0.935	2.83 J	2.66 J	1.34 J	1.77 J
Arsenic (inorganic)	0.144 J	0.095 J	0.074 J	0.176	0.116	0.199 J	0.164 J	0.443	0.096 J	0.094 J	0.244 J	0.151 J
Cadmium	0.09	0.11	0.11	0.09	0.08	0.04	na	0.06	0.07	0.11	0.04	na
Chromium	0.8	0.5	0.5	0.5	0.4	0.3	na	0.6	0.6	0.5	1.0	na
Cobalt	0.14	0.14	0.13	0.18	0.13	0.12	na	0.36	0.15	0.13	0.17	na
Copper	7.64	6.85	5.21	9.67	6.56	1.52	na	2.81	5.62	9.64	2.54	na
Lead	0.6	0.8	1.2	0.4	0.4 U	0.6	na	0.5	0.4 U	0.4 U	0.9	na
Mercury	0.01	0.01	0.012	0.03	0.02	0.01	na	0.017	0.02	0.028	0.011	na
Molybdenum	0.3	0.5 J	0.6 J	0.6 J	0.6 J	0.4 J	na	0.5 J	0.3	0.4	0.3	na
Nickel	1.2	0.9	0.8	0.8	0.6	0.6	na	0.9	0.8	0.7	0.9	na
Selenium	0.42	0.39	0.33	0.37	0.33	0.39	na	0.27	0.34	0.37	0.52	na
Silver	0.11 J	0.13 J	0.13 J	0.19 J	0.13 J	0.06 UJ	na	0.06 UJ	0.20 J	0.26 J	0.06 UJ	na
Vanadium	0.36	0.36	0.32	0.45	0.32	0.52	na	0.82	0.29	0.25	0.76	na
Zinc	18.3	20.9	17.3	17.1	15.2	14.2	na	13.3	20.0	19.9	20.4	na

J – estimated concentration

na – not analyzed

U – not detected at reporting limit shown

UJ – not detected at estimated reporting limit shown

ww – wet weight

5.1.1.2 Sediment co-located with intertidal clam tissue samples

Table 5-4 presents a summary of the metals analyzed in the co-located composite sediment samples, including the number of detections, the range of detected metals concentrations, and the range of RLs. Results for metals detected in each sediment sample are presented in Table 5-5 and compared to sediment quality standards (SQS) and cleanup screening levels (CSLs) of the Washington State Sediment Management Standards (SMS). If SQS or CSL values were not available for a particular chemical, the screening level (SL) or maximum level (ML) of the Dredged Material Management Program (DMMP) were used. Mercury results are shown on Map 5-1. The results for all chemicals, including non-detected chemicals, are presented in Appendix A, Tables A-2 through A-4.

Table 5-4. Summary of metals data for composite sediment samples co-located with intertidal clam tissue samples

Analyte	Detection Frequency	Detected Concentration (mg/kg dw)		Reporting Limit (mg/kg dw)
		Minimum	Maximum	Min – Max
Antimony	2/5	0.4 J	0.4 J	0.2 – 0.3
Arsenic	5/5	5.2 J	12.8 J	na
Cadmium	3/5	0.3	1.6	0.3 – 0.7
Chromium	5/5	22	32.5	na
Cobalt	5/5	4.5	6.9	na
Copper	5/5	24.1 J	78.8 J	na
Lead	5/5	13	98	na
Mercury	3/5	0.08	0.23	0.05 – 0.06
Molybdenum	5/5	1.2	5	na
Nickel	5/5	15	38	na
Selenium	0/5	nd	nd	0.6 – 0.7
Silver	1/5	2.3	2.3	0.4 – 1
Thallium	0/5	nd	nd	0.2 – 0.3
Vanadium	5/5	35	48.8	na
Zinc	5/5	84	308	na

dw – dry weight

J – estimated concentration

na – not applicable

nd – not detected

Table 5-5. Concentrations of metals in composite sediment samples co-located with intertidal clam tissue samples compared to SQS/SL and CSL/ML

Analyte	Concentration (mg/kg dw)						
	EW-B03-SS-030	EW-B06-SS-030	EW-B08-SS-030	EW-B09A-SS-030	EW-B10-SS-030	SQS/SL	CSL/ML
Antimony[a]	0.4 J	0.4 J	0.3 UJ	0.2 UJ	0.3 UJ	150	200
Arsenic	12.8 J	11.8 J	6.9 J	5.2 J	10.0 J	57	93
Cadmium	0.7 U	1.6	0.3	0.3 U	1.0	5.1	6.7
Chromium	22	32.5	24.9	31.1	22.2	260	270
Copper	42.2 J	78.8 J	37.0 J	24.1 J	46.9 J	390	390
Lead	60	98	43	13	86	450	530
Mercury	0.05 U	0.23	0.10	0.06 U	0.08	0.41	0.59
Nickel[a]	23	18	15	38	19	140	370
Silver	1 U	0.4 U	0.4 U	0.4 U	2.3	6.1	6.1
Zinc	135	308	84	146	118	410	960

[a] Metals compared to SL and ML.

CSL – cleanup screening level

dw – dry weight

ML – maximum level

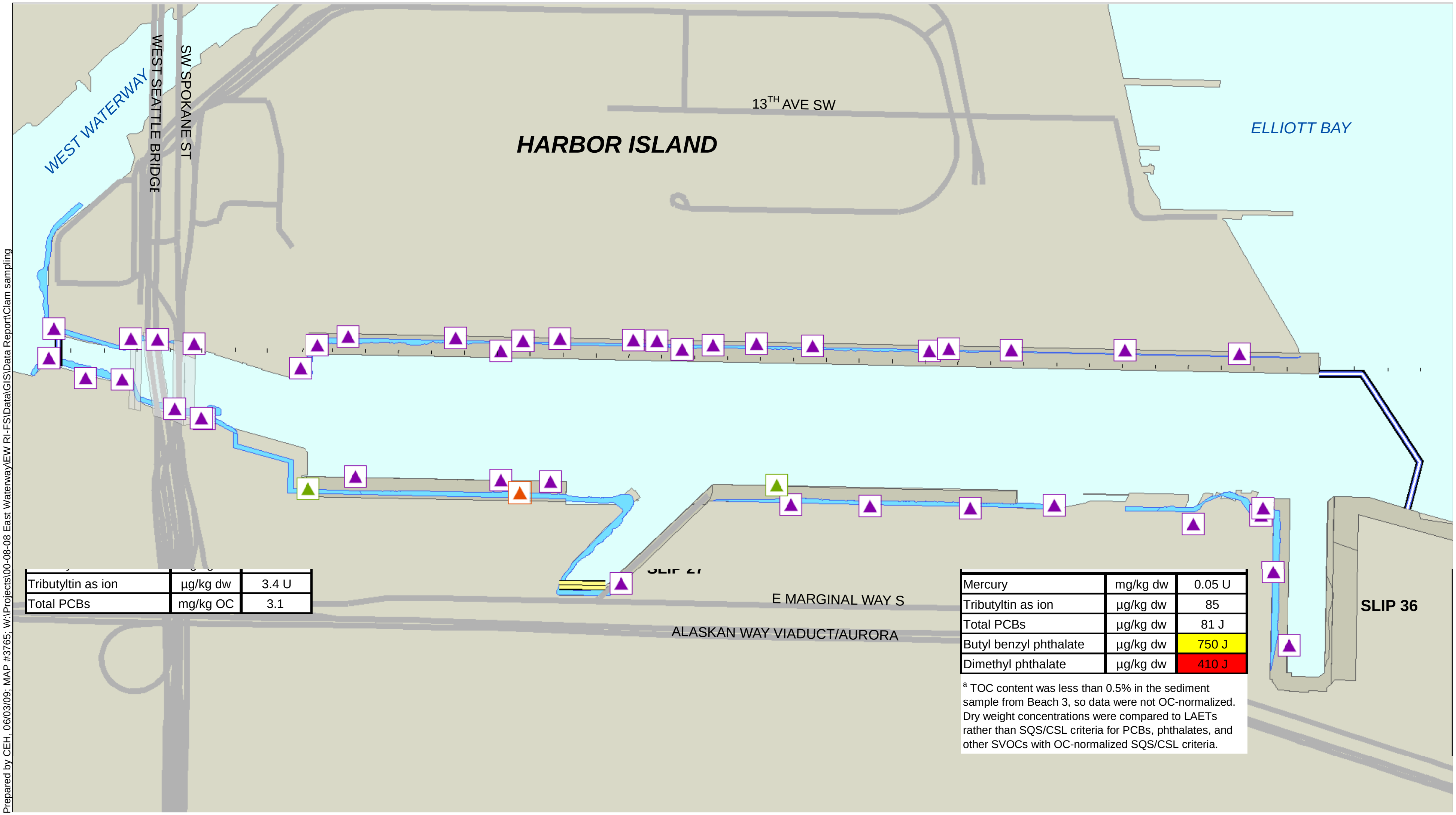
SL – screening level

SQS – sediment quality standards

J – estimated concentration

U – not detected at reporting limit shown

UJ – not detected at estimated reporting limit shown



Tributyltin as ion	µg/kg dw	3.4 U
Total PCBs	mg/kg OC	3.1

Mercury	mg/kg dw	0.05 U
Tributyltin as ion	µg/kg dw	85
Total PCBs	µg/kg dw	81 J
Butyl benzyl phthalate	µg/kg dw	750 J
Dimethyl phthalate	µg/kg dw	410 J

[a] TOC content was less than 0.5% in the sediment sample from Beach 3, so data were not OC-normalized. Dry weight concentrations were compared to LAETs rather than SQS/CSL criteria for PCBs, phthalates, and other SVOCs with OC-normalized SQS/CSL criteria.

Prepared by CEH, 06/03/09; MAP #3765; W:\Projects\00-08-08 East Waterway\EW RI-FS\Data\GIS\Data Report\Clam sampling

- Clam collection beach
- CSO
- Storm drain
- CSO/storm drain
- Intertidal zone
- Dock/pier
- Road
- Bridge
- Slip 27 bridge
- East Waterway Study Area boundary

Figure notes:
Chemical results are shown in addition to PCBs, mercury, and TBT if concentrations exceed the SQS.
Yellow shaded cells indicate SQS exceedance.
Mercury: SQS = 0.41 mg/kg dw, CSL = 0.59 mg/kg dw.
Total PCBs: SQS = 12 mg/kg OC, CSL = 65 mg/kg OC.

0 600
Scale in feet

Map 5-1
Sampling locations and results for PCBs, mercury, and TBT in intertidal co-located sediment
Clam Sampling Data Report
East Waterway Study Area

All metals except two were detected in at least one sediment sample; selenium and thallium were not detected in samples from any of the locations. Antimony, cadmium, mercury, and silver were each detected in a subset of the five sediment samples. The remaining nine metals were detected in every sediment sample. The highest concentrations of metals were detected in sediment from the following beaches: Beach 3 (antimony, arsenic, and molybdenum), Beach 6 (antimony, cadmium, chromium, copper, lead, mercury, and zinc), Beach 9 (cobalt and nickel), and Beach 10 (silver and vanadium) (Table 5-5). None of the samples had detected concentrations (or RLs for non-detected concentrations) that exceeded the SQS/SL or CSL/ML for metals (Table 5-5).

5.1.1.3 Geoduck tissue

Table 5-6 presents a summary of the metals analyzed in geoduck tissue samples, including the number of detections, the range of detected metals concentrations, and the range of RLs. Results for detected metals in geoduck tissue samples are presented in Tables 5-7 and in Appendix A, Table A-5. Seven of the metals (arsenic, inorganic arsenic, cadmium, copper, molybdenum, selenium, and zinc) were detected in all samples. Eight other metals (antimony, chromium, cobalt, lead, mercury, nickel, silver, and vanadium) were each detected in three to seven samples. Thallium was not detected in any of the samples. Concentrations of all metals except cadmium, chromium, lead, and nickel were higher in each of the three gutball samples than in the six edible-meat samples.

Table 5-6. Summary of metals data for geoduck tissue samples

Analyte	Detection Frequency	Detected Concentration (mg/kg ww)		Reporting Limit (mg/kg ww)
		Minimum	Maximum	Min – Max
Antimony				
Edible meat	0/6	nd	nd	0.008
Gutball	3/3	0.008	0.011	na
Arsenic				
Edible meat	6/6	0.950 J	1.29 J	na
Gutball	3/3	1.79 J	2.73 J	na
Arsenic (inorganic)				
Edible meat	6/6	0.012 J	0.063 J	na
Gutball	3/3	0.075 J	0.110 J	na
Cadmium				
Edible meat	6/6	0.07	0.38	na
Gutball	3/3	0.12	0.19	na
Chromium				
Edible meat	3/6	0.1	0.5	0.1
Gutball	3/3	0.3	0.5	na
Cobalt				
Edible meat	1/6	0.08	0.08	0.06

Analyte	Detection Frequency	Detected Concentration (mg/kg ww)		Reporting Limit (mg/kg ww)
		Minimum	Maximum	Min – Max
Gutball	3/3	0.12	0.17	na
Copper				
Edible meat	6/6	3.93	15.0	na
Gutball	3/3	19.2	28.1	na
Lead				
Edible meat	1/6	0.5	0.5	0.4
Gutball	3/3	0.4	0.6	na
Mercury				
Edible meat	4/6	0.01	0.011	0.01
Gutball	3/3	0.02	0.02	na
Molybdenum				
Edible meat	6/6	0.8	1.4	na
Gutball	3/3	1.6	1.7	na
Nickel				
Edible meat	1/6	0.3	0.3	0.2
Gutball	3/3	0.2	0.4	na
Selenium				
Edible meat	6/6	0.41	0.60	na
Gutball	3/3	1.00	1.27	na
Silver				
Edible meat	3/6	0.06 J	0.09 J	0.06
Gutball	3/3	0.25 J	0.30 J	na
Thallium				
Edible meat	0/6	nd	nd	0.008
Gutball	0/3	nd	nd	0.008
Vanadium				
Edible meat	4/6	0.06	0.34	0.06
Gutball	3/3	0.46	0.69	na
Zinc				
Edible meat	6/6	7.8	15.0	na
Gutball	3/3	20.6	27.1	na

J – estimated concentration

na – not applicable

nd – not detected

ww – wet weight

Table 5-7. Concentrations of detected metals in individual geoduck edible-tissue and composite gutball tissue samples

Analyte	Concentration (mg/kg ww)								
	Edible Meat						Gutball		
	EW-S01-GD-01	EW-S01-GD-02	EW-S01-GD-03	EW-S01-GD-04	EW-S01-GD-07	EW-S01-GD-10	EW-S01-GD-GB-comp01	EW-S01-GD-GB-comp02	EW-S01-GD-GB-comp03
Antimony	0.008 U	0.008 U	0.008 U	0.008 U	0.008 U	0.008 U	0.008	0.008	0.011
Arsenic	1.29 J	0.999 J	1.21 J	0.950 J	1.08 J	0.968 J	1.84 J	2.73 J	1.79 J
Arsenic (inorganic)	0.063 J	0.016 J	0.034 J	0.012 J	0.017 J	0.031 J	0.075 J	0.075 J	0.110 J
Cadmium	0.38	0.12	0.30	0.09	0.20	0.07	0.12	0.15	0.19
Chromium	0.5	0.2	0.1 U	0.1 U	0.1	0.1 U	0.3	0.4	0.5
Cobalt	0.08	0.06 U	0.06 U	0.06 U	0.06 U	0.06 U	0.12	0.14	0.17
Copper	15.0	6.84	9.76	3.93	6.91	4.09	19.2	28.1	28.1
Lead	0.5	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4	0.6	0.6
Mercury	0.01	0.011	0.01	0.01 U	0.01	0.01 U	0.02	0.02	0.02
Molybdenum	0.8	0.9	1.4	1.2	1.0	1.1	1.7	1.6	1.6
Nickel	0.3	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2	0.3	0.4
Selenium	0.57	0.60	0.45	0.45	0.50	0.41	1.00	1.15	1.27
Silver	0.06 J	0.06 UJ	0.09 J	0.06 J	0.06 UJ	0.06 UJ	0.30 J	0.25 J	0.30 J
Vanadium	0.34	0.09	0.06 U	0.06 U	0.06	0.07	0.46	0.47	0.69
Zinc	12.6	9.6	15.0	7.9	9.3	7.8	20.6	25.1	27.1

J – estimated concentration

U – not detected at reporting limit shown

UJ – not detected at estimated reporting limit shown

ww – wet weight

5.1.2 Butyltins

This section presents results from the butyltins analyses for intertidal clam composite tissue, clam co-located composite sediment, and geoduck tissue samples.

5.1.2.1 Intertidal clam tissue

Table 5-8 presents a summary of the butyltins analyzed in intertidal clam composite tissue samples, including the number of detections, the range of detected butyltin concentrations, and the range of RLs. Results for butyltins in individual intertidal clam tissue samples are presented in Table 5-9 and Appendix A, Table A-1. Tributyltin was the only butyltin detected in any of the tissue samples and was detected in all samples at concentrations ranging from 15 to 140 µg/kg ww. The highest concentration was in the composite sample from Beach 9.

Table 5-8. Summary of butyltin data for intertidal clam tissue samples

Analyte	Detection Frequency	Detected Concentration (µg/kg ww)		Reporting Limit (µg/kg ww)
		Minimum	Maximum	Min – Max
Monobutyltin as ion	0/10	nd	nd	6.8 – 8.0
Dibutyltin as ion	0/10	nd	nd	9.7 – 11
Tributyltin as ion	10/10	15	140	na

na – not applicable

nd – not detected

ww – wet weight

Table 5-9. Concentrations of detected butyltins in individual intertidal clam tissue samples

Analyte	Concentration (µg/kg ww)											
	EW-B03-BC-03-comp1	EW-B06-BC-01-comp1	EW-B06-BC-01-comp2	EW-B08-BC-01-comp1	EW-B08-BC-01-comp2	EW-B08-CN-02-comp1	EW-B08-NL-03-comp1	EW-B09-MY-M-comp1	EW-B10-BC-01-comp1	EW-B10-BC-01-comp2	EW-B10-CN-05-comp1	EW-B10-NL-06-comp1
Tributyltin as ion	72	52	38	39	27	15	na	140	32	38	18	na

na – not analyzed

ww – wet weight

5.1.2.2 Sediment samples co-located with intertidal clam tissue samples

Table 5-10 presents a summary of the butyltins analyzed in composite sediment samples co-located with intertidal clam tissue samples, including the number of detections, the range of detected butyltin concentrations, and the range of RLs. Results for butyltins in individual sediment samples are presented in Table 5-11 and Appendix A, Tables A-2 through A-4. All three butyltins were detected in sediment. The maximum concentration of each butyltin was detected in the sample from Beach 3. TBT results are shown on Map 5-1.

Table 5-10. Summary of butyltin data for composite sediment samples co-located with intertidal clam tissue samples

Analyte	Detection Frequency	Detected Concentration (µg/kg dw)		Reporting Limit (µg/kg dw)
		Minimum	Maximum	Min – Max
Monobutyltin as ion	2/5	5.1	7.6 J	3.6 – 3.9
Dibutyltin as ion	3/5	9.2	16 J	5.1 – 5.5
Tributyltin as ion	4/5	10	85	3.4

dw – dry weight

J – estimated concentration

Table 5-11. Concentrations of detected butyltins in composite sediment samples co-located with intertidal clam tissue samples

Analyte	Concentration (µg/kg dw)				
	EW-B03-SS-030	EW-B06-SS-030	EW-B08-SS-030	EW-B09A-SS-030	EW-B10-SS-030
Monobutyltin as ion	7.6 J	3.6 U	5.1	3.6 U	3.9 U
Dibutyltin as ion	16 J	12	9.2	5.1 U	5.5 U
Tributyltin as ion	85	18	19	3.4 U	10

dw – dry weight

J – estimated concentration

U – not detected at reporting limit shown

5.1.2.3 Geoduck tissue

Table 5-12 presents a summary of the butyltins analyzed in geoduck tissue samples, including the number of detections, the range of detected butyltin concentrations, and the range of RLs. Results for butyltins in individual geoduck tissue samples are presented in Table 5-13 and in Appendix A, Table A-5. Tributyltin was detected in all samples, dibutyltin was detected in one gutball composite sample, and monobutyltin was not detected in any of the samples. The maximum tributyltin concentrations were in the three gutball composite samples (14 to 29 µg/kg ww); concentrations in edible-meat samples ranged from 5.1 to 9.8 µg/kg ww.

Table 5-12. Summary of butyltin data for geoduck tissue samples

Analyte	Detection Frequency	Detected Concentration (µg/kg ww)		Reporting Limit (µg/kg ww)
		Minimum	Maximum	Min – Max
Monobutyltin as ion				
Edible meat	0/6	nd	nd	7.7 – 8.0
Gutball	0/3	nd	nd	7.5 – 8.0
Dibutyltin as ion				
Edible meat	0/6	nd	nd	11
Gutball	1/3	7.4 J	7.4 J	11
Tributyltin as ion				
Edible meat	6/6	5.1 J	9.8	na
Gutball	3/3	14	29	na

J – estimated concentration

na – not applicable

nd – not detected

ww – wet weight

Table 5-13. Concentrations of detected butyltins in individual geoduck tissue samples

Analyte	Concentration (µg/kg ww)								
	Edible Meat						Gutball		
	EW-S01-GD-01	EW-S01-GD-02	EW-S01-GD-03	EW-S01-GD-04	EW-S01-GD-07	EW-S01-GD-10	EW-S01-GD-GB-comp01	EW-S01-GD-GB-comp02	EW-S01-GD-GB-comp03
Dibutyltin as ion	11 U	11 U	11 U	11 U	11 U	11 U	11 U	11 U	7.4 J
Tributyltin as ion	9.8	5.1 J	8.7	7.6	6.8 J	7.6	15	14	29

J – estimated concentration

U – not detected at reporting limit shown

ww – wet weight

5.1.3 PAHs

This section presents results from the PAHs analyses for intertidal clam composite tissue, clam co-located composite sediment, and geoduck tissue samples.

5.1.3.1 Intertidal clam tissue

PAHs were detected in all intertidal clam composite tissue samples, as summarized in Table 5-14, based on the results of the low-level PAH analysis. The results for PAHs in each intertidal clam composite tissue sample are presented in Table 5-15. Total PAH concentrations ranged from 41 to 800 µg/kg ww. 2-Chloronaphthalene was not an analyte for the low-level PAH analysis and was not detected in any clam tissue samples analyzed using the SVOC method (EPA 8270).

Table 5-14. Summary of PAH data for composite intertidal clam tissue samples

Analyte	Detection Frequency	Detected Concentration (µg/kg dw)		Reporting Limit (µg/kg dw)
		Minimum	Maximum	Min – Max
1-Methylnaphthalene	11/11	0.28 J	15	na
2-Chloronaphthalene	0/10[a]	nd	nd	280 – 300
2-Methylnaphthalene	10/11	0.50 J	43	0.97
Acenaphthene	11/11	0.53	18	na
Acenaphthylene	11/11	0.11 J	1.7	na
Anthracene	11/11	0.44 J	30	na
Benzo(a)anthracene	11/11	3.0	47	na
Benzo(a)pyrene	11/11	1.3	44	na
Benzo(b)fluoranthene	11/11	4.1	61	na
Benzo(g,h,i)perylene	10/11	1.7	53	1.4
Benzo(k)fluoranthene	11/11	1.5	15	na
Total benzofluoranthenes	11/11	5.6	76	na
Chrysene	11/11	4.8	64	na
Dibenzo(a,h)anthracene	3/11	1.4	8.5	0.49 – 0.76
Dibenzofuran	11/11	0.39 J	27	na
Fluoranthene	11/11	12	210	na
Fluorene	11/11	0.62	16	na
Indeno(1,2,3-cd)pyrene	9/11	1.8	45	1.1 – 1.5
Naphthalene	3/11	1.0	130	0.96 – 1.0
Perylene	11/11	0.64	12	na
Phenanthrene	11/11	3.0	110	na
Pyrene	11/11	7.2	120	na
Total HPAHs	11/11	36	530	na
Total LPAHs	11/11	4.7 J	310	na
Total cPAHs[b]	11/11	2.4	63	na

Analyte	Detection Frequency	Detected Concentration (µg/kg dw)		Reporting Limit (µg/kg dw)
		Minimum	Maximum	Min – Max
Total PAHs	11/11	41 J	800	na

[a] 2-Chloronaphthalene was not a target analyte for the low-level PAH analysis. The results for this chemical reflect the SVOC analysis (EPA 8270).

[b] Total cPAHs are expressed as TEQs based on the relative toxicity of seven carcinogenic PAH compounds compared to the toxicity of benzo(a)pyrene. For each cPAH compound (benzo(a)anthracene, benzo(b)fluoranthene, benzo(a)pyrene, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene) the concentration is multiplied by the respective PEF to derive a TEQ (see Appendix B for PEFs). The TEQs for individual cPAHs were then summed to derive a total cPAH TEQ (expressed in µ/kg dw).

cPAH – carcinogenic polycyclic aromatic hydrocarbon

dw – dry weight

EPA – US Environmental Protection Agency

HPAH – high-molecular-weight polycyclic aromatic hydrocarbon

J – estimated concentration

LPAH – low-molecular-weight polycyclic aromatic hydrocarbon

PAH – polycyclic aromatic hydrocarbon

PEF – potency equivalency factor

SVOC – semivolatile organic compound

TEQ – toxic equivalent

U – not detected at reporting limit shown

Table 5-15. PAH data for intertidal clam composite tissue samples

Chemical	Concentration (µg/kg ww)										
	EW-B03-BC-03-comp1	EW-B06-BC-01-comp1	EW-B06-BC-01-comp2	EW-B08-BC-01-comp1	EW-B08-BC-01-comp2	EW-B08-CN-02-comp1	EW-B08-NL-03-comp1	EW-B09-MY-M-comp1	EW-B10-BC-01-comp1	EW-B10-BC-01-comp2	EW-B10-CN-05-comp1
1-Methylnaphthalene	0.96	0.95	0.85	0.45 J	0.45 J	0.40 J	15	0.28 J	0.37 J	0.70	0.72
2-Chloronaphthalene[a]	300 U	300 U	290 U	290 U	290 U	300 U	na	290 U	290 U	280 U	290 U
2-Methylnaphthalene	1.4	1.2	1.1	0.50 J	0.54 J	0.53 J	43	0.97 U	0.55 J	1.0	1.1
Acenaphthene	8.4	4.2	3.6	1.6	1.7	1.2	18	0.53	2.0	2.4	2.7
Acenaphthylene	0.94	0.53	0.38 J	0.23 J	0.29 J	0.27 J	1.7	0.11 J	0.20 J	0.25 J	0.51
Anthracene	20	7.8	6.2	3.3	3.0	2.3	30	0.44 J	3.1	2.1	4.5
Benzo(a)anthracene	47	9.7	9.6	6.9	6.0	12	29	3.0	5.3	5.2	17
Benzo(a)pyrene	18	8.0	6.3	5.7	5.1	7.2	44	1.3	2.9	3.3	10
Benzo(b)fluoranthene	46	20	15	12	10	18	61	4.1	6.7	8.0	27
Benzo(g,h,i)perylene	5.9	3.7	2.8	2.9	2.5	3.3	53	2.2	1.4 U	1.7	5.4
Benzo(k)fluoranthene	13	5.7	4.6	3.4	3.1	5.9	15	1.5	2.1	2.3	9.1
Total benzofluoranthenes	59	26	20	15	13	24	76	5.6	8.8	10.3	36
Chrysene	64	11	12	10	8.5	17	53	4.8	7.1	7.2	26
Dibenzo(a,h)anthracene	1.5	0.72 U	0.61 U	0.59 U	0.50 U	0.76 U	8.5	0.49 U	0.50 U	0.49 U	1.4
Dibenzofuran	6.7	3.8	2.9	1.2	1.3	0.95	27	0.39 J	1.4	1.7	2.0
Fluoranthene	210	57	50	28	24	30	110	12	26	25	49
Fluorene	14	5.5	4.2	2.0	1.9	1.5	16	0.62	2.5	2.3	3.2
Indeno(1,2,3-cd)pyrene	7.1	4.3	3.3	3.4	2.9	4.1	45	1.1 U	1.5 U	1.8	6.3
Naphthalene	1.0 U	1.0 U	1.0	0.99 U	0.96 U	0.99 U	130	0.97 U	1.0 U	0.97 U	1.8
Perylene	4.4	2.4	1.8	1.7	1.3	2.4	12	0.64	0.81	1.0	3.9
Phenanthrene	84	29	22	9.7	9.7	8.0	110	3.0	15	10	15
Pyrene	120	62	63	21	17	20	79	7.2	21	19	32
Total HPAHs	530	181	167	93	79	118	500	36	71	74	183
Total LPAHs	127	47	37 J	16.8 J	16.6 J	13.3 J	310	4.7 J	23 J	17 J	28

Chemical	Concentration (µg/kg ww)										
	EW-B03-BC-03-comp1	EW-B06-BC-01-comp1	EW-B06-BC-01-comp2	EW-B08-BC-01-comp1	EW-B08-BC-01-comp2	EW-B08-CN-02-comp1	EW-B08-NL-03-comp1	EW-B09-MY-M-comp1	EW-B10-BC-01-comp1	EW-B10-BC-01-comp2	EW-B10-CN-05-comp1
Total cPAHs[b]	31	12	9.8	8.5	7.5	12	63	2.4	4.6	5.2	17
Total PAHs	660	228	204 J	110 J	96 J	131 J	800	41 J	94 J	91 J	211

[a] 2-Chloronaphthalene was not a target analyte for the low-level PAH analysis. The results for this chemical reflect the SVOC analysis (EPA 8270).

[b] Total cPAHs are expressed as TEQs based on the relative toxicity of seven carcinogenic PAH compounds compared to the toxicity of benzo(a)pyrene. For each cPAH compound (benzo(a)anthracene, benzo(b)fluoranthene, benzo(a)pyrene, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene) the concentration is multiplied by the respective PEF to derive a TEQ (see Appendix B for PEFs). The TEQs for individual cPAHs were then summed to derive a total cPAH TEQ (expressed in µ/kg dw).

cPAH – carcinogenic polycyclic aromatic hydrocarbon

dw – dry weight

EPA – US Environmental Protection Agency

HPAH – high-molecular-weight polycyclic aromatic hydrocarbon

J – estimated concentration

LPAH – low-molecular-weight polycyclic aromatic hydrocarbon

PAH – polycyclic aromatic hydrocarbon

PEF – potency equivalency factor

SVOC – semivolatile organic compound

TEQ – toxic equivalent

U – not detected at reporting limit shown

ww – wet weight

5.1.3.2 Sediment samples co-located with intertidal clam tissue samples

Table 5-16 presents a summary of the PAHs analyzed in composite sediment samples co-located with intertidal clam tissue samples, including the number of detections, the range of detected concentrations, and the range of RLs. Results for detected PAHs in each co-located sediment sample are presented in Table 5-17 (see Appendix A, Tables A-2 through A-4, for all results, included non-detected PAH compounds). Fluoranthene and pyrene were the individual PAH compounds with the highest detected concentrations (1,400 µg/kg dw for each compound). Beaches 6 and 8 had the highest concentrations of total PAHs (6,700 µg/kg dw at each beach).

Table 5-16. Summary of PAH data for composite sediment samples co-located with intertidal clam tissue samples

Analyte	Detection Frequency	Detected Concentration (µg/kg dw)		Reporting Limit (µg/kg dw)
		Minimum	Maximum	Min – Max
1-Methylnaphthalene	0/5	nd	nd	19 – 59
2-Chloronaphthalene	0/5	nd	nd	19 – 59
2-Methylnaphthalene	0/5	nd	nd	19 – 59
Acenaphthene	3/5	42 J	72	19 – 58
Acenaphthylene	3/5	35 J	40 J	19 – 58
Anthracene	5/5	9.7 J	200	na
Benzo(a)anthracene	5/5	35	420	na
Benzo(a)pyrene	5/5	38	730	na
Benzo(b)fluoranthene	5/5	83	890	na
Benzo(g,h,i)perylene	5/5	15 J	170	na
Benzo(k)fluoranthene	5/5	86	910	na
Total benzofluoranthenes	5/5	169	1,800	na
Chrysene	5/5	73	810	na
Dibenzo(a,h)anthracene	4/5	31	160	6
Dibenzofuran	1/5	42 J	42 J	19 – 59
Fluoranthene	5/5	64	1,400 J	na
Fluorene	3/5	30 J	61	19 – 58
Indeno(1,2,3-cd)pyrene	5/5	15 J	170	na
Naphthalene	0/5	nd	nd	19 – 59
Phenanthrene	5/5	15 J	380	na
Pyrene	5/5	45	1,400	na
Total HPAHs	5/5	454 J	6,200	na
Total LPAHs	5/5	25 J	720 J	na
Total cPAHs[a]	5/5	62 J	1,000	na
Total PAHs	5/5	479 J	6,700 J	na

[a] Total cPAHs are expressed as TEQs based on the relative toxicity of seven carcinogenic PAH compounds compared to the toxicity of benzo(a)pyrene. For each cPAH compound (benzo(a)anthracene, benzo(b)fluoranthene, benzo(a)pyrene, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene) the concentration is multiplied by the respective PEF to derive a TEQ (see Appendix B for PEFs). The TEQs for individual cPAHs were then summed to derive a total cPAH TEQ (expressed in µ/kg dw).

cPAH – carcinogenic polycyclic aromatic hydrocarbon
dw – dry weight
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
J – estimated concentration
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
na – not applicable
nd – not detected
PAH – polycyclic aromatic hydrocarbon
PEF – potency equivalency factor
TEQ – toxic equivalent

Table 5-17. Concentrations of detected PAHs in composite sediment samples co-located with intertidal clam tissue samples

Analyte	Concentration (µg/kg dw)				
	EW-B03-SS-030	EW-B06-SS-030	EW-B08-SS-030	EW-B09A-SS-030	EW-B10-SS-030
Acenaphthene	43 J	72	42 J	19 U	58 U
Acenaphthylene	37 J	35 J	40 J	19 U	58 U
Anthracene	120	170	200	9.7 J	80
Benzo(a)anthracene	350	420	370	35	200
Benzo(a)pyrene	270	470	730	38	220
Benzo(b)fluoranthene	480	850	890	83	410
Benzo(g,h,i)perylene	62	120	170	15 J	67
Benzo(k)fluoranthene	450	740	910	86	270
Total benzofluoranthenes	930	1,590	1,800	169	680
Chrysene	640	810	650	73	350
Dibenzo(a,h)anthracene	160	71	86	6.0 U	31
Dibenzofuran	59 U	42 J	59 U	19 U	58 U
Fluoranthene	1,400 J	960	810	64	350
Fluorene	30 J	61	35 J	19 U	58 U
Indeno(1,2,3-cd)pyrene	67	120	170	15 J	56 J
Phenanthrene	300	380	240	15 J	140
Pyrene	1,200 J	1,400	1,400	45	690
Total HPAHs	5,100 J	6,000	6,200	454 J	2,640 J
Total LPAHs	530 J	720 J	560 J	25 J	220
Total cPAHs[a]	480	720	1,000	62 J	330 J
Total PAHs	5,600 J	6,700 J	6,700 J	479 J	2,860 J

[a] Total cPAHs are expressed as TEQs based on the relative toxicity of seven carcinogenic PAH compounds compared to the toxicity of benzo(a)pyrene. For each cPAH compound (benzo(a)anthracene, benzo(b)fluoranthene, benzo(a)pyrene, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene) the concentration is multiplied by the respective PEF to derive a TEQ (see Appendix B for PEFs). The TEQs for individual cPAHs were then summed to derive a total cPAH TEQ (expressed in µ/kg dw).

cPAH – carcinogenic polycyclic aromatic hydrocarbon
dw – dry weight
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
J – estimated concentration
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
PAH – polycyclic aromatic hydrocarbon
PEF – potency equivalency factor
TEQ – toxic equivalent
U – not detected at reporting limit shown

Table 5-18 presents the results for PAHs in organic carbon (OC)-normalized units for every co-located sediment sample compared with SQS and CSL criteria. PAH concentrations for the co-located sediment sample from Beach 3 were not OC-normalized because the TOC was < 0.5% (Michelsen and Bragdon-Cook 1993). Therefore, Table 5-19 presents the results for Beach 3 in comparison with lowest apparent effects thresholds (LAETs), which are dry weight values. None of the samples had detected concentrations (or RLs for non-detected concentrations) that exceeded the SQS/LAET or CSL/second lowest apparent effects threshold (2LAET) for PAHs.

Table 5-18. Concentrations of PAHs in co-located composite sediment samples compared with SQS and CSL

Analyte	Concentration (mg/kg OC)					
	EW-B06-SS-030	EW-B08-SS-030	EW-B09A-SS-030	EW-B10-SS-030	SQS	CSL
2-Methylnaphthalene	1.8 U	2.3 U	2.7 U	5.8 U	38	64
Acenaphthene	2.3	1.6 J	2.7 U	5.8 U	16	57
Acenaphthylene	1.1 J	1.6 J	2.7 U	5.8 U	66	66
Anthracene	5.3	7.8	1.4 J	8.0	220	1,200
Benzo(a)anthracene	13	15	5.0	20	110	270
Benzo(a)pyrene	15	29	5.4	22	99	210
Benzo(g,h,i)perylene	3.8	6.7	2.1 J	6.7	31	78
Total benzofluoranthenes	49.8	70.6	24.1	68	230	450
Chrysene	25	25	10	35	110	460
Dibenzo(a,h)anthracene	2.2	3.4	0.86 U	3.1	12	33
Dibenzofuran	1.3 J	2.3 U	2.7 U	5.8 U	15	58
Fluoranthene	30	32	9.1	35	160	1,200
Fluorene	1.9	1.4 J	2.7 U	5.8 U	23	79
Indeno(1,2,3-cd)pyrene	3.8	6.7	2.1 J	5.6 J	34	88
Naphthalene	1.8 U	2.3 U	2.7 U	5.8 U	99	170
Phenanthrene	12	9.4	2.1 J	14	100	480
Pyrene	44	55	6.4	69	1,000	1,400
Total HPAHs	190	240	64.8 J	265 J	960	5,300
Total LPAHs	23 J	22 J	3.6 J	22	370	780

CSL – cleanup screening level
dw – dry weight
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon

J – estimated concentration

LPAH – low-molecular-weight polycyclic aromatic hydrocarbon

ML – maximum level

OC – organic carbon normalized

PAH – polycyclic aromatic hydrocarbon

SQS – sediment quality standards

U – not detected at reporting limit shown

Table 5-19. Concentrations of PAHs in the co-located sediment sample from Beach 3 (TOC < 0.5%) compared to LAETs

Analyte	Concentration (µg/kg dw)		
	EW-B03-SS-030	LAET	2LAET
2-Methylnaphthalene	59 U	670	1,400
Acenaphthene	43 J	500	730
Acenaphthylene	37 J	1,300	1,300
Anthracene	120	960	4,400
Benzo(a)anthracene	350	1,300	1,600
Benzo(a)pyrene	270	1,600	3,000
Benzo(g,h,i)perylene	62	670	720
Total benzofluoranthenes	930	3,200	3,600
Chrysene	640	1,400	2,800
Dibenzo(a,h)anthracene	160	230	540
Dibenzofuran	59 U	540	700
Fluoranthene	1,400 J	1,700	2,500
Fluorene	30 J	540	1,000
Indeno(1,2,3-cd)pyrene	67	600	690
Naphthalene	59 U	2,100	2,400
Phenanthrene	300	1,500	5,400
Pyrene	1,200 J	2,600	3,300
Total HPAHs	5,100 J	12,000	17,000
Total LPAHs	530 J	5,200	13,000

dw – dry weight

HPAH – high-molecular-weight polycyclic aromatic hydrocarbon

J – estimated concentration

LPAH – low-molecular-weight polycyclic aromatic hydrocarbon

LAET – lowest apparent effects threshold

2LAET – second lowest apparent effects threshold

PAH – polycyclic aromatic hydrocarbon

TOC – total organic carbon

U – not detected at reporting limit shown

5.1.3.3 Geoduck tissue

PAHs were detected in all geoduck tissue samples. A summary of PAH results in geoduck samples is presented in Table 5-20. The results for each individual sample are presented in Table 5-21. 2-Chloronaphthalene was not an analyte for the low-level PAH analysis and was not detected in any clam samples analyzed using the SVOC method (EPA 8270).

Table 5-20. Summary of PAH data for geoduck tissue samples

Analyte	Detection Frequency	Detected Concentration (µg/kg ww)		Reporting Limit (µg/kg ww)
		Minimum	Maximum	Min – Max
1-Methylnaphthalene	0/9	nd	nd	0.49 – 1.9
2-Chloronaphthalene	0/9	nd	nd	58 - 420
2-Methylnaphthalene	0/9	nd	nd	0.97 - 3.8
Acenaphthene	1/9	0.65	0.65	0.49 - 1.9
Acenaphthylene	9/9	0.092 J	0.96 J	na
Anthracene	9/9	0.29 J	3.2	na
Benzo(a)anthracene	3/9	3.9	8.2	0.92 - 1.6
Benzo(a)pyrene	9/9	0.64	6.8	na
Benzo(b)fluoranthene	9/9	1.5	15	na
Benzo(g,h,i)perylene	9/9	0.37 J	5.1	na
Benzo(k)fluoranthene	9/9	0.71	4.9	na
Total benzofluoranthenes	9/9	2.2	20	na
Chrysene	3/9	4.8	11	0.90 - 1.9
Dibenzo(a,h)anthracene	9/9	0.11 J	1.2 J	na
Dibenzofuran	9/9	0.12 J	1.3 J	na
Fluoranthene	3/9	10	21	0.85 - 1.6
Fluorene	9/9	0.19 J	2.6	na
Indeno(1,2,3-cd)pyrene	9/9	0.33 J	5.8	na
Naphthalene	0/9	nd	nd	0.97 - 3.8
Perylene	7/9	0.29 J	4.3	0.50
Phenanthrene	9/9	0.38 J	13	na
Pyrene	3/9	4.0	12	0.49 - 1.0
Total HPAHs	9/9	3.7 J	91 J	na
Total LPAHs	9/9	1.00 J	20 J	na
Total cPAHs[b]	9/9	0.99 J	11 J	na
Total PAHs	9/9	4.7 J	111 J	na

[a] 2-Chloronaphthalene was not a target analyte for the low-level PAH analysis. The results for this chemical reflect the SVOC analysis (EPA 8270).

[b] Total cPAHs are expressed as TEQs based on the relative toxicity of seven carcinogenic PAH compounds compared to the toxicity of benzo(a)pyrene. For each cPAH compound (benzo(a)anthracene, benzo(b)fluoranthene, benzo(a)pyrene, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, and

indeno(1,2,3-cd)pyrene) the concentration is multiplied by the respective PEF to derive a TEQ (see Appendix B for PEFs). The TEQs for individual cPAHs were then summed to derive a total cPAH TEQ (expressed in µ/kg dw).

cPAH – carcinogenic polycyclic aromatic hydrocarbon

dw – dry weight

EPA – US Environmental Protection Agency

HPAH – high-molecular-weight polycyclic aromatic hydrocarbon

J – estimated concentration

LPAH – low-molecular-weight polycyclic aromatic hydrocarbon

PAH – polycyclic aromatic hydrocarbon

PEF – potency equivalency factor

SVOC – semivolatile organic compound

TEQ – toxic equivalent

ww – wet weight

Table 5-21. PAH results for geoduck tissue samples

Chemical	Concentration (µg/kg ww)								
	EW-S01-GD-01	EW-S01-GD-02	EW-S01-GD-03	EW-S01-GD-04	EW-S01-GD-07	EW-S01-GD-10	EW-S01-GD-GB-comp01	EW-S01-GD-GB-comp02	EW-S01-GD-GB-comp03
1-Methylnaphthalene	0.50 U	0.49 U	0.50 U	0.50 U	0.49 U	0.49 U	0.49 U	0.50 U	1.9 U
2-Chloronaphthalene	110 U	58 U	60 U	59 U	60 U	60 U	200 U	420 U	280 U
2-Methylnaphthalene	0.99 U	0.97 U	1.0 U	1.0 U	0.97 U	0.98 U	0.97 U	1.0 U	3.8 U
Acenaphthene	0.50 U	0.49 U	0.50 U	0.50 U	0.49 U	0.49 U	0.65	0.55 U	1.9 U
Acenaphthylene	0.12 J	0.13 J	0.092 J	0.16 J	0.11 J	0.16 J	0.46 J	0.66	0.96 J
Anthracene	0.34 J	0.36 J	0.30 J	0.48 J	0.29 J	0.44 J	2.1	2.8	3.2
Benzo(a)anthracene	0.92 U	1.1 U	1.0 U	1.6 U	1.0 U	1.4 U	3.9	4.9	8.2
Benzo(a)pyrene	0.72	0.90	1.0	1.9	0.64	1.5	4.2	4.6	6.8
Benzo(b)fluoranthene	1.5	2.1	2.3	3.7	1.5	2.9	9.0	10	15
Benzo(g,h,i)perylene	0.44 J	0.52	0.42 J	0.92	0.37 J	0.62	2.5	3.4	5.1
Benzo(k)fluoranthene	0.72	0.98	1.2	1.9	0.71	1.2	2.9	3.7	4.9
Total benzofluoranthenes	2.2	3.1	3.5	5.6	2.2	4.1	11.9	14	20
Chrysene	0.90 U	1.1 U	1.3 U	1.9 U	0.92 U	1.6 U	4.8	6.6	11
Dibenzo(a,h)anthracene	0.12 J	0.14 J	0.13 J	0.41 J	0.11 J	0.15 J	0.55	0.73	1.2 J
Dibenzofuran	0.16 J	0.16 J	0.12 J	0.19 J	0.14 J	0.25 J	0.77	0.87	1.3 J
Fluoranthene	1.1 U	1.5 U	0.93 U	1.6 U	0.85 U	1.5 U	10	10	21
Fluorene	0.25 J	0.26 J	0.23 J	0.34 J	0.19 J	0.41 J	1.3	1.5	2.6
Indeno(1,2,3-cd)pyrene	0.44 J	0.50	0.40 J	0.78	0.33 J	0.61	2.7	3.6	5.8
Naphthalene	0.99 U	0.97 U	1.2 U	1.0 U	1.1 U	1.9 U	1.2 U	1.3 U	3.8 U
Phenanthrene	0.69	0.53	0.38 J	0.71	0.44 J	1.0	6.6	6.2	13
Perylene	0.29 J	0.36 J	0.50 U	0.50 U	0.31 J	0.75	3.3	4.3	1.2 J
Pyrene	0.50 U	0.71 U	1.0 U	0.51 U	0.49 U	0.83 U	5.9	4.0	12
Total HPAHs	3.9 J	5.1 J	5.5 J	9.6 J	3.7 J	7.0 J	46	52	91 J
Total LPAHs	1.40 J	1.28 J	1.00 J	1.69 J	1.03 J	2.0 J	11.1 J	13.0	20 J
Total cPAHs[b]	1.1 J	1.4 J	1.5 J	2.8 J	0.99 J	2.1 J	6.3	7.2	11 J
Total PAHs	5.3 J	6.4 J	6.5 J	11.3 J	4.7 J	9.0 J	58 J	65	111 J

[a] 2-Chloronaphthalene was not a target analyte for the low-level PAH analysis. The results for this chemical reflect the SVOC analysis (EPA 8270).

[b] Total cPAHs are expressed as TEQs based on the relative toxicity of seven carcinogenic PAH compounds compared to the toxicity of benzo(a)pyrene. For each cPAH compound (benzo(a)anthracene,

benzo(b)fluoranthene, benzo(a)pyrene, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene) the concentration is multiplied by the respective PEF to derive a TEQ (see Appendix B for PEFs). The TEQs for individual cPAHs were then summed to derive a total cPAH TEQ (expressed in µ/kg dw).

cPAH – carcinogenic polycyclic aromatic hydrocarbon
dw – dry weight
EPA – US Environmental Protection Agency
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
J – estimated concentration
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
PAH – polycyclic aromatic hydrocarbon
PEF – potency equivalency factor
SVOC – semivolatile organic compound
TEQ – toxic equivalent
U – not detected at reporting limit shown
ww – wet weight

5.1.4 Phthalates

This section presents results of the phthalate analyses for intertidal clam composite tissue, clam co-located composite sediment, and geoduck tissue samples.

5.1.4.1 Intertidal clam tissue

None of the six phthalate compounds were detected in intertidal clam composite tissue, at RLs ranging from 18 to 300 µg/kg ww (Appendix A, Table A-5).

5.1.4.2 Sediment co-located with intertidal clam tissue samples

Table 5-22 presents a summary of phthalates in composite sediment samples co-located with intertidal clam tissue, including the number of detections, the range of detected concentrations, and the range of RLs. Results for detected phthalates in each co-located sediment sample are presented in Table 5-23 (see Appendix A, Tables A-2 through A-4 for all results, including non-detected phthalates). BEHP was detected in all samples. Diethyl phthalate was not detected in any of the samples. The four remaining phthalates (butyl benzyl phthalate [BBP], dimethyl phthalate, di-n-butyl phthalate, and di-n-octyl phthalate) were each detected in one or two samples. The highest concentrations of phthalates were detected at the following beaches: Beach 3 (BBP and dimethyl phthalate), Beach 6 (BEHP and di-n-butyl phthalate), and Beach 8 (di-n-octyl phthalate).

Table 5-22. Summary of phthalate data in co-located composite sediment samples

Analyte	Detection Frequency	Detected Concentration (µg/kg dw)		Reporting Limit (µg/kg dw)
		Minimum	Maximum	Min – Max
BEHP	5/5	34	590	na
BBP	2/5	25	750 J	15 – 45
Diethyl phthalate	0/5	nd	nd	19 – 59
Dimethyl phthalate	1/5	410 J	410 J	15 – 45
Di-n-butyl phthalate	1/5	280	280	19 – 59
Di-n-octyl phthalate	1/5	74	74	19 – 59

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
dw – dry weight
J – estimated concentration
na – not applicable
nd – not detected

Table 5-23. Concentrations of detected phthalates in co-located composite sediment samples

Analyte	Concentration (µg/kg dw)				
	EW-B03-SS-030	EW-B06-SS-030	EW-B08-SS-030	EW-B09A-SS-030	EW-B10-SS-030
BEHP	120	590	320	34	310
BBP	750 J	25	45 U	15 U	45 U
Dimethyl phthalate	410 J	15 U	45 U	15 U	45 U
Di-n-butyl phthalate	59 U	280	59 U	19 U	58 U
Di-n-octyl phthalate	59 U	58 U	74	19 U	58 U

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
dw – dry weight
J – estimated concentration
U – not detected at reporting limit shown

Table 5-24 presents the results for phthalates in OC-normalized units for every co-located sediment sample compared with SQS and CSL criteria, which are in units of mg/kg OC. The phthalate concentrations for the co-located sediment sample from Beach 3 were not OC-normalized because the TOC was < 5% (Michelsen and Bragdon-Cook 1993). Therefore, Table 5-25 presents the results for Beach 3 in comparison with LAETs, which are dry weight values. None of the phthalate concentrations in sediment exceeded the SQS or CSL. Concentrations of BBP and dimethyl phthalate in sediment from Beach 3 exceeded the LAET and 2LAET, respectively.

Table 5-24. Concentrations of phthalates in co-located composite sediment samples compared to SQS and CSL

Analyte	Concentration (mg/kg OC)					
	EW-B06-SS-030	EW-B08-SS-030	EW-B09A-SS-030	EW-B10-SS-030	SQS	CSL
BEHP	18	13	4.9	31	47	78
BBP	0.78	1.8 U	2.1 U	4.5 U	4.9	64
Diethyl phthalate	1.8 U	2.3 U	2.7 U	5.8 U	61	110
Dimethyl phthalate	0.47 U	1.8 U	2.1 U	4.5 U	53	53
Di-n-butyl phthalate	8.8	2.3 U	2.7 U	5.8 U	220	1,700
Di-n-octyl phthalate	1.8 U	2.9	2.7 U	5.8 U	58	4,500

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
CSL – cleanup screening level
OC – organic carbon normalized

SQS – sediment quality standards

U – not detected at reporting limit shown

Table 5-25. Concentrations of phthalates in the co-located composite sediment sample from Beach 3 (TOC < 0.5%) compared with LAETs

Analyte	Concentration (µg/kg dw)		
	EW-B03-SS-030	LAET	2LAET
BEHP	120	1,300	1,900
BBP	**750 J**	63	900
Diethyl phthalate	59 U	200	1,200
Dimethyl phthalate	**<u>410 J</u>**	71	160
Di-n-butyl phthalate	59 U	1,400	5,100
Di-n-octyl phthalate	59 U	6,200	nc

BBP – butyl benzyl phthalate

BEHP – bis(2-ethylhexyl) phthalate

dw – dry weight

J – estimated concentration

LAET – lowest apparent effects threshold

2LAET – second lowest apparent effects threshold

TOC – total organic carbon

U – not detected at reporting limit shown

Bold indicates LAET exceedance.

<u>Bold underline</u> indicates 2LAET exceedance.

5.1.4.3 Geoduck tissue

None of the six phthalate compounds were detected in geoduck tissue at RLs ranging from 17 to 420 µg/kg ww (see Appendix A, Table A-5).

5.1.5 SVOCs

This section presents results from the SVOCs analyses for intertidal clam composite tissue, clam co-located composite sediment, and geoduck tissue samples.

5.1.5.1 Intertidal clam tissue

Benzoic acid and PCP were the only SVOCs detected in intertidal clam composite tissue samples. Benzoic acid was detected in seven samples at concentrations ranging from 2,900 to 13,000 µg/kg ww, and PCP was detected in two samples ranging from 6.0 to 8.2 µg/kg ww (see Appendix A, Tables A-2 through A-4, for results for individual samples, including RLs for non-detected chemicals). The maximum concentrations for benzoic acid and PCP were detected in the clam tissue samples collected at Beach 9 and Beach 3, respectively.

5.1.5.2 Sediment co-located with intertidal clam tissue samples

Four SVOCs (1,4-dichlorobenzene, benzoic acid, carbazole, and phenol) were detected in co-located composite sediment samples at concentrations ranging from 18 to 190 µg/kg dw (Table 5-26). RLs for non-detected chemicals ranged from 6.0 to

590 µg/kg ww (see Appendix A, Tables A-2 through A-4, for complete results for each sample).

Table 5-26. Concentrations of detected SVOCs in co-located composite sediment samples

Analyte	Concentration (µg/kg dw)				
	EW-B03-SS-030	EW-B06-SS-030	EW-B08-SS-030	EW-B09A-SS-030	EW-B10-SS-030
1,4-Dichlorobenzene	30 U	6.0 U	18	6.0 U	18 U
Benzoic acid	590 U	580 U	590 U	190 J	580 U
Carbazole	50 J	86	63	19 U	37 J
Phenol	170	58 U	220	19 U	430

dw – dry weight

J – estimated concentration

SVOC – semivolatile organic compound

U – not detected at reporting limit shown

Table 5-27 presents the results for SVOCs for every co-located sediment sample compared with SQS/SL and CSL/ML (OC-normalized or dry weight values, depending on SQS/SL and CSL/ML units). The SVOC concentrations for the co-located sediment sample from Beach 3 were not OC-normalized because the TOC was < 5% (Michelsen and Bragdon-Cook 1993). Therefore, Table 5-28 presents the results for Beach 3 in comparison with LAETs (dry weight values) for chemicals in Table 5-27 that had OC-normalized SQS or CSL values. Phenol was the only SVOC with a detected concentration that exceeded the SQS; one sample collected from Beach 10 had a concentration of 430 µg/kg dw, slightly exceeding the SQS of 420 µg/kg dw. Three other SVOCs were not detected in sediment but had RLs that exceeded their respective SQS values (1,2,4-trichlorobenzene in two samples, 2,4-dimethylphenol in one sample, and benzyl alcohol in four samples).

Table 5-27. Concentrations of SVOCs in co-located composite sediment samples compared with SQS/SL and CSL/ML

Analyte	Unit	EW-B03-SS-030	EW-B06-SS-030	EW-B08-SS-030	EW-B09A-SS-030	EW-B10-SS-030	SQS/SL	CSL/ML
1,2,4-Trichlorobenzene	mg/kg OC	na[a]	0.19 UJ	0.71 UJ	**0.86 UJ**	**1.8 UJ**	0.81	1.8
1,2-Dichlorobenzene	mg/kg OC	na[a]	0.19 U	0.71 U	0.86 U	1.8 U	2.3	2.3
1,3-Dichlorobenzene[b]	µg/kg dw	59 U	58 U	59 U	19 U	58 U	170	nc
1,4-Dichlorobenzene	mg/kg OC	na[a]	0.19 U	0.71	0.86 U	1.8 U	3.1	9
2,4-Dimethylphenol	µg/kg dw	**30 UJ**	6.0 UJ	18 UJ	6.0 UJ	18 UJ	29	29
2-Methylphenol	µg/kg dw	30 U	6.0 U	18 U	6.0 U	18 U	63	63
4-Methylphenol	µg/kg dw	59 U	58 U	59 U	19 U	58 U	670	670
Benzoic acid	µg/kg dw	590 U	580 U	590 U	190 J	580 U	650	650

Analyte	Unit	EW-B03-SS-030	EW-B06-SS-030	EW-B08-SS-030	EW-B09A-SS-030	EW-B10-SS-030	SQS/SL	CSL/ML
Benzyl alcohol	µg/kg dw	**59 U**	**58 U**	**59 U**	19 U	**58 U**	57	73
Hexachlorobenzene[b]	mg/kg OC	na[a]	0.030 U	0.19 U	0.14 U	0.096 U	0.38	2.3
Hexachlorobutadiene	mg/kg OC	na[a]	0.030 U	0.19 U	0.14 U	0.096 U	3.9	6.2
Hexachloroethane	µg/kg dw	0.98 U	0.96 U	4.8 U	0.95 U	0.96 U	1,400	14,000
n-Nitrosodiphenylamine	mg/kg OC	na[a]	0.19 U	0.71 U	0.86 U	1.8 U	11	11
Pentachlorophenol	µg/kg dw	150 U	30 U	90 U	30 U	90 U	360	690
Phenol	µg/kg dw	170	58 U	220	19 U	**430**	420	1,200

[a] OC-normalized concentrations were not calculated because TOC was < 0.5%.

[b] SVOCs compared to SL and ML.

CSL – cleanup screening level
dw – dry weight
J – estimated concentration
ML – maximum level
na – not applicable
OC – organic carbon normalized
SL – screening level
SQS – sediment quality standards
SVOC – semivolatile organic compound
U – not detected at reporting limit shown
UJ – not detected at estimated reporting limit shown

Bold indicates SQS/SL exceedance.

Bold underline indicates CSL/ML exceedance.

Table 5-28. Concentrations of SVOCs in the co-located composite sediment sample from Beach 3 (TOC < 0.5%) compared to LAETs

Analyte	Concentration (µg/kg dw)		
	EW-B03-SS-030	LAET	2LAET
1,2,4-Trichlorobenzene	30 UJ	31	51
1,2-Dichlorobenzene	30 U	35	50
1,4-Dichlorobenzene	30 U	110	120
Hexachlorobenzene	0.98 U	22	70
Hexachlorobutadiene	0.98 U	11	120

dw – dry weight
LAET – lowest apparent affects threshold
2LAET – second lowest apparent affects threshold
SVOC – semivolatile organic compound
TOC – total organic carbon
U – not detected at reporting limit shown
UJ – not detected at estimated reporting limit shown

5.1.5.3 Geoduck

Benzoic acid was the only SVOC detected in geoduck tissue and was detected in all nine samples at concentrations ranging from 530 to 2,700 µg/kg ww in edible meat tissue and 3,400 to 11,000 µg/kg ww in gutball composite tissue. The results for individual samples, including RLs for non-detected chemicals, are presented in Appendix A, Table A-5.

5.1.6 PCBs

This section presents results from the PCBs analyses for intertidal clam composite tissue, clam co-located composite sediment, and geoduck tissue samples.

5.1.6.1 Intertidal clam tissue

Table 5-29 presents a summary of PCB concentrations in intertidal clam composite tissue samples, including the number of detections, the range of detected concentrations, and the range of RLs. Results for PCBs in individual intertidal clam tissue samples are presented in Table 5-30 and in Appendix A, Table A-1. Two PCB Aroclors were detected in clam composite tissue samples: Aroclor 1254 in 10 of the 11 samples and Aroclor 1260 in all 11 samples. The highest PCB concentrations were in clams collected from Beach 8: 35 µg/kg ww for Aroclor 1254 in cockle tissue and 49 µg/kg ww for Aroclor 1260 in butter clam tissue.

Table 5-29. Summary of PCB data for intertidal clam composite tissue samples

Analyte	Detection Frequency	Detected Concentration (µg/kg ww)		Reporting Limit (µg/kg ww)
		Minimum	Maximum	Min – Max
Aroclor 1016	0/11	nd	nd	9.8 – 13
Aroclor 1221	0/11	nd	nd	20 – 25
Aroclor 1232	0/11	nd	nd	9.9 – 18
Aroclor 1242	0/11	nd	nd	9.9 – 16
Aroclor 1248	0/11	nd	nd	9.9 – 20
Aroclor 1254	10/11	15	35	9.9 – 9.9
Aroclor 1260	11/11	4.7 JN	49	na
Total PCBs	11/11	4.7 JN	82	na

JN – tentatively identified compound with an estimated concentration

na – not applicable

nd – not detected

PCB – polychlorinated biphenyl

ww – wet weight

Table 5-30. Concentrations of detected PCBs in individual intertidal clam tissue samples

Analyte	Concentration (µg/kg ww)											
	EW-B03-BC-03-comp1	EW-B06-BC-01-comp1	EW-B06-BC-01-comp2	EW-B08-BC-01-comp1	EW-B08-BC-01-comp2	EW-B08-CN-02-comp1	EW-B08-NL-03-comp1	EW-B09-MY-M-comp1	EW-B10-BC-01-comp1	EW-B10-BC-01-comp2	EW-B10-CN-05-comp1	EW-B10-NL-06-comp1
Aroclor 1254	17	31	27	26	15	35	26	9.9 U	16	16	30	na
Aroclor 1260	34	47	44 J	49	27 J	47	46	4.7 JN	22 J	24 J	36 J	na
Total PCBs	51	78	71 J	75	42 J	82	72	4.7 JN	38 J	40 J	66 J	na

na – not analyzed

J – estimated concentration

JN – tentatively identified compound with an estimated concentration

PCB – polychlorinated biphenyl

ww – wet weight

U – not detected at reporting limit shown

5.1.6.2 Sediment co-located with intertidal clam tissue samples

Table 5-31 presents a summary of PCBs in co-located composite sediment samples, including the number of detections, the range of detected concentrations, and the range of RLs. Results for detected PCBs in each co-located sediment sample are presented in Table 5-32 (see Appendix A, Tables A-2 through A-4, for RLs for non-detected Aroclors). Aroclors 1254 and 1260 were detected in all sediment samples, and Aroclors 1242 and 1248 were detected in one and two samples, respectively. The highest concentrations of PCBs were detected in sediment collected from Beach 8 (Aroclors 1254, 1260, 1242, and total PCBs) and Beach 10 (Aroclor 1248). Total PCB results are shown on Map 5-1.

Table 5-31. Summary of PCB data for co-located composite sediment samples

Analyte	Detection Frequency	Detected Concentration (µg/kg dw)		Reporting Limit (µg/kg dw)
		Minimum	Maximum	Min – Max
Aroclor 1016	0/5	nd	nd	3.9 – 270
Aroclor 1221	0/5	nd	nd	3.9 – 270
Aroclor 1232	0/5	nd	nd	3.9 – 270
Aroclor 1242	1/5	440	440	3.9 – 35
Aroclor 1248	2/5	190	250	3.9 – 270
Aroclor 1254	5/5	10	750	na
Aroclor 1260	5/5	12	1,900	na
Aroclor 1262	0/5	nd	nd	3.9 – 270
Aroclor 1268	0/5	nd	nd	3.9 – 270
Total PCBs	5/5	22	3,100	na

dw – dry weight
na – not applicable
nd – not detected
PCB – polychlorinated biphenyl

Table 5-32. Concentrations of detected PCBs in co-located composite sediment samples

Analyte	Concentration (µg/kg dw)				
	EW-B03-SS-030	EW-B06-SS-030	EW-B08-SS-030	EW-B09A-SS-030	EW-B10-SS-030
Aroclor 1242	12 U	35 U	440	3.9 U	35 U
Aroclor 1248	12 U	190	270 U	3.9 U	250
Aroclor 1254	35 J	220	750	10	95
Aroclor 1260	46 J	190	1,900	12	44
Total PCBs	81 J	600	3,100	22	390

dw – dry weight
J – estimated concentration
PCB – polychlorinated biphenyl
U – not detected at reporting limit shown

Table 5-33 presents the results for PCBs in OC-normalized units for every co-located sediment sample compared to SQS and CSL criteria, which are in units of mg/kg OC. The PCB concentrations for the co-located composite sediment sample from Beach 3 were not OC-normalized because the TOC was < 5% (Michelsen and Bragdon-Cook 1993). Therefore, Table 5-34 presents the results for Beach 3 in comparison with LAETs, which are dry weight values. Total PCBs exceeded the SQS in sediment samples collected from Beaches 6 and 10 and exceeded the CSL in the sediment sample from Beach 8.

Table 5-33. Concentrations of PCBs in co-located composite sediment samples compared to SQS and CSL

Analyte	Concentration (mg/kg OC)					
	EW-B06-SS-030	EW-B08-SS-030	EW-B09A-SS-030	EW-B10-SS-030	SQS	CSL
Total PCBs	**19**	**<u>120</u>**	3.1	**39**	12	65

CSL – cleanup screening level

OC – organic carbon normalized

PCB – polychlorinated biphenyl

SQS – sediment quality standards

Bold indicates SQS/SL exceedance.

<u>Bold underline</u> indicates CSL/ML exceedance.

Table 5-34. Concentrations of PCBs in the co-located composite sediment sample from Beach 3 (TOC < 0.5%) compared to LAETs

Analyte	Concentration (µg/kg dw)		
	EW-B03-S-030	LAET	2LAET
Total PCBs	81 J	130	1,000

dw – dry weight

J – estimated concentration

LAET – lowest apparent effects threshold

2LAET – second lowest apparent effects threshold

PCB – polychlorinated biphenyl

TOC – total organic carbon

5.1.6.3 Geoduck

Table 5-35 presents a summary of PCB concentrations in geoduck tissue samples, including the number of detections, the range of detected concentrations, and the range of RLs (see Appendix A, Table A-5, for complete results). Aroclor 1254 and Aroclor 1260 were the only individual PCB Aroclors detected in tissue samples. Concentrations of Aroclor 1254 ranged from 8.0 to 12 µg/kg ww in five of the six edible-meat samples and were higher in the three gutball composite samples, ranging from 26 to 42 µg/kg ww. Concentrations of Aroclor 1260 ranged from 7.9 to 14 µg/kg ww in the six edible-meat samples and were higher in the three gutball composite samples, ranging from 22 to 36 µg/kg ww.

Table 5-35. Summary of PCB data for geoduck tissue samples

Analyte	Detection Frequency	Detected Concentration (µg/kg ww)		Reporting Limit (µg/kg ww)
		Minimum	Maximum	Min – Max
Aroclor 1016				
Edible meat	0/6	nd	nd	3.5 – 6.4
Gutball	0/3	nd	nd	3.6 – 7.4
Aroclor 1221				
Edible meat	0/6	nd	nd	3.5 – 6.4
Gutball	0/3	nd	nd	3.6 – 7.4
Aroclor 1232				
Edible meat	0/6	nd	nd	3.5 – 6.4
Gutball	0/3	nd	nd	3.6 – 7.4
Aroclor 1242				
Edible meat	0/6	nd	nd	3.5 – 6.4
Gutball	0/3	nd	nd	3.6 – 49
Aroclor 1248				
Edible meat	0/6	nd	nd	12 – 24
Gutball	0/3	nd	nd	3.6 – 30
Aroclor 1254				
Edible meat	5/6	8.0	12 J	11
Gutball	3/3	26 J	42	na
Aroclor 1260				
Edible meat	6/6	7.9	14	na
Gutball	3/3	25	36	na
Aroclor 1262				
Edible meat	0/6	nd	nd	3.5 – 6.4
Gutball	0/3	nd	nd	3.6 – 7.4
Aroclor 1268				
Edible meat	0/6	nd	nd	3.5 – 6.4
Gutball	0/3	nd	nd	3.6 – 7.4
Total PCBs				
Edible meat	6/6	14	24 JN	na
Gutball	3/3	51 J	78	na

J – estimated concentration
na – not applicable
nd – not detected
PCB – polychlorinated biphenyl
ww – wet weight

5.1.7 Pesticides

Pesticides were not detected in any of the intertidal clam composite tissue, co-located composite sediment, or geoduck tissue samples. RLs for each sample are presented in Appendix A, Table A-1. RLs for total DDTs in three co-located sediment samples (9.9 to 11 µg/kg dw) exceeded the SL (6.9 µg/kg dw), and the RL for dieldrin in one sample (57 µg/kg dw) exceeded the SL (10 µg/kg dw).

5.1.8 Lipids in intertidal clam tissue samples

Table 5-36 summarizes the percent lipids and total solids in the intertidal clam composite tissue samples. Lipid content ranged from 0.353 to 0.943% ww in intertidal clam composite samples and from 0.413 to 0.560% ww in geoduck edible-tissue samples. Lipid content was higher in geoduck gutball composite tissue, ranging from 1.13 to 1.87% ww. Results for each sample are presented in Table 5-37 and in Appendix A, Table A-1, for intertidal clam tissue. Table 5-38 summarizes the percent lipids and total solids in the geoduck tissue samples. Results for each geoduck tissue sample are presented in Table 5-39 and in Appendix A, Table A-5.

Table 5-36. Summary of lipid and total solids data for intertidal clam composite tissue samples

Analyte	Detection Frequency	Detected Concentration (% ww)		Reporting Limit (% ww)
		Minimum	Maximum	Min – Max
Lipid	10/10	0.353	0.943	na
Total solids	10/10	8.95	18.01	na

na – not applicable

ww – wet weight

Table 5-37. Concentrations of lipids and total solids in individual intertidal clam tissue samples

Analyte	Concentration (% ww)											
	EW-B03-BC-03-comp1	EW-B06-BC-01-comp1	EW-B06-BC-01-comp2	EW-B08-BC-01-comp1	EW-B08-BC-01-comp2	EW-B08-CN-02-comp1	EW-B08-NL-03-comp1	EW-B09-MY-M-comp1	EW-B10-BC-01-comp1	EW-B10-BC-01-comp2	EW-B10-CN-05-comp1	EW-B10-NL-06-comp1
Lipid	0.766	0.943	0.748	0.678	0.585	0.431	na	0.353	0.638	0.529	0.800	na
Total solids	18.01	17.22	16.16	12.90	12.14	11.61	na	8.95	13.59	13.83	14.46	na

na – not analyzed

ww – wet weight

Table 5-38. Summary of lipid and total solids data for geoduck tissue samples

Analyte	Detection Frequency	Detected Concentration (% ww)		Reporting Limit (% ww)
		Minimum	Maximum	Min – Max
Lipid				
Edible meat	6/6	0.413	0.560	na
Gutball	3/3	1.13	1.87	na
Total solids				
Edible meat	6/6	14.04	19.13	na
Gutball	3/3	12.70	15.02	na

na – not applicable

nd –not detected

ww – wet weight

Table 5-39. Concentrations of lipids and total solids in individual geoduck tissue samples

Analyte	Concentration (% ww)								
	EW-S01-GD-01	EW-S01-GD-02	EW-S01-GD-03	EW-S01-GD-04	EW-S01-GD-07	EW-S01-GD-10	EW-S01-GD-GB-comp01	EW-S01-GD-GB-comp02	EW-S01-GD-GB-comp03
Lipid	0.456	0.413	0.560	0.480	0.476	0.440	1.13	1.87	1.63
Total solids	19.13	16.32	15.70	14.04	17.11	15.38	12.70	15.02	13.41

ww – wet weight

5.1.9 Grain size, TOC, and total solids in co-located sediment samples

Table 5-40 presents the results of grain size, TOC, and total solids analyses of co-located composite sediment samples. Results for grain size, TOC, and total solids for individual co-located sediment samples are presented in Table 5-41 and Appendix A, Tables A-2 through A-4. Percent fines ranged from 8.3% dw at Beach 6 to 12.3% dw at Beach 8. TOC ranged from 0.412% dw at Beach 3 to 3.19% dw at Beach 6. Total solids ranged from 69.3% ww at Beach 8 to 77.1% ww at Beach 9A.

Table 5-40. Summary of grain size, TOC and total solids data in composite sediment samples co-located with intertidal clam tissue samples

Analyte	Unit	Detection Frequency	Detected Concentration		Reporting Limit
			Minimum	Maximum	Min – Max
Total gravel	% dw	5/5	11.7	62.4	na
Total sand	% dw	5/5	28.5	76.9	na
Total silt	% dw	5/5	5.3	8.3	na
Total clay	% dw	5/5	2.7	5.6	na
Total fines (percent silt+clay)	% dw	5/5	8.3	12.3	na

Analyte	Unit	Detection Frequency	Detected Concentration Minimum	Detected Concentration Maximum	Reporting Limit Min – Max
TOC	% dw	5/5	0.412 J	3.19 J	na
Total solids	% ww	5/5	69.30	77.10	na

dw – dry weight

na – not applicable

TOC – total organic carbon

ww – wet weight

Table 5-41. Percentages of grain size, TOC, and total solids in sediment samples co-located with intertidal clam tissue samples

Analyte	Concentration (% dw, unless otherwise noted)				
	EW-B03-SS-030	EW-B06-SS-030	EW-B08-SS-030	EW-B09A-SS-030	EW-B10-SS-030
Total gravel	62.4	17.9	32.6	11.7	30.9
Total sand	28.5	73.8	54.9	76.9	58.4
Total silt	6.5	5.3	8.3	5.8	6.4
Total clay	2.7	3.0	4.0	5.6	4.4
Total fines (percent silt+clay)	9.2	8.3	12.3	11.4	10.8
TOC	0.412 J	3.19 J	2.55 J	0.701 J	0.998 J
Total solids (% ww)	75.50	74.40	69.30	77.10	70.80

J – estimated concentration

TOC – total organic carbon

ww – wet weight

5.1.10 Comparison of non-detected results to analytical concentration goals

This section compares RLs and method detection limits (MDLs) for non-detected concentrations in intertidal clam composite tissue samples, geoduck tissue samples, and co-located composite sediment samples to site-specific ACGs that were presented in Appendix C (intertidal clam and geoduck tissue) and Appendix D (sediment) of the QAPP (Windward 2009a). The target detection limits for the intertidal clam composite tissue, geoduck tissue, and co-located clam sediment analyses were also identified in the QAPP appendices and are presented in tables in this section.

Actual MDLs and RLs may differ from the target detection limits as a result of necessary analytical dilutions or the adjustment of extracted sample volumes for some samples based on a preliminary screen of the sample prior to analysis. When sample extracts were diluted because the concentrations for one or more target analytes exceeded the upper end of the calibration curve, RLs from the original undiluted extract were reported for chemicals other than the target analytes that required dilution. The sample-specific RL is based on the lowest point of the calibration curve associated with each analysis, whereas the MDL is statistically derived following EPA methods (40 CFR 136). Both the RL and MDL will be elevated in cases where the sample extract required dilution. Detected concentrations between the MDL and RL were reported by the laboratories and flagged with a J-qualifier to indicate that the reported concentration was an estimate because it fell below the lowest point on the calibration curve. Non-detect results were reported at the RL. The analytical laboratory performed the appropriate sample cleanups to achieve the lowest possible detection limits.

The RLs and MDLs for clam tissue samples were lower than the risk-based ecological ACGs developed for intertidal clam tissue for all analytes. The RLs for several analytes were above human health ACGs as presented in Table 5-42, including mercury, thallium, 3 individual PAHs, BEHP, 20 other SVOCs, 6 individual Aroclors, and 12 pesticides. The MDLs for these analytes were also above human health ACGs for tissue, with the exception of mercury, thallium, benzo(a)anthracene, dibenzo(a,h) anthracene, indeno(1,2,3-cd)pyrene, 1,3-dichlorobenzene, 4-chloroaniline, and Aroclor 1016. All of these chemicals were identified in Appendix C of the QAPP as having target MDLs and/or RDLs above human health ACGs, with the exception of BEHP, Aroclor 1016, and 11 other SVOCs. RLs and MDLs were elevated because of analytical dilutions and/or analytical interferences.

Table 5-42. Number of RLs and MDLs above human health ACGs in intertidal clam and geoduck tissue

Analyte	Unit	No. of Detected Results	Range of Detected Results	No. of Non-Detected Results	Range of RLs for Non-Detected Results	No. of RLs > ACG	Range of MDLs for Non-Detected Results	No. of MDLs > ACG	Target RL	Target MDL	Human Health ACG
Metals											
Mercury	mg/kg ww	17	0.01 – 0.03	2	0.01	2	0.00099	0	0.01	0.005	0.0084
Thallium	mg/kg ww	0	nd	19	0.004 – 0.008	15	0.0001 – 0.0002	0	0.2	0.005	0.0059
PAHs											
Benzo(a)anthracene	µg/kg ww	14	3.0 – 47	6	0.92 – 1.6	2	0.16	0	0.50	0.16	1.1
Dibenzo(a,h)anthracene	µg/kg ww	12	0.11 – 8.5	8	0.18 –0.76	8	0.045	0	0.50	0.045	0.11
Indeno(1,2,3-cd)pyrene	µg/kg ww	18	0.33 – 45	2	1.1 – 1.5	1	0.10	0	0.50	0.10	1.1
Phthalates											
BEHP	µg/kg ww	0	nd	19	17 – 290	5	16 – 280	2	70 – 130	16	58
Other SVOCs											
1,3-Dichlorobenzene	µg/kg ww	0	nd	19	58 – 420	12	33 – 240	14	67	16	250
1,4-Dichlorobenzene	µg/kg ww	0	nd	19	58 – 420	19	36 – 260	14	67	14	34
2,4,6-Trichlorophenol	µg/kg ww	0	nd	19	290 – 2,100	19	160 – 1,100	14	330	65	73
2,4-Dichlorophenol	µg/kg ww	0	nd	19	290 – 2,100	19	170 – 1,200	14	330	120	250
2,4-Dinitrophenol	µg/kg ww	0	nd	19	580 – 4,200	19	310 – 2,200	14	670	110	170
2,4-Dinitrotoluene	µg/kg ww	0	nd	19	290 – 2,100	19	210 – 1,500	14	330	100	170
2,6-Dinitrotoluene	µg/kg ww	0	nd	19	290 – 2,100	19	260 – 1,900	14	330	110	84
3,3'-Dichlorobenzidine	µg/kg ww	0	nd	18	290 – 2,100	18	49 – 350	14	330	210	1.8
4-Chloroaniline	µg/kg ww	0	nd	18	290 – 2,100	14	35 – 250	14	330	200	340
Aniline	µg/kg ww	0	nd	18	58 – 420	13	58 – 420	14	67	67	140
Bis(2-chloroethyl)ether	µg/kg ww	0	nd	19	58 – 420	19	43 – 310	14	67	15	0.73
Bis(2-chloroisopropyl)ether	µg/kg ww	0	nd	19	58 – 420	19	30 – 210	14	67	15	0.73
Carbazole	µg/kg ww	0	nd	19	58 – 420	19	42 – 300	14	67	7.7	40
Hexachlorobenzene	µg/kg ww	0	nd	19	4.6 – 5.0	19	1.9 – 2.1	14	10	0.0042	0.5
Hexachloroethane	µg/kg ww	0	nd	19	5.0 – 300	10	5.0 – 250	10	67	16	58
Nitrobenzene	µg/kg ww	0	nd	19	58 – 420	19	42 – 300	14	67	14	42

Analyte	Unit	No. of Detected Results	Range of Detected Results	No. of Non-Detected Results	Range of RLs for Non-Detected Results	No. of RLs > ACG	Range of MDLs for Non-Detected Results	No. of MDLs > ACG	Target RL	Target MDL	Human Health ACG
n-Nitrosodimethylamine	µg/kg ww	0	nd	9	290 – 2,100	9	150 – 1,000	14	330	86	0.016
n-Nitroso-di-n-propylamine	µg/kg ww	0	nd	19	290 – 2,100	19	160 – 1,100	14	330	67	0.12
n-Nitrosodiphenylamine	µg/kg ww	0	nd	19	58 – 420	13	31 – 220	14	67	16	160
Pentachlorophenol	µg/kg ww	2	nd	17	4.0 – 1,400	2	2.5 – 9900	2	5.0	2.5	6.7
PCBs											
Aroclor 1016	µg/kg ww	0	nd	20	3.5 – 13	1	2.3 – 11	0	20	2.9	12
Aroclor 1221	µg/kg ww	0	nd	20	3.5 – 25	20	2.3 – 20	20	20	2.9	0.4
Aroclor 1232	µg/kg ww	0	nd	20	3.5 – 18	20	2.3 – 18	20	20	2.9	0.4
Aroclor 1242	µg/kg ww	0	nd	20	3.5 – 49	20	2.2 – 16	20	20	3.9	0.4
Aroclor 1248	µg/kg ww	0	nd	20	3.6 – 30	20	0.51 – 20	20	20	3.9	0.4
Aroclor 1254	µg/kg ww	18	8.0 – 42	2	9.9 – 11	2	3.0 – 4.2	2	20	3.9	0.4
Pesticides											
4,4'-DDD	µg/kg ww	0	nd	19	9.1 – 10	19	3.5 – 7.3	19	20	15	3.4
4,4'-DDE	µg/kg ww	0	nd	19	9.1 – 10	19	2.9 – 6.1	19	20	12	2.4
4,4'-DDT	µg/kg ww	0	nd	19	9.1 – 10	19	3.3 – 6.7	19	20	13	2.4
Aldrin	µg/kg ww	0	nd	19	4.6 – 5.0	19	1.6 – 2.8	19	10	5.7	0.048
Dieldrin	µg/kg ww	0	nd	19	9.1 – 10	19	2.6 – 6.0	19	20	12	0.05
alpha-BHC	µg/kg ww	0	nd	19	4.6 – 5.0	19	2.4 – 2.6	19	10	4.8	0.13
beta-BHC	µg/kg ww	0	nd	19	4.6 – 5.0	19	1.9 – 3.9	19	10	3.9	0.45
gamma-BHC	µg/kg ww	0	nd	19	4.6 – 5.0	19	1.6 – 2.5	19	10	5.0	0.62
Total chlordane	µg/kg ww	0	nd	19	9.1 – 10	19	1.5 – 10	9	100	60	2.3
Heptachlor	µg/kg ww	0	nd	19	4.6 – 5.0	19	1.7 – 2.8	19	10	5.6	0.18
Heptachlor epoxide	µg/kg ww	0	nd	19	4.6 – 5.0	19	2.0 – 2.8	19	10	5.1	0.089
Toxaphene	µg/kg ww	0	nd	19	460 – 500	19	460 – 500	19	1,000	1,000	0.73

ACG – analytical concentration goal
BEHP – bis(2-ethylhexyl) phthalate
BHC – benzene hexachloride
DDD – dichlorodiphenyldichloroethane
DDE – dichlorodiphenyldichloroethylene
DDT – dichlorodiphenyltrichloroethane
MDL – method detection limit
na – not applicable
nd – not detected
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyls
RL – reporting limit
SVOC – semivolatile organic compounds
tbd – to be determined
ww – wet weight

The RLs for co-located composite sediment samples were lower than the applicable SQS or SL, except for the results summarized in Table 5-43 for four individual PAHs, BBP, seven other SVOCs, dieldrin, and total DDT. All MDLs for these chemicals were below the associated SQS or SL.

All RLs for co-located sediment samples were lower than the risk-based ACGs developed for human health with direct exposure, with the following exceptions: ni-nitrosodimethylamine, n-nitroso-di-n-propylamine, Aroclor 1221, Aroclor 1232, Aroclor 1248, dieldrin, and toxaphene. All MDLs for these chemicals were below the ACGs for human health with direct exposure except for n-nitrosodimethylamine, which is known to be difficult to quantify in sediment and was identified in the QAPP as having a target MDL greater than the ACG. These chemicals and the human health ACGs are presented in Table 5-44.

All RLs and MDLs for co-located sediment samples were lower than the risk-based ACGs developed for human health with indirect exposure, with the exception of the non-detected results listed in Table 5-45. These chemicals were identified in Appendix D of the QAPP (Windward 2009a) as having target RLs and MDLs above the ACGs for human health with indirect exposure, with the exception of the results for cadmium, tributyltin, four individual Aroclors, 2,4-DDT, total DDTs, aldrin, dieldrin, and heptachlor. All MDLs for mercury, 2,4-dichlorodiphenyldichloroethane (DDD), and 4,4-DDD were lower than the ACGs for human health with indirect exposure.

Table 5-43. Number of RLs and MDLs above the benthic ACGs in composite sediment samples co-located with intertidal clam tissue samples

Analyte	Unit	No. of Detected Results	Range of Detected Results	No. of Non-Detected Results	Range of RLs for Non-Detected Results	No. of RLs > ACG	Range of MDLs for Non-Detected Results	No. of MDLs > ACG	Target RL	Target MDL	Benthic Invertebrate ACG[a]
PAHs											
2-Methylnaphthalene	mg/kg OC	0	nd	4	19 – 59	3	0.75 – 2.4	0	na[b]	na[b]	38
Acenaphthene	mg/kg OC	2	42 – 72	2	19 – 58	2	1.1 – 2.4	0	na[b]	na[b]	16
Dibenzofuran	mg/kg OC	1	42	3	19 – 59	3	0.86 – 2.2	0	na[b]	na[b]	15
Fluorene	mg/kg OC	2	35 – 61	2	19 – 58	1	1.2 – 2.6	0	na[b]	na[b]	23
Phthalates											
BBP	mg/kg OC	1	25	3	15 – 45	3	0.43 – 1.1	0	na[b]	na[b]	4.9
Other SVOCs											
1,2,4-Trichlorobenzene	mg/kg OC	0	nd	4	6.0 – 18	4	0.063 – 0.59	0	na[b]	na[b]	0.81
1,2-Dichlorobenzene	mg/kg OC	0	nd	4	6.0 – 18	4	0.038 – 0.37	0	na[b]	na[b]	2.3
1,4-Dichlorobenzene	mg/kg OC	1	18	3	6.0 – 18	3	0.063 – 0.60	0	na[b]	na[b]	3.1
Benzyl alcohol	µg/kg dw	0	nd	4	19 – 59	3	14 – 43	0	20	15	57
Hexachlorobenzene	mg/kg OC	0	nd	4	0.95 – 4.8	4	0.014 – 0.090	0	na[b]	na[b]	0.38
Hexachlorobutadiene	mg/kg OC	0	nd	4	0.95 – 4.8	1	0.016 – 0.098	0	na[b]	na[b]	3.9
n-Nitrosodiphenylamine	mg/kg OC	0	nd	4	6.0 – 18	2	0.085 – 0.83	0	na[b]	na[b]	11
Pesticides											
Total DDTs	µg/kg dw	0	nd	4	1.9 – 9.9	2	0.96 – 4.9	0	2.0	1.3	6.9
Dieldrin	µg/kg dw	0	nd	4	1.9 – 57	1	0.80 – 4.1	0	2.0	0.84	10

[a] In Appendix D of the QAPP, the OC-normalized ACGs were converted to dry weight for comparison to dry weight RLs and MDLs using an OC content of 0.5%. In the comparison presented in this table, the RLs and MDLs were converted to OC-normalized values using sample-specific TOC contents for comparison to OC-normalized ACGs.

[b] The target RLs and MDLs presented in the QAPP are dry weight values.

ACG – analytical concentration goal
BBP – butyl benzyl phthalate
DDT – dichloro-diphenyl-trichloroethane
dw – dry weight
MDL – method detection limit
na – not applicable
OC – organic carbon
QAPP – quality assurance project plan
PAH – polycyclic aromatic hydrocarbon
RL – reporting limit
TOC – total organic carbon

Table 5-44. Number of RLs and MDLs above the human health ACGs for direct exposure in composite sediment samples co-located with intertidal clam tissue samples

Analyte	Unit	No. of Detected Results	Range of Detected Results	No. of Non-Detected Results	Range of RLs for Non-Detected Results	No. of RLs > ACG	Range of MDLs for Non-Detected Results	No. of MDLs > ACG	Target RL	Target MDL	Human Health ACG with Direct Exposure
Other SVOCs											
n-Nitrosodimethylamine	µg/kg dw	0	nd	5	30 – 150	5	21 – 110	5	33	24	2.3
n-Nitroso-di-n-propylamine	µg/kg dw	0	nd	5	30 – 150	3	2.4 – 12	0	33	2.7	69
PCBs											
Aroclor 1221	µg/kg dw	0	nd	5	3.9 – 270	1	3.9 – 90	0	4.0	1.3	170
Aroclor 1232	µg/kg dw	0	nd	5	3.9 – 270	1	3.9 – 90	0	4.0	1.3	170
Aroclor 1248	µg/kg dw	2	190 – 250	3	3.9 – 270	1	3.9 – 90	0	4.0	2.8	220
Pesticides											
Dieldrin	µg/kg dw	0	nd	5	1.9 – 57	1	0.80 – 4.1	0	2.0	0.84	30
Toxaphene	µg/kg dw	0	nd	5	95 – 480	1	46 – 230	0	100	48	440

ACG – analytical concentration goal

dw – dry weight

MDL – method detection limit

na – not applicable

PCB – polychlorinated biphenyl

RL – reporting limit

SVOC – semivolatile organic compound

Table 5-45. Number of RLs and MDLs above the human health ACGs for indirect exposure in composite sediment samples co-located with intertidal clam tissue samples

Analyte	Unit	No. of Detected Results	Range of Detected Results	No. of Non-Detected Results	Range of RLs for Non-Detected Results	No. of RLs > ACG	Range of MDLs for Non-Detected Results	No. of MDLs > ACG	Target RL	Target MDL	Human Health ACG with Indirect Exposure
Metals											
Cadmium	mg/kg dw	3	0.3 – 1.6	2	0.3 – 0.7	2	0.025 – 0.065	2	0.2	0.016	0.003
Mercury	mg/kg dw	3	0.08 – 0.23	2	0.05 – 0.06	2	0.0052 – 0.0057	0	0.05	0.005	0.016
Organometals											
Tributyltin as ion	µg/kg dw	4	10 – 85	1	3.4	1	1.6	1	4.0	1.2	0.28
PCBs											
Aroclor 1016	µg/kg dw	0	nd	5	3.9 – 270	4	3.9 – 90	3	4.0	1.3	6.1
Aroclor 1221	µg/kg dw	0	nd	5	3.9 – 270	5	3.9 – 90	5	4.0	1.3	0.21
Aroclor 1232	µg/kg dw	0	nd	5	3.9 – 270	5	3.9 – 90	5	4.0	1.3	0.21
Aroclor 1242	µg/kg dw	1	440	4	3.9 – 35	4	3.9 – 12	4	4.0	2.8	0.21
Aroclor 1248	µg/kg dw	2	190 – 250	3	3.9 – 270	3	3.9 – 90	3	4.0	2.8	0.21
Pesticides											
2,4'-DDD	µg/kg dw	0	nd	5	1.9 – 9.7	1	1.2 – 6	0	2.0	1.2	8.3
2,4'-DDE	µg/kg dw	0	nd	5	1.9 – 9.7	1	0.89 – 4.5	1	2.0	0.93	2.6
2,4'-DDT	µg/kg dw	0	nd	5	1.9 – 9.7	5	0.96 – 4.9	5	2.0	1.0	0.92
4,4'-DDD	µg/kg dw	0	nd	5	1.9 – 11	3	1.2 – 6.2	0	2.0	1.3	8.3
4,4'-DDE	µg/kg dw	0	nd	5	1.9 – 9.9	2	1.1 – 5.6	1	2.0	1.2	2.6
4,4'-DDT	µg/kg dw	0	nd	5	1.9 – 9.7	5	0.84 – 4.3	1	2.0	0.88	0.92
Total DDTs	µg/kg dw	0	nd	5	1.9 – 11	5	0.96 – 4.9	5	2.0	1.3	0.92
Aldrin	µg/kg dw	0	nd	5	0.95 – 4.8	5	0.46 – 2.3	5	1.0	0.48	0.063
Dieldrin	µg/kg dw	0	nd	5	1.9 – 57	5	0.8 – 4.1	5	2.0	0.84	0.033
beta-BHC	µg/kg dw	0	nd	5	0.95 – 4.8	5	0.37 – 1.9	1	1.0	0.39	0.63
gamma-BHC	µg/kg dw	0	nd	5	0.95 – 4.8	5	0.47 – 2.4	1	1.0	0.49	0.83

Analyte	Unit	No. of Detected Results	Range of Detected Results	No. of Non-Detected Results	Range of RLs for Non-Detected Results	No. of RLs > ACG	Range of MDLs for Non-Detected Results	No. of MDLs > ACG	Target RL	Target MDL	Human Health ACG with Indirect Exposure
Total chlordane	µg/kg dw	0	nd	5	1.9 – 9.7	5	0.91 – 5	1	2.0	1.0	1.7
Heptachlor	µg/kg dw	0	nd	5	0.95 – 4.8	5	0.39 – 2	5	1.0	0.4	0.25

ACG – analytical concentration goal

BHC – benzene hexachloride

DDD – dichlorodiphenyldichloroethane

DDE – dichlorodiphenyldichloroethylene

DDT – dichlorodiphenyltrichloroethane

dw – dry weight

MDL – method detection limit

na – not applicable

PAH – polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

RL – reporting limit

5.2 DATA VALIDATION RESULTS

The analyses of the intertidal clam composite tissue, co-located clam composite sediment, and geoduck tissue samples were conducted using the sample delivery group (SDG) assignments designated by the laboratories listed in Table 5-46. Analyses were conducted on a tiered analysis plan in order of analytical priority because of limited sample volume; therefore, multiple SDGs were assigned.

Table 5-46. SDGs of intertidal clam tissue, geoduck tissue, and sediment samples co-located with intertidal clam tissue samples

SDG	Laboratory	Matrix	No. of Samples	Analyses
NQ27	ARI	intertidal clam tissue	10	SVOCs, pesticides, butyltins, total mercury, lipids, total solids
NR74	ARI	co-located sediment	5	SVOCs, selected SVOCs by SIM, pesticides, PCBs (as Aroclors), butyltins, total metals including mercury, total solids, TOC, grain size
NV39	ARI	co-located sediment	1	total metals (confirmation analysis)
OF25	ARI	intertidal clam tissue	4	total metals including mercury, lipids, total solids
OO20	ARI	intertidal clam tissue	6	total metals
OP97	ARI	geoduck tissue	9	SVOCs, pesticides, PCB Aroclors, butyltins, total metals including mercury, lipids, total solids
PH47	ARI	intertidal clam tissue	10	low-level BEHP and PCP
PL54	ARI	geoduck tissue	7	low-level BEHP and PCP
K0900409	CAS	intertidal clam tissue	1	PCBs (as Aroclors)
K0901208	CAS	intertidal clam tissue	11	PCBs (as Aroclors)
K0906647	CAS	intertidal clam tissue	11	low-level PAHs
K0907713	CAS	geoduck tissue	9	low-level PAHs
0839004	Brooks Rand Labs	intertidal clam tissue	3	total and inorganic arsenic, total selenium
0908018	Brooks Rand Labs	intertidal clam tissue	7	total and inorganic arsenic
0911010	Brooks Rand Labs	geoduck tissue	9	total and inorganic arsenic
0902011	Brooks Rand Labs	intertidal clam tissue	2	total and inorganic arsenic

ARI – Analytical Resources, Inc.
BEHP – bis(2-ethylhexyl) phthalate
CAS – Columbia Analytical Services, Inc.
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
PCP – pentachlorophenol
SDG – sample delivery group
SIM – selective ion monitoring
SVOC – semivolatile organic compound
TOC – total organic carbon

Independent data validation was performed on all results by EcoChem. A minimum of one SDG per analysis underwent full-level data validation; the rest of the results underwent summary-level data validation. The data validation included a review of all QC summary forms, including initial calibration, continuing calibration verification (CCV), internal standard, surrogate, laboratory control sample (LCS), laboratory control sample duplicate (LCSD), matrix spike (MS), matrix spike duplicate (MSD), and interference check sample summary forms. The majority of the data did not require qualification or were qualified with a J, indicating an estimated value. Twenty-three results for nine chemicals were rejected as a result of data validation. Rejected results will not be used for any purpose. Based on the information reviewed, the overall data quality was considered acceptable for all uses, as qualified. Issues that resulted in the qualification of data are summarized below. Detailed information regarding every qualified sample is presented in Appendix D.

- Ten results for n-nitrosodimethylamine in intertidal clam composite tissue samples and five results for benzyl alcohol in co-located clam composite sediment samples were rejected because of extremely low LCS and MS/MSD recoveries (less than 10%). These chemicals are known to be difficult to quantify, so reanalyses were not performed.
- Results for the following chemicals were rejected because of extremely low MS/MSD recoveries (less than 10%): 2 results for endrin aldehyde, one in an intertidal clam composite tissue sample and one in a co-located clam composite sediment sample; 1 result for hexachlorocyclopentadiene in an intertidal clam composite tissue sample; and 1 result each for 3,3-dichlorobenzidine, 3-nitroaniline, 4-chloroaniline, 4-nitroaniline, aniline in a geoduck edible meat tissue sample. LCS recoveries were acceptable so reanalyses were not performed.
- Several results from the low-level analyses for BEHP and PAHs were U-qualified as non-detect because of method blank contamination, including the following: 17 results for naphthalene; 10 results for 2-methylnapththalene and BEHP; 9 results for 1-methylnapthalene; 8 results for acenaphthene and dibenzo(a,h,)anthracene, 6 results for benzo(a)anthracene, chrysene, fluoranthene, and pyrene; 2 results for indeno(1,2,3-cd)pyrene; and 1 result for benzo(g,h,i)perylene.
- Results for various chemicals were qualified as estimated (J or UJ) because MS/MSD, LCS/LCSD, CCV, surrogate or contract-required detection limit standard recoveries or relative percent differences (RPDs) were outside of control limits. Results qualified as estimated include the following: 13 results for silver; 10 results for benzoic acid; 9 results each for endrin aldehyde and 1,2,4-trichlorobenzene; 6 results for TOC; 5 results each for antimony, copper, arsenic, nitrobenzene, 2,4-methylphenol, aniline, and hexachlorobutadiene; 4 results for PCP; and 1 result each for alpha-benzene hexachloride (BHC), beta-BHC, alpha-endosulfan, gamma chlordane, Aroclor 1260, 4-chloroaniline, butylbenzyphthalate, dimethylphthalate, monobutyltin, and dibutyltin.

- The RPDs between the results of dual-column analyses for Aroclor 1254 in four samples and Aroclor 1260 in five samples were greater than the control limit of ±40% and less than ±60%. These results were J-qualified to indicate estimated concentrations. The dual-column RPDs for Aroclor 1260 in sample EW-09-MY-M-comp1 and Aroclor 1254 in sample EW-S01-GD02 were greater than ±60% and were requalified as estimated with tentative identification (JN).
- When more than one Aroclor is present in a sample, the potential exists for a high bias from the contribution of one Aroclor to another caused by common peaks or peaks that cannot be completely resolved. Analytical peaks are selected, and Aroclor identification is made based on the best resolution possible for that particular sample. Reported Aroclor concentrations were reported based on the individual Aroclors that provided the best match to the observed sample pattern. RLs for 24 individual Aroclor or pesticide results were Y-qualified by the laboratory as non-detects at elevated RLs because of overlapping Aroclor patterns. The Y-qualifier indicated that chromatographic interference in the sample prevented adequate resolution of the compound at the standard RLs. Seven BEHP results in tissue samples were also Y-flagged with elevated RLs because of analytical interferences.

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