Post Point (Bellingham Bay) Sediment Sulfide and Toxicity Assessment

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Post Point (Bellingham Bay) Sediment Sulfide and Toxicity Assessment

by
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Abstract

During October 2004, sediments from 11 sampling stations near Post Point, in Bellingham Bay, were collected and evaluated for sulfide and ammonia concentrations. Sediments from ten of these stations were also evaluated for compliance with Washington State Sediment Management Standards biological criteria. Elevated sulfide levels have previously been found at Post Point near the Post Point Wastewater Treatment Plant outfalls and near the Harris Avenue Shipyard.

Samples were evaluated for toxicity and chemistry. Three bioassay tests – amphipod, larval bivalve, and Microtox® – were conducted on each sample.

Results show a large area of sediments with elevated sulfide levels at Post Point between the previously sampled locations near the treatment plant outfalls and the shipyard.

Of the ten locations tested with bioassays, four exceeded (did not meet) Microtox Sediment Quality Standards. There were no exceedances of regulatory criteria with the amphipod bioassay, and only one station had an exceedance with the bivalve bioassay. The bioassay results are in general agreement with those from previous testing of sediment samples collected near the treatment plant outfalls.

Of the sediment bioassays included in this study, only Microtox showed some evidence of sulfide toxicity. Exceedances of regulatory criteria for this bioassay were more frequent with increasing sulfide concentration.

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Introduction

Background

Elevated sulfide concentrations have been found in sediments near Post Point in Bellingham Bay, Washington. The Post Point area, located at the southern end of the bay (Figure 1), receives discharges from the City of Bellingham's Post Point Wastewater Treatment Plant. In 2003, sediments were investigated near the main outfall and the alternate outfall from the treatment plant. Up to 2,110 mg/kg total sulfides were found near the main outfall and even higher concentrations (up to 4,970 mg/kg total sulfides) near the alternate outfall (Anchor, 2004).

The alternate outfall typically receives overflow discharges from the treatment plant four to six times per year, lasting from several minutes to several hours, under high flow conditions caused by wet-weather storms (Hart Crowser, 2005). The overflow discharges are a blend of primary and secondary treated wastewater. Some stormwater is also discharged through this alternate outfall, originating from part of the treatment plant property, an adjacent industrial park, and a paved area in a nearby shoreline park. This combined wastewater and stormwater flow is released from breaks in the outfall pipe approximately 300 ft from the shoreline, rather than the original pipe terminus at 500 ft which has become buried by sediment. Plans for repairing this alternate outfall have been prepared by the City of Bellingham (Hart Crowser, 2005).

In addition to the outfall areas, sediments have been sampled at another location near Post Point, the Harris Avenue Shipyard, where elevated sulfide concentrations were also reported. During a Remedial Investigation at the shipyard, up to 3,800 mg/kg total sulfides were found at some sampling stations in 2003 (RETEC, 2004). The Remedial Investigation report proposed the Post Point Wastewater Treatment Plant as the likely source. The report also suggested that amphipod (*Ampelisca abdita*) bioassay test failures for shipyard sediments may have resulted from elevated sulfide and ammonia concentrations from the treatment plant.

Study Objectives

Because sampling of Post Point sediments has been limited to select locations, the spatial distribution of sulfide levels in the area has not been well defined. A primary objective of this study is to characterize sulfide levels in the Post Point area that has not been previously sampled, between the Post Point Treatment Plant outfalls and the Harris Avenue Shipyard. Sulfide data would be used to determine current concentrations and possible source identification.

A second objective of this study is to evaluate the sediments in the study area for compliance with regulatory biological criteria in the Sediment Management Standards (Chapter 173-204 WAC). Because bioassay responses can be affected by ammonia, a typically co-occurring toxicant with sulfide, ammonia levels were also examined in this study.

