Quality Assurance Project Plan

Ostrich Bay Sediment Toxicity Evaluation

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December 2004

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Approvals

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Abstract

Sediment from twelve stations in Ostrich Bay will be evaluated for compliance with the Washington State Sediment Management Standards. Four bioassays will be used to test the sediments for toxicity: amphipod, marine larva, juvenile polychaete (*Neanthes*) and Microtox®. Previous testing in 1994 and 1997 showed widespread toxicity in the bay and a former Naval ammunition depot is known to have polluted it with munitions chemicals, metals, and other chemicals during operations from 1904 to 1959.

Sediment to be collected for toxicity testing will also be analyzed for chemical pollutants. These include mercury and other priority pollutant metals, semivolatile organic compounds, and munitions chemicals (nitroaromatics, nitramines, and perchlorate). Testing will also be conducted for sulfides, which can have a natural or anthropogenic origin and can contribute to sediment toxicity.

Results from this study will be used by the Department of Ecology Toxic Cleanup Program's Sediment Management Unit to assist in making sediment cleanup decisions for Ostrich Bay.

Background

Ostrich Bay is part of the complex system of Puget Sound embayments and channels near the city of Bremerton (Figure 1). The bay connects with Dyes Inlet to the north and with Oyster Bay to the south. It is a relatively small (about 1.2 miles long and 0.5 mile wide) and shallow embayment (generally -20 to -30 ft MLLW). The maximum depth is about 45 feet.

On the west shore, a former Naval ammunition depot discharged ordnance (munitions) chemicals, metals, and other organic chemicals into the bay during operations from 1904 to 1959 (EPA, 1994). Sediment contamination in the bay has subsequently been investigated in a number of studies including a Remedial Investigation conducted by the US Navy in 1994-1997 (URS, 1994; EA, 1998a,b).

Regulatory standards for sediment contamination in Puget Sound have been established in Washington State's Sediment Management Standards (SMS), Chapter 173-204 WAC. The SMS establishes two levels for sediment quality, the Sediment Quality Standards (SQS) and the Cleanup Screening Levels (CSL).

Cleanup Screening Levels are "minor adverse effects" levels, used as an upper regulatory level for source control and as minimum cleanup levels. SMS sets criteria for CSLs based on bioassay testing. It also sets numerical CSLs based on chemical concentrations for some substances. Of the two approaches, biological effects CSLs have precedence over chemistry, and exceedance of a numerical CSL can be overridden by a demonstration that biological effects criteria are not exceeded. Similarly, a finding of no exceedances, based on chemical criteria, can be overridden by a demonstration of biological effects exceedances.

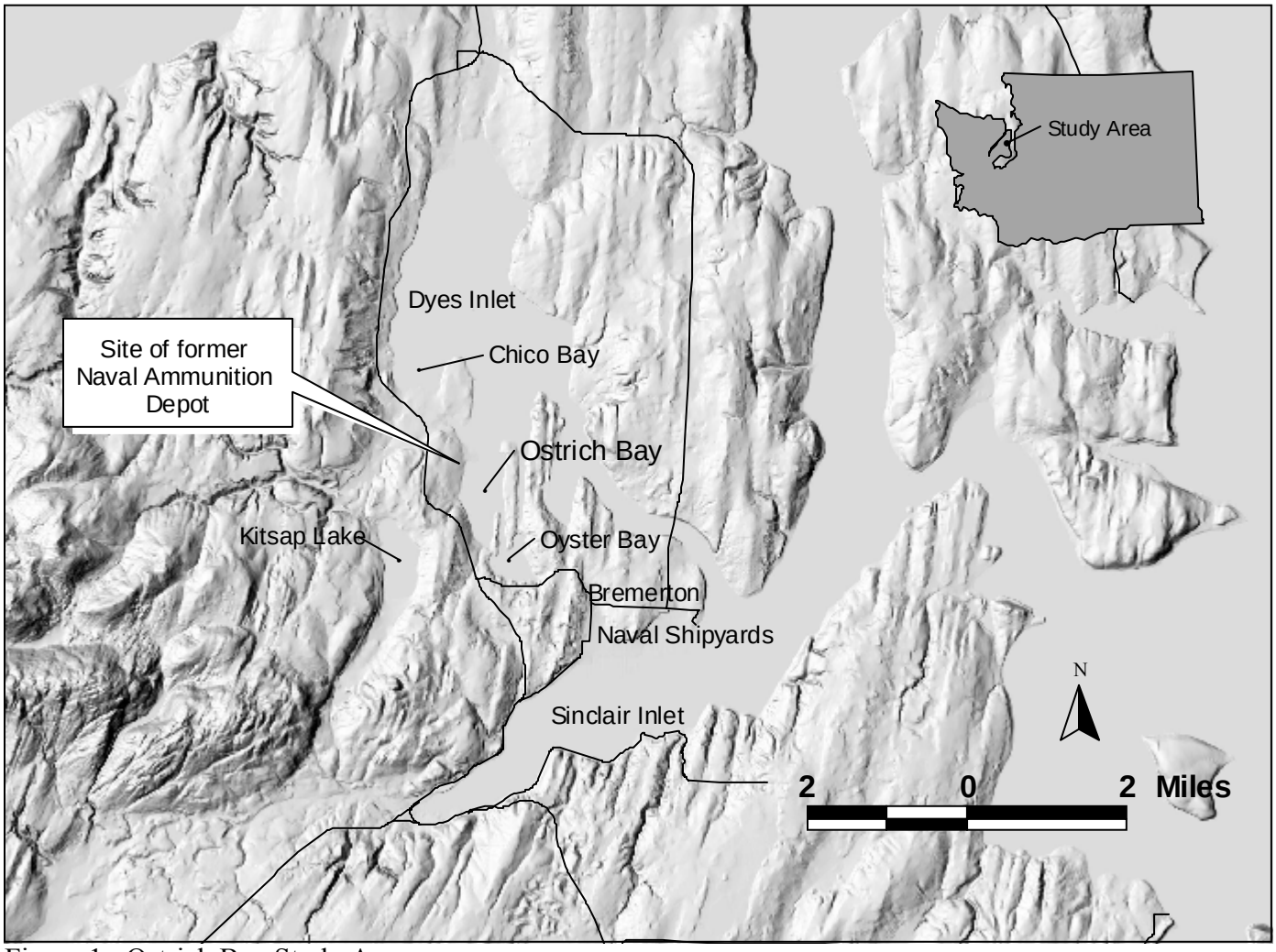

Figure 1: Ostrich Bay Study Area.

Sediment Quality Standards are "no adverse biological effects" levels and are used as a sediment quality goal for Washington State sediments. Although a single SQS exceedance at a sediment location does not represent a CSL exceedance, SMS imposes a limit by specifying that a location exceeding more than one SQS constitutes a CSL exceedance. A more detailed description of the sediment quality evaluation procedures is provided in Ecology (2003).

Ostrich Bay sediments tested in 1994 exceeded one or more bioassay CSLs at most sampling locations during Phase II of the Navy Remedial Investigation (Figure 2). Sampling in 1997 gave similar results during a Remedial Investigation Treatability Study (Figure 3). The 1997 sampling included retesting at some of the same locations sampled in 1994 ("300" series locations). Note that the locations of identically numbered stations in Figures 2 and 3 are close, but not identical, due to variability in field positioning. The "400" series stations in Figure 3 are new locations not sampled in 1994.

Chemical contaminants found in Ostrich Bay sediments include metals (e.g., cadmium, silver, and mercury), semivolatile organic compounds, and a variety of nitroaromatic and other ordnance compounds. Several problems were encountered in previous chemical analyses of these sediments (EA, 1998a). All Phase I Remedial Investigation ordnance data were rejected due to difficulty in interpreting results from gas chromatography/electron capture detection methods. This method will not be used in the present study. A better technique (EPA Method 8330) which relies on high performance liquid chromatography (HPLC) using a UV detector is available and will be employed in this study. Picric acid (an ordnance compound) was successfully analyzed using HPLC in the Phase I Remedial Investigation and was detected in three sediment samples. Problems were also encountered in the analyses for nitroaromatic and ordnance compounds during the Remedial Investigation Treatability Study. Some of these were related to the sample quality (low percent solid content, handling procedures) while others were related to analytical problems. However, there is no information to suggest that there were systemic problems that should be anticipated in planning future sampling, with one exception. Total Sulfide data were qualified as unusable in the treatability study due to exceedance of a seven-day holding time without preservation (EA, 1998b). The need for preservative to allow a longer holding time has been recognized in the present sampling plan.

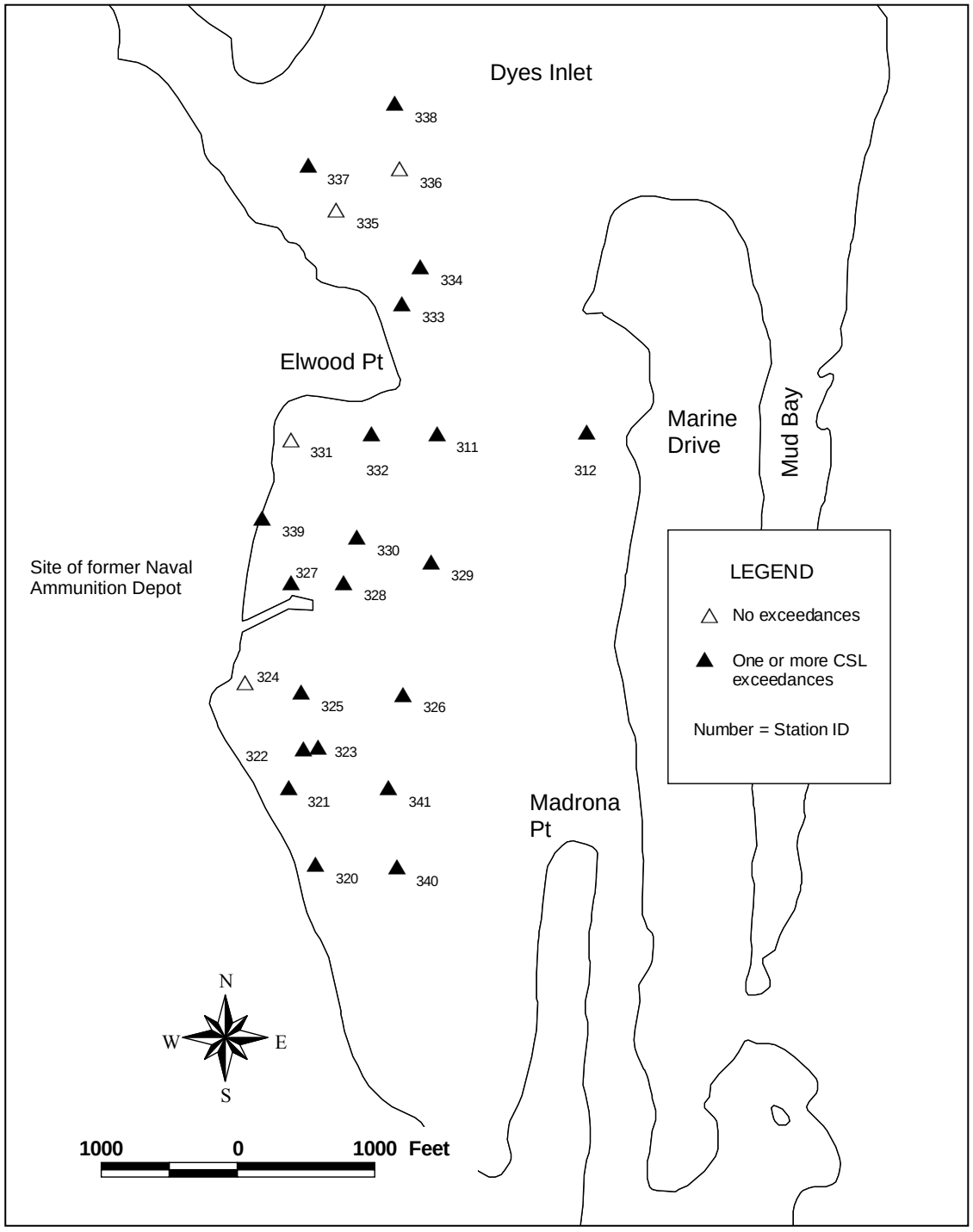

Figure 2: Exceedances of Bioassay Cleanup Screening Levels (CSLs) in 1994 Sediment Investigation of Ostrich Bay (Phase II Remedial Investigation).

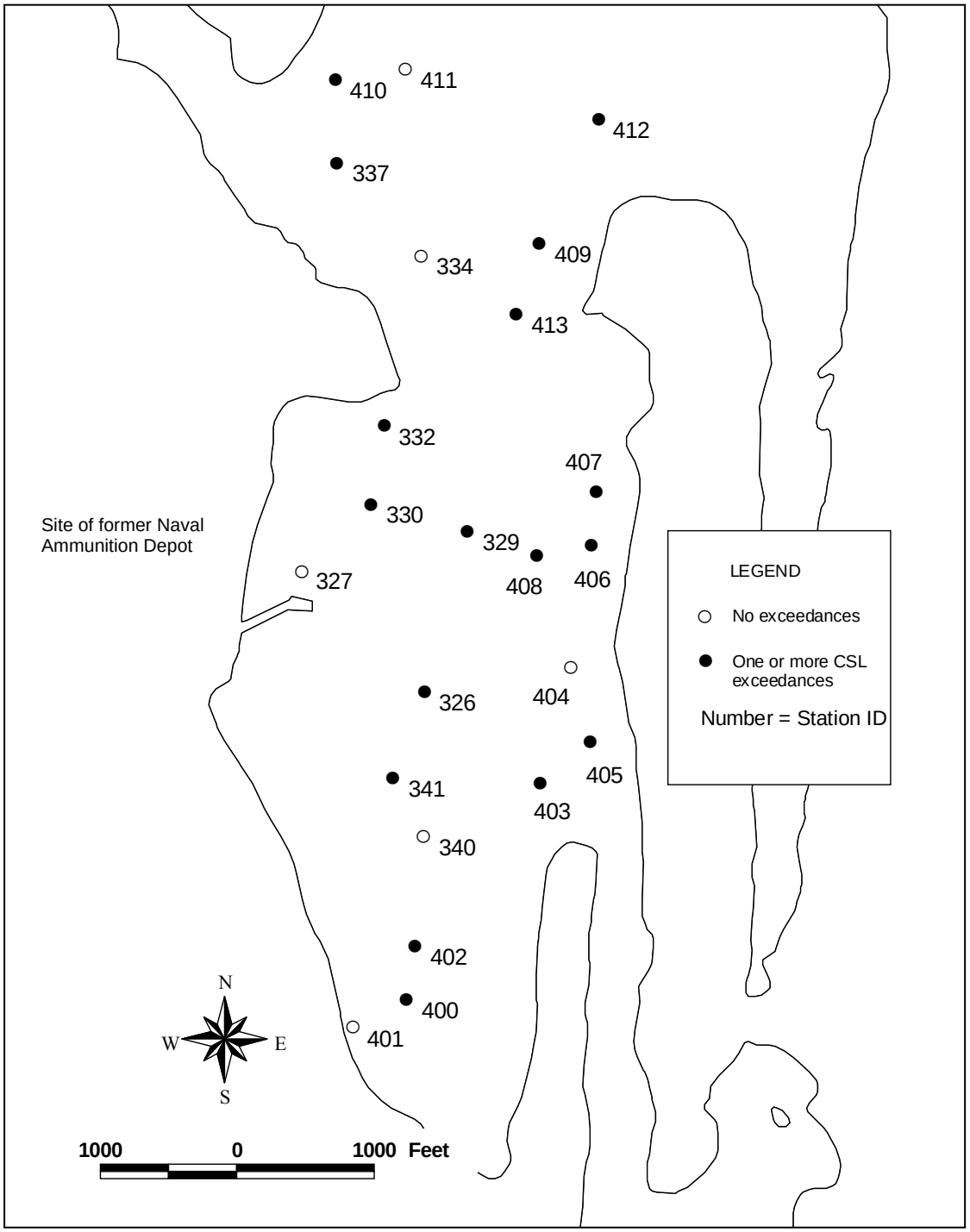

Figure 3: Exceedances of Bioassay Cleanup Screening Levels (CSLs) in 1997 Sediment Investigation of Ostrich Bay (Remedial Investigation Treatability Study).

Project Description

The goal of this project is to conduct an evaluation of sediment contamination in Ostrich Bay requested by the Washington Department of Ecology Sediment Management Unit to make cleanup decisions. The project will address the questions of whether current conditions have changed since earlier investigations were conducted, and whether sediment quality in Ostrich Bay currently meets regulatory standards.

The primary objective of this project is to establish whether sediment samples meet Sediment Management Standards for toxicity. A secondary objective is to characterize the chemical contaminants in the samples. The samples will be analyzed for primary pollutant metals, semivolatile organic compounds (Base/Neutral/Acids (BNA) Semivolatiles), and ordnance compounds (nitroaromatics, nitramines and perchlorate). Testing will also be conducted for sulfides, which can have a natural or anthropogenic origin and can contribute to sediment toxicity.

Sampling will be conducted throughout Ostrich Bay, with a preference for locations that have previously been tested to facilitate comparisons with data from earlier investigations. In addition, locations will be included that are representative of areas most likely to contain any residual contamination.

Sediment samples will be obtained using a grab sampler operated from Ecology's R.V. *Skookum*. At each sampling location, 3-5 grab samples will be collected for use in bioassay toxicity testing, chemistry analysis, and characterization of physical properties, such as grain size. Because munitions associated with the former Naval ammunition depot have previously been recovered from Ostrich Bay, a field safety officer will be present during sampling to assume responsibility if any unexploded ordnance is recovered in a grab sample.

Organization and Schedule

Participants in this study are listed below:

Project Manager	Nigel Blakley (360) 407-6770	Project management, Quality Assurance (QA) Project Plan, and report.
Project Assistant	Erika Wittmann (360) 407-6530	Assist with project planning, QA Project Plan, and sampling.
Client (TCP-HQ)	Ted Benson (360) 407-6683	Selection of sampling locations, review QA Project Plan and report, assist with collection of grab samples.
TSU Supervisor	Dale Norton (360) 407-6765	Project review, boat operator, supervise collection of grab samples.
Field Safety Officer	Greg Johnson (360) 407-6487	Ordnance recovery safety, assist with collection of grab samples.
Bioassays	Pam Covey (360) 871-8827	Laboratory contract.
Organics Analysis	John Weakland (360) 871-8820	Assistance in QA Project Plan preparation, data review.
Lab Quality Assurance	Karin Feddersen (360) 871-8829	Assistance in QA Project Plan preparation, data review.
EIM Data Entry	Carolyn Lee (360) 407-6430	Data entry.

Schedule and Budget

Field Sample Collection	October 2004
Laboratory Analysis Complete	December 2004
Draft Report	June 2005
Final Report	August 2005
EIM Data Entry	June 2005
Data Transfer to SEDQUAL	June 2005

Summary of Estimated Laboratory Cost (FY04)*

Analysis	# Samples	# QA Samples	Total	Unit Cost	Subtotal
Conventionals					
Percent solids	13		13	$10	$130
Grain size	13	1	14	$100	$1,400
Total Organic Carbon	13	1	14	$39	$546
Metals					
Priority pollutant metals	13	1	14	$185	$2,590
Organics					
BNAs (no TICs)	13		13	$325	$4,225
Ordnance compounds					
EPA Method 8330	13	2	15	$175	$2,625
EPA Method 314.0	13	2	15	$100	$1,500
Toxicity					
Amphipod bioassay	13		13	$600	$7,800
Larval bioassay	13		13	$480	$6,240
Neanthes bioassay	13		13	$680	$8,840
Pore water ammonia and sulfides	13		13	$30	$390
Microtox bioassay	13		13	$250	$3,250
Other					
Total sulfides	13	1	14	$40	$560
				Subtotal	$40,096
				Contracting fee	$10,024
				TOTAL	$50,120

* Includes field QA samples and is based on 50% discount rate for analysis at Manchester Environmental Laboratory (MEL).

Quality Objectives

Quality Assurance/Quality Control (QA/QC) requirements for the biological tests included in this investigation are specified in the Sediment Sampling and Analysis Plan Appendix, Section 7.2 and Table 14 (Ecology, 2003).

For all other analyses (conventional and chemical analytes), the Measurement Quality Objectives are the lowest concentrations (or values) of interest listed in Table 1. These are set at the Practical Quantitation Limits (PQLs, more commonly known as Estimated Quantitation Limits or EQLs) listed in Ecology (2003), which notes that achievement of these values will generally allow comparison with the numerical SQS and CSL for sediments with a normal range of TOC values. The analytes detected in Ostrich Bay sediments in the Navy Remedial Investigation and a subsequent USGS study (Carr et al., 2001) are of primary interest. These are identified in Table 1, together with the ranges in previously reported results.

Table 2 lists the QC samples for this investigation and shows how the information from these samples will be used. Because of the importance of grain size for bioassay test interpretation, the objective for a triplicate analysis of grain size is an RSD ≤ 20 % as recommended in the Sediment Sampling and Analysis Plan Appendix (Ecology, 2003). The remaining criteria listed in the table will be used for comparison in reporting the results from this investigation but do not represent thresholds for data acceptability.

Table 1: Method Quality Objectives (Lowest Concentrations of Interest) for this Study and Summary of Results from Previous Ostrich Bay Sampling.

Analyte	MQO	Previously Detected in Ostrich Bay Sampling	Range of Previous Reported Results
Metals	**(mg/kg dry weight)**		**(mg/kg dry weight)**
Antimony	50		
Arsenic	19	X	2 - 13
Cadmium	1.7	X	0.5 - 16
Chromium	87	X	18 - 52
Copper	130	X	5 - 67
Lead	150	X	7 - 51
Mercury	0.14	X	0.2 - 0.9
Nickel	47	X	20 - 58
Silver	2	X	≤10
Zinc	137	X	26 - 129
Nonionizable Organic Compounds	**(ug/kg dry weight)**		**(ug/kg dry weight)**
LPAH Compounds			
Naphthalene	700	X[a]	>34
Acenaphthylene	433	X	31 - 31
Acenaphthene	167	X[a]	>6.7
Fluorene	180	X[a]	>21
Phenanthrene	500	X	30 - 470
Anthracene	320	X	14 - 62
2-Methylnaphthalene	223	X[a]	>20
HPAH Compounds			
Fluoranthene	567	X	20 - 1100
Pyrene	867	X	16 - 680
Benz[a]anthracene	433	X	23 - 200
Chrysene	467	X	19 - 3000
Total benzofluoranthenes	1067	X	33 - 720
Benzo[a]pyrene	533	X	33 - 230
Indeno[1,2,3-cd]pyrene	200	X	22 - 110
Dibenzo[a,h]anthracene	77	X[a]	>6
Benzo[ghi]perylene	223	X	27 - 91
Chlorinated Benzenes	**(ug/kg dry weight)**		
1,2-Dichlorobenzene	35		
1,3-Dichlorobenzene	57		
1,4-Dichlorobenzene	37		

Analyte	MQO	Previously Detected in Ostrich Bay Sampling	Range of Previous Reported Results
1,2,4-Trichlorobenzene	31		
Hexachlorobenzene	22		
Phthalate Esters	**(ug/kg dry weight)**		**(ug/kg dry weight)**
Dimethyl phthalate	24		
Diethyl phthalate	67		
Di-n-butyl phthalate	467	X	14 - 24
Butyl benzyl phthalate	21		
Bis[2-ethylhexyl]phthalate	433	X	41 - 800
Di-n-octyl phthalate	2067		
Miscellaneous Extractable Compounds	**(ug/kg dry weight)**		
Dibenzofuran	180		
Hexachlorobutadiene	11		
Hexachloroethane	47		
N-nitrosodiphenylamine	28		
Ionizable Organic Compounds	**(ug/kg dry weight)**		
Phenol	140	X	580 - 2000
2-Methylphenol	63		
4-Methylphenol	223	X	58 - 600
2,4-Dimethylphenol	29		
Pentachlorophenol	120		
Benzyl alcohol	57		
Benzoic acid	217	X	0.094 - 0.16
Site Specific Compounds	**(ug/kg dry weight)**		
Explosive compounds[b]	250	X	2 - 3500
Conventional Sediment Variables			
Grain size	1%	X	2% - 95% fines
Total solids	0.1% (wet wt.)	X	
Total organic carbon (TOC)	0.1%	X	0.8% - 4%
Total sulfides	10 mg/kg	X	25-250 mg/kg[c]

Notes:
An additional Method Quality Objective for grain size is listed in Table 2.
Lowest concentrations of interest are set at the PQL values from Ecology (2003), Table 5.

[a] Reported in Carr et al. (2001) but not in Remedial Investigation reports.

[b] The following nitroaromatic and ordnance compounds were detected in the Phase II Remedial Investigation: 1,3-dinitrobenze; 2,4,6-trinitrotoluene; 2,4-dinitrotoluene; 2,6-dinitrotoluene; 2-amino-4,6-dinitrotoluene; *m*-nitrotoluene; *p*-nitrotoluene; nitrobenzene; picramic acid; picric acid; tetryl.

[c] All sulfide data were qualified as unusable during data validation due to exceedance of holding time without preservative.

Table 2: Quality Control Samples and Evaluation Benchmarks for Project Report.

	Field Duplicates[1]		Method Blank		Analytical Replicates[2]		Laboratory Control Sample[3]		Matrix Spike and Matrix Spike Duplicate	
Parameter	**Number**	**Evaluation**	**Number**	**Evaluation**	**Number**	**Evaluation**	**Number**	**Evaluation**	**Number**	**Evaluation**
Grain size	1	See footnote 4	--		1 triplicate analysis[5]	Method Quality Objective: RSD ≤ 20 %[5]	--		--	
TOC	1		1/batch	Analyte concentration < PQL[6]	1 triplicate analysis[5]	RSD ≤ 20 %[5]	--		--	
BNAs	--		1/batch	Analyte concentration < PQL[6]	1 duplicate analysis per batch[7]	RPD ≤ 35 % applied when the analyte concentration is > PQL[7]	--		--	
Priority pollutant metals	1	See footnote 4	1/batch	Analyte concentration < PQL[6]	1 duplicate analysis per batch[8]	RPD ≤ 20 % applied when the analyte concentration is > PQL[8]	1	80– 20 % recovery, or performance based intralaboratory control limits, whichever is lower[8]	--	
Nitroaromatics, nitramines[9]	--		1/batch	Analyte concentration < EQL[10]			1/batch	120-60% recovery[11]	1	120-60% recovery and RPD ≤ 30 %[11]
Perchlorate[12]	--		1/batch	Analyte concentration < 2.0 µ/L[13]	1 duplicate analysis per batch[14]	RPD ≤ 15 %[14]	--		1	120-80% recovery and RPD ≤ 15 %[14]
Total Sulfides	--		1/batch	Analyte concentration < PQL[6]	1 triplicate analysis[5]	RSD ≤ 20 %[5]	1/batch	135-65% recovery[13]	1 (MS only)	135-65% recovery[13]

Notes:
RPD Relative percent difference.
RSD Relative standard deviation.

[1] Field duplicates: Independent samples that are collected as close as possible to the same point in space and time. They are two separate samples, stored in separate containers, and analyzed independently.
[2] Synonymous with Laboratory Replicates or, if applicable, Laboratory Duplicates.
[3] A known matrix spiked with analytes representative of the target analytes used to document laboratory performance. A Fortified Blank or a commercially available Certified Reference Material containing the analytes of interest may be used.
[4] Variation between field duplicates at one station will be compared with variation among 1994, 1997, and 2004 data for that station. This evaluation evaluates the magnitude of between-year variability relative to between-duplicate variability. (A high value suggests temporal changes are meaningful.)
[5] Source: Sediment Sampling and Analysis Plan Appendix (Ecology, 2003), Table 13.
[6] Source: Sediment Sampling and Analysis Plan Appendix (Ecology, 2003), Table 11 (Organics) and Table 12 (Metals). Recommended PQLs for many analytes are provided in Table 5. Alternatively, the Method Detection Limit (MDL) may be used for this evaluation. [The PQL is also known as the EQL (Estimated Quantitation Limit).]
[7] Source: Sediment Sampling and Analysis Plan Appendix (Ecology, 2003), Table 11.
[8] Source: Sediment Sampling and Analysis Plan Appendix (Ecology, 2003), Table 12.
[9] SW-846 Method 8330.
[10] EQLs are listed in Table 1 of SW-846 Method 8330.
[11] Massachusetts Department of Environmental Protection (2004), Table VIII A-1.
[12] EPA Method 314.0.
[13] EPA Method 314.0, Table 6, assuming a laboratory minimum reporting level of 4.0 μ/L.
[14] EPA Method 314.0, Table 6.

Sampling Process Design

The proposed sampling locations for this investigation are listed in Table 3 and are shown in Figure 4. Most of these locations have been sampled previously during the Phase II Remedial Investigation in 1994 and the Treatability Study in 1997. Two additional locations (OB1, OB2) have been added to provide more comprehensive coverage of the bay and a reference station in Carr Inlet is also included.

The objectives in the selection of sampling locations are:

1. Evaluate previously sampled locations to allow comparisons of results with existing data.

2. Select locations that can be used to characterize the current condition of Ostrich Bay sediments.

3. Include locations that will characterize the northern extent of residual contamination in Ostrich Bay.

The Carr Inlet reference station was selected based on grain size analysis data for this location from previous sampling and is close to Carr Inlet stations used in the previous Ostrich Bay sediment toxicity studies.

Table 3: Sediment Sampling Locations in Ostrich Bay and Carr Inlet (Reference Sample).

				Coordinates (NAD 1983)*			
Area	**Station ID**	**1994 Station ID**	**1997 Station ID**	**Latitude**		**Longitude**	
Ostrich Bay	OB311	311	311	47	35.397	122	41.001
Ostrich Bay	OB312	312	312	47	35.403	122	40.735
Ostrich Bay	OB326	326	326	47	35.082	122	41.047
Ostrich Bay	OB327	327	327	47	35.211	122	41.252
Ostrich Bay	OB329	329	329	47	35.242	122	41.004
Ostrich Bay	OB334	334	334	47	35.597	122	41.038
Ostrich Bay	OB338	338	338	47	35.792	122	41.092
Ostrich Bay	OB340	340	340	47	34.873	122	41.050
Ostrich Bay	OB341	341	341	47	34.968	122	41.068
Ostrich Bay	OB400	---	400	47	34.715	122	41.025
Ostrich Bay	OB1	---	---	47	35.151	122	40.873
Ostrich Bay	OB2	---	---	47	35.896	122	40.866
Carr Inlet	CR02	---	---	47	20.150	122	39.855

"300" station numbers correspond to those shown in Figure 2. OB400 is a resampling of Station 400, shown in Figure 3. Stations OB1 and OB2 are locations not previously sampled during the Naval Remedial Investigation.
* Degree and decimal minutes.

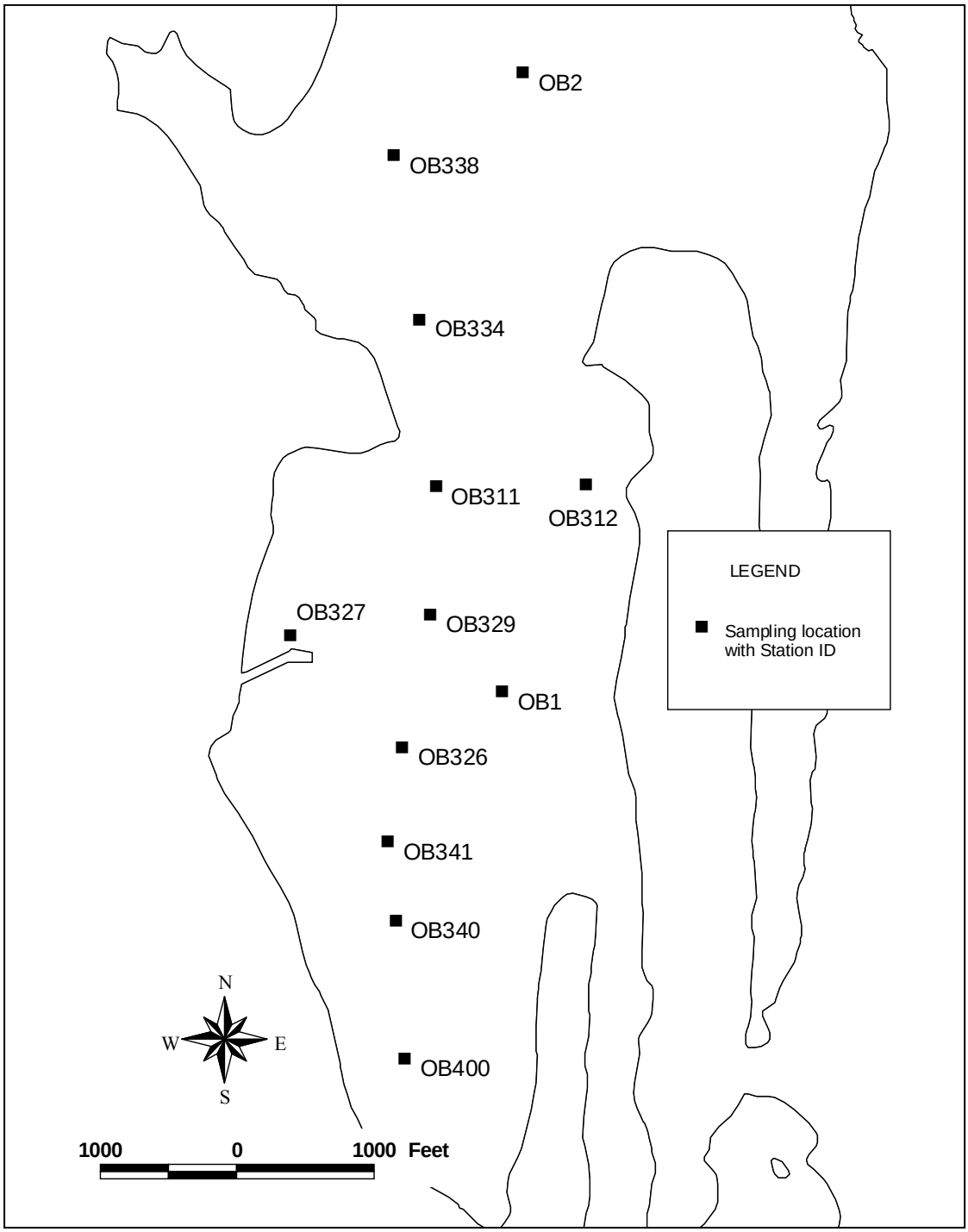

Figure 4: Proposed Sediment Sampling Locations.

Comparability in the data from resampled locations is supported by the use of standard PSEP sampling methods and the availability of coordinates for these stations from the Navy Remedial Investigation reports (EA, 1998a,b). Stations will be located and positions recorded using a differentially corrected global positioning system (GPS). Because the protocols and data interpretation procedures for bioassay testing of sediments are highly specific (Ecology, 2003), data from this testing should be within the regulatory framework for comparability with previous bioassay results. The criteria used in bioassay data interpretation are summarized in Appendix A.

The objective for completeness is 100% valid bioassay data. However, a CSL exceedance for any one bioassay would not be affected by incomplete data from other bioassays. Since grain size is important for the bioassay testing procedures, the grain size analysis falls within the objective for valid bioassay data. However, because chemistry data are not essential for establishing whether sediment samples meet Sediment Management Standards for toxicity, valid data from these chemistry analyses is not a prerequisite for successful completion of this project.

Sampling Procedures

Where applicable, sampling methods will follow Puget Sound Estuary Protocols (PSEP, 1996) and requirements of Ecology's Sediment Management Standards (Chapter 173-204 WAC; Ecology 2003).

Samples will be collected from Ecology's 26-foot research vessel R.V. *Skookum* using a 0.1 m^2 stainless steel van Veen grab. To be considered acceptable, a grab should not be over-filled with sediment, there should be overlying water on the sediment that is not excessively turbid, and the sediment surface should be relatively flat.

Each sample will consist of a composite containing a minimum of three individual grabs. For each grab, the overlying water will be siphoned off. The top 10-cm layer of sediment, not in contact with the sidewalls of the grab, will then be removed with a stainless steel scoop, placed in a stainless steel bucket, and homogenized by stirring.

Subsamples of the homogenized sediment will be transferred to glass jars cleaned to EPA QA/QC specifications (EPA, 1990). Containers and holding times are shown in Table 4.

An exception to this procedure is required for the sulfide subsample, where disturbance of the sediment should be minimized to avoid the loss of sulfide gases (PSEP, 1997). This subsample will be taken directly from the first grab sample prior to homogenization of the remaining sediment.

Table 4: Containers, Preservatives, and Holding Times for Sediment Samples.

Analyte	Container	Preservation Techniques	Holding Time
TOC	2 oz glass jar	Cool to 4°C	14 days
Grain Size	8 oz plastic jar	Cool to 4°C	6 months
Percent Solids	2 oz glass jar	Cool to 4°C	7 days
SVOCs (BNAs)	8 oz glass jar[1]	Cool to 4°C	14 days
Priority Pollutant Metals	8 oz glass jar	Cool to 4°C	6 months (Hg 28 days)
Nitroaromatics and Nitramines (Method 8330)	8 oz glass jar[1] foil wrapped	Cool to 4°C Store in dark	14 days
Perchlorate (Method 314.0)	8 oz glass jar or as specified by contract lab	Cool to 4°C	28 days
Total Sulfides	8 oz glass jar or as specified by contract lab	Cool to 4°C No headspace	7 days See footnote for 28 day holding time
Amphipod Bioassay (10-day acute)	½ gallon glass jar	Cool to 4°C	2 weeks
Larval Bioassay (acute)	½ gallon glass jar	Cool to 4°C	2 weeks
Neanthes Bioassay (20-day chronic)	½ gallon glass jar	Cool to 4°C	2 weeks
Microtox® Bioassay	0.5 liter glass jar	Cool to 4°C	2 weeks

Total Sulfides 28-day holding time: Requires 250 ml sample and 5 ml 2N zinc acetate preservative.

[1] Organic free with Teflon lined lids, with certificate of analysis.

All utensils used to manipulate the samples (stainless steel scoops and buckets) will be precleaned by washing with Liquinox® detergent, followed by sequential rinses with tap water, dilute (10%) nitric acid, deionized water, pesticide-grade acetone, and pesticide-grade hexane. The grab sampler will be thoroughly washed with detergent and on-site water at the beginning of each sampling day. Between stations, cleaning of the sampler will consist of thoroughly brushing and rinsing with on-site water. If oil or visible contamination is encountered, the sampler will be cleaned between sampling locations with detergent followed by a rinse with on-site water.

All samples will be stored in coolers on ice at 4°C and transported to the Ecology Manchester Environmental Laboratory (MEL) or contract laboratories within 72 hours of collection. Storage temperatures and holding time requirements specified by PSEP and other sources are listed in Table 4. Chain-of-custody will be maintained.

At each station, vertical profiles of salinity, temperature, DO (dissolved oxygen), and depth will be recorded with a Seabird CTD. Water samples collected at the surface and at one foot above the bottom with a Van Dorn bottle will be used to measure pH with a pH meter.

Measurement Procedures

A Sediment Sample Log (Appendix B) will be maintained during sampling to record information for each location including GPS coordinates. For each grab sample judged acceptable, the following observations will be entered in the field log:

- Date and time.
- Station location at the time of bottom contact.
- Station depth.
- Gross characteristics of the surficial sediment.
  - Texture.
  - Color.
  - Biological structures (e.g., shells, tubes, macrophytes).
  - Presence of debris (e.g., wood chips, wood fibers, human artifacts).
  - Presence of oily sheen.
  - Obvious odor (e.g., hydrogen sulfide, oil, creosote).
- Gross characteristics of the vertical profile (determined after the surficial sediments have been collected).
  - Vertical changes in sediment characteristics.
  - Presence and depth of any apparent redox potential discontinuity layer.
- Penetration depth of sampler.

Laboratory measurement methods to be used are listed in Table 5. The chemistry analytical methods can be used to analyze for multiple chemicals. The chemicals for which there are Measurement Quality Objectives are listed in Table 1.

Not all of the chemicals listed in Table 1 may be found in Ostrich Bay sediments. The laboratory's ability to meet Measurement Quality Objectives for those identified in Table 1 as having been detected in previous Ostrich Bay investigations is of primary importance.

Table 5: Measurement Methods.

Parameter	Sample Matrix	Analytical Method
TOC	Sediment	PSEP-TOCM (reported on a dry weight basis at 70°C)
Grain Size	Sediment	Plumb (1981)
Percent Solids	Sediment	EPA Method 160.3
Priority Pollutant Metals[1]	Sediment	EPA Method 245.5 (CVAA) for Mercury. EPA Method 200.8
BNA	Sediment	EPA Method 8270 GC/MS
Nitroaromatics and Nitramines	Sediment	EPA Method 8330 HPLC
Perchlorates	Sediment	EPA Method 314.0 Ion Chromatography
Total Sulfides	Sediment	PSEP (1986) (Accreditation method: PSEP – 1995)
Amphipod Bioassay[2] (*Ampelisca abdita*)	Sediment	PSEP (1996) 10-day acute (Accreditation method: PSEP – 1995)
Larval Bioassay[2,3]	Sediment	PSEP (1996) Acute (Accreditation method: PSEP – 1995)
Neanthes Bioassay[2]	Sediment	PSEP (1996) 20-day chronic (Accreditation method: PSEP – 1995)
Microtox Bioassay[4]	Sediment porewater	Ecology (2003)

[1] Priority Pollutant Metals refers to a list of 13 metals which includes Antimony (Sb), Arsenic (As), Beryllium (Be), Cadmium (Cd), Chromium (Cr), Copper (Cu), Lead (Pb), Mercury (Hg), Nickel (Ni), Selenium (Se), Silver (Ag), Thallium (Tl), and Zinc (Zn).

[2] Test requirements include monitoring of water in the test chambers for sulfides and ammonia. In addition, the bulk sediment porewater will be analyzed for ammonia and sulfides.

[3] Test to be conducted with one of the following species:

Pacific oyster, *Crassostrea gigas.*

Blue mussel, *Mytilus galloprovincialis.*

Purple sea urchin, *Strongylocentrotus purpuratus.*

Green sea urchin, *Strongylocentrotus droebachiensis.*

Sand dollar, *Dendraster excentricus.*

[4] Microtox 100 percent sediment porewater extract.

Quality Control Procedures

Table 2 lists the quality control samples for this project and shows how the information from these samples will be used. Additional laboratory quality control procedures for sediment bioassays are listed in Ecology (2003), Table 14. For other laboratory analyses, quality control procedures are provided in the method protocol and laboratory Standard Operating Procedures.

Data Management Procedures

Prior to completion of the project, all project data will be entered into Ecology's Environmental Information Management System (EIM). The sediment data will also be processed for entry into validated electronic SEDQUAL templates for inclusion into Ecology's SEDQUAL database.

Audits and Reports

The Manchester Environmental Laboratory participates in performance and system audits of their routine procedures. Results of these audits are available on request. The EA Program Quality Assurance Unit must accredit all contract laboratories performing work for Ecology. The accreditation process includes performance and system audits.

Data Verification and Validation

The Manchester Environmental Laboratory will conduct a review of all laboratory analysis for the project including contract laboratory's data and case narratives. MEL will verify that the methods and protocols specified in the QA Project Plan were followed; that all calibrations, checks on quality control, and intermediate calculations were performed; and that the data are consistent, correct, and complete, with no errors or omissions. Evaluation criteria will include the acceptability of instrument calibration, procedural blanks, spike samples' analysis, precision data, laboratory control sample analysis, and appropriateness of the data qualifiers assigned. MEL will prepare a written report on the results of their data review.

The project manager will review the contract laboratory's data package and MEL's data QA report and verify that MQOs were met. The project manager will check these data and reports for completeness and reasonableness. Based on these assessments, the data will either be accepted, accepted with appropriate qualifications, or rejected.

Data Quality Assessment

Once the data have been reviewed, verified, and validated, the EA Program project manager will make a determination whether they are usable for characterizing sediment toxicity and chemistry. If the results are satisfactory, each station will be evaluated for compliance with the Sediment Management Standards based on results from the bioassay testing.

A draft report will be completed on or before June 2005. The report will include the following:

- Site maps showing sampling locations and locations of past samples.
- Description of field and laboratory methods.
- Sample information (dates, times, depths, coordinates, etc.).
- Discussion of data quality and the significance of any problems encountered in the sampling or analysis.
- Analysis of bioassay results regarding compliance with Sediment Management Standards, using tables and maps.
- Summary of all laboratory analyses results. The summary will include descriptive statistics. If stations can be grouped based on the bioassay testing results, summaries of laboratory analytical results may be presented for each group.
- Discussion of spatial patterns and comparisons with results from the Navy Remedial Investigation, which includes Phase I, Phase II, and treatability studies.

A final report will be prepared on or before August 2005. Upon completion of the project, all project data will be entered into Ecology's Environmental Information Management System (EIM) and processed for entry into SEDQUAL. Public access to electronic versions of the data and reports generated from this project will be available via Ecology's internet homepage (http:\\www.ecy.wa.gov).

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Appendix A

Biological Effects Criteria for Puget Sound Marine Sediments (from Ecology, 2003)

Biological Test	Sediment Quality Standards [a]	Cleanup Screening Levels [b]
Amphipod	The test sediment has a significantly higher (t-test, P≤0.05) mean mortality than the reference sediment, and the test sediment mean mortality is more than 25 percent greater, on an absolute basis, than the reference sediment mean mortality.	The test sediment has a significantly higher (t-test, P≤0.05) mean mortality than the reference sediment, and the test sediment mean mortality is more than 30 percent greater, on an absolute basis, than the reference sediment mean mortality.
Larval	The test sediment has a mean survivorship of normal larvae that is significantly less (t-test, P≤0.1) than the mean normal survivorship in the reference sediment, and the mean normal survivorship in the test sediment is less than 85 percent of the mean normal survivorship in reference sediment.	The test sediment has a mean survivorship of normal larvae that is significantly less (t-test, P≤0.1) than the mean normal survivorship in the reference sediment, and the mean normal survivorship in the test sediment is less than 70 percent of the mean normal survivorship in the reference sediment.
Juvenile polychaete	The mean individual growth rate of polychaetes in the test sediment is less than 70 percent of the mean individual growth rate of the polychaetes in the reference sediment, and the test sediment mean individual growth rate is statistically different (t-test, P≤0.05) from the reference sediment mean individual growth rate.	The mean individual growth rate of polychaetes in the test sediment is less than 50 percent of the mean individual growth rate of the polychaetes in the reference sediment, and the test sediment mean individual growth rate is statistically different (t-test, P≤0.05) from the reference sediment mean individual growth rate.
Microtox® (porewater)	The mean light output of the highest concentration of the test sediment is less than 80 percent of the mean light output of the reference sediment, and the two means are statistically different (t-test, P≤0.05).	Not applicable

Source: Ecology (1993).

[a] The sediment quality standards are exceeded if one test fails the listed criteria [WAC 173-204-320(3)].

[b] The sediment impact zone maximum level, cleanup screening level, or minimum cleanup level is exceeded if one test fails the listed sediment impact zone maximum level, cleanup screening level, or minimum cleanup level criteria [WAC 173-204-520(3)] or if two tests fail the sediment quality standards criteria [WAC 173-204-320(3)].

Appendix B

Sediment Sample Log

Site: _____

Station	Grab No.	Depth (ft)	Date	Time	Sediment Penetration (cm)	pH		Sample Description
						Surface	Bottom	

Recorder: _____