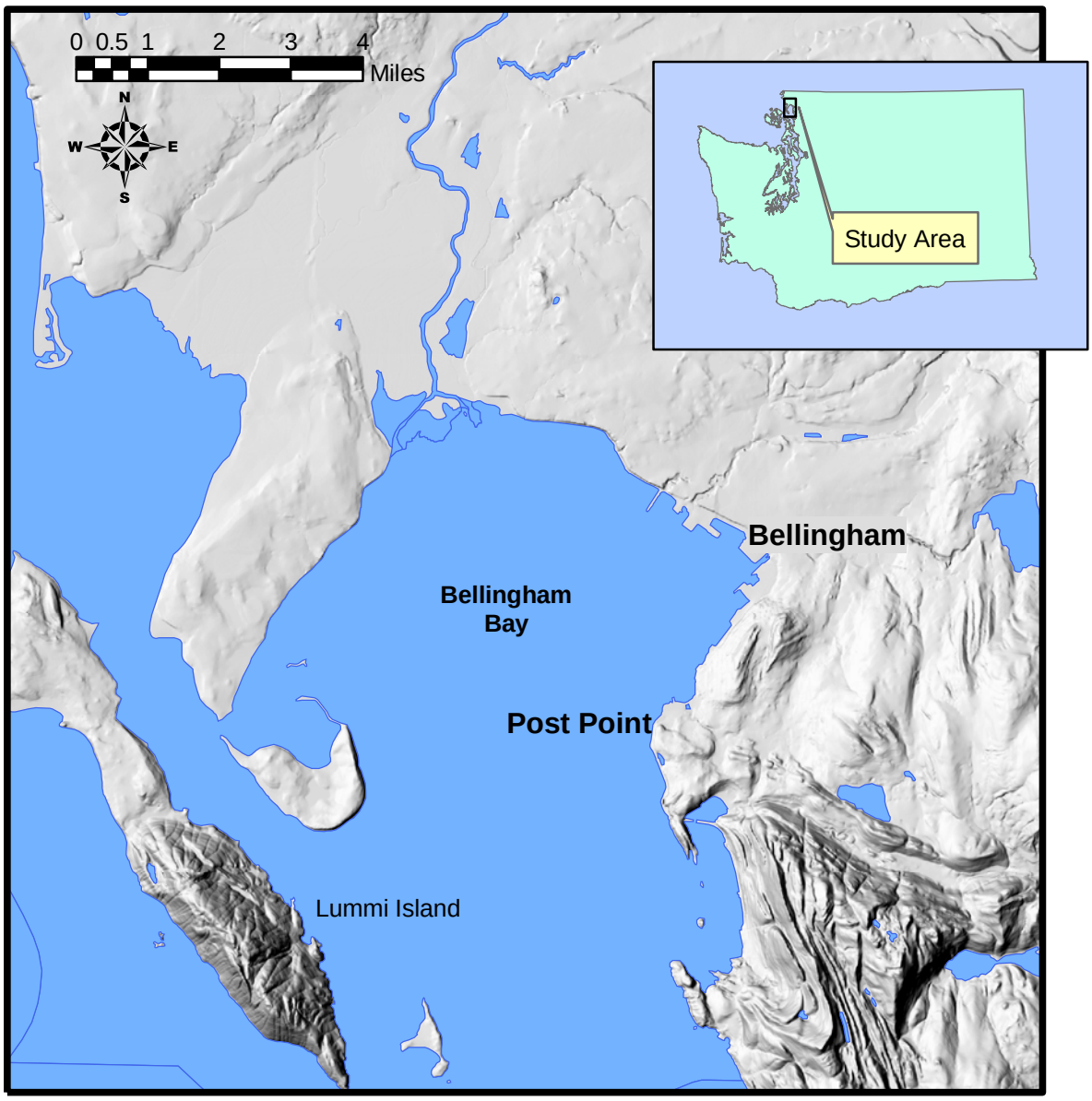

Figure 1. Post Point Study Area.

Methods

Sampling Design

Sampling locations were selected to characterize the area bounded by the Post Point Treatment Plant outfalls and the Harris Avenue Shipyard (Figure 2). A systematic sampling plan was designed using a grid superimposed on this area (Blakley and Wittmann, 2004).

A reference station (CR02) in Carr Inlet, about ten miles northwest of Tacoma, was selected based on grain-size analysis data for this location from previous sampling. The CR02 reference sample was also used in a concurrent study in Ostrich Bay; additional details concerning this station are provided in the report for that study (Blakley, 2005).

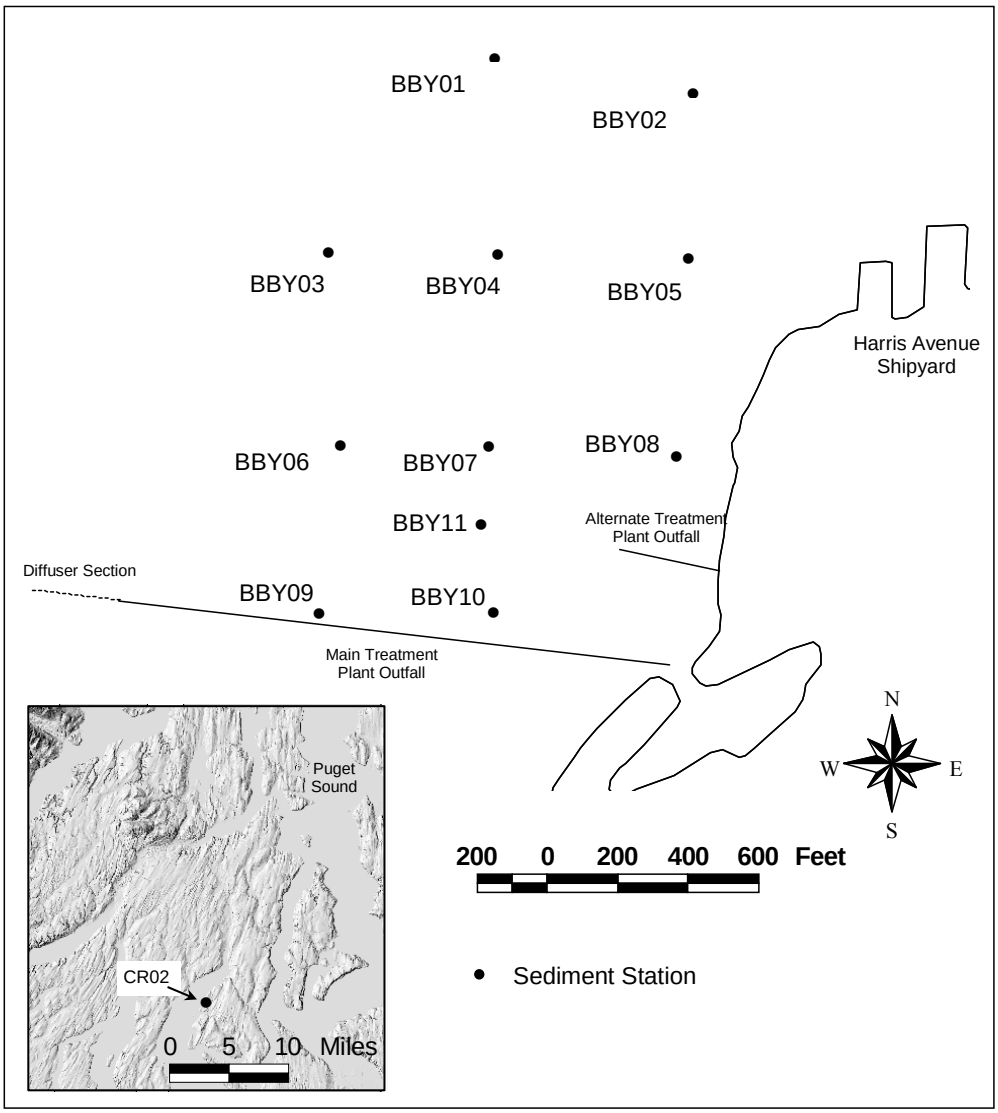

Figure 2. Post Point Sampling Stations and Reference Station Location (Inset).

Sampling Methods

Where applicable, sampling methods followed Puget Sound Estuary Protocols (PSEP, 1996) and requirements of Ecology's Sediment Management Standards (Chapter 173-204 WAC; Ecology 2003). Samples were collected from Ecology's 26-foot research vessel *R.V. Skookum* using a 0.1 m^2 stainless steel Van Veen grab sampler. Station positions were located using a Northstar GPS (Global Positioning System) Receiver with differential correction. A field log, with location information and physical descriptions of the samples collected, was maintained during sampling (Appendix A).

Sampling was conducted on October 25 and 26, 2004 (Appendix A). The CR02 reference station was sampled on October 8, 2004 and analyzed in conjunction with samples from the Ostrich Bay study (Blakley, 2005). However, part of the CR02 sample was stored in the dark at 4±2°C for inclusion with the bioassay testing conducted on the Post Point samples.

Surface Sediments

Except as noted below, three independent grab samples were taken at each station. A grab was considered adequate if it was filled with sediment and both the grab and access doors on top of the grab were closed tightly. For each grab, the overlying water was siphoned off upon retrieval. The top 10-cm layer of sediment, not in contact with the sidewalls of the grab, was then removed with a stainless steel scoop for analysis. An 8-oz subsample from the first grab at each station was carefully removed with minimal disturbance and placed in a container for sulfide analysis. Subsamples for all other analyses were taken from a homogenate derived from the three grab samples. Sediment from each grab was placed in a stainless steel bucket, and homogenized by stirring. Objects that could not be homogenized (e.g., rocks, shells, algae, macroinvertebrates) were removed before stirring.

Exceptions to the procedure of taking three grabs per station are noted in the field log (Appendix A). At some stations, one or more of the grabs was unsuccessful, and sampling was continued until three acceptable grabs were obtained. However, only two acceptable grabs were obtained at both BBY09 and BBY10, and results for BBY11 are from a single grab due to time constraints and poor weather conditions.

Sediment subsamples were placed in glass jars (Teflon lid liners) that had been cleaned to EPA QA/QC specifications (EPA, 1990). Separate 2-oz jars were used for total organic carbon (TOC), solids, and sulfides analyses; 8-oz jars for ammonia; 8-oz plastic jars for grain size; and ½-gallon jars for bioassays (except Microtox®, where a ½-liter glass jar was used).

All utensils used to manipulate the samples (stainless steel scoops and buckets) were 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 was thoroughly washed with detergent and rinsed with deionized water. The equipment was then air-dried and wrapped in aluminum foil until used in the field. Between stations, the grab sampler was thoroughly brushed and rinsed with seawater.

All samples were stored in coolers on ice at 4°C and transported to the Ecology Manchester Environmental Laboratory (MEL) or contract laboratories within 24 hours of collection. Chain-of-custody was maintained throughout the study.

Water Column

At each station, vertical profiles of salinity, temperature, dissolved oxygen (DO), and depth were recorded with a Seabird CTD. Water samples were collected at the surface and at one foot above the bottom with a Van Dorn bottle to measure pH, using a portable on-board pH meter. The meter was calibrated at the beginning of each sampling day with pH 7 and 10 buffers.

Analytical Methods

Table 1 summarizes the analytical methods and laboratories used in this study. Samples were analyzed by MEL or by MEL-accredited contract laboratories. The bioassay test methods are shown in Table 2. A more detailed description of the bioassay tests is provided in Appendix B.

Table 1. Analytical Test Methods.

Parameter	Method	Laboratory
Grain Size	Plumb (1981)	ARI
Total Organic Carbon	PSEP-TOC (reported on a dry-weight basis at 70°C)	MEL
Percent Solids	EPA Method 160.3	MEL
Total Sulfides (bulk sediment)	PSEP (1986) (Accreditation method: PSEP, 1995)	CAS
Ammonia (bulk sediment)	Plumb (1981)	CAS

ARI Analytical Resources, Inc.
CAS Columbia Analytical Services
MEL Manchester Environmental Laboratory

Table 2. Bioassay Test Methods.

Test	Reference	Laboratory
Amphipod – 10-day acute (*Ampelisca abdita*)	PSEP (1996) (Accreditation method: PSEP, 1995)	Nautilus Environmental
Larval Bivalve – 48-hr acute (*Mytilus galloprovincialis*)	PSEP (1996) (Accreditation method: PSEP, 1995)	Nautilus Environmental
Microtox Bioassay	Ecology (2003)	Nautilus Environmental

Data Quality

Physical/Chemical

Data quality was assessed through analysis of field duplicates, laboratory replicates, laboratory control samples, and matrix spikes. Procedural blanks were analyzed in order to assess laboratory contamination.

Most data quality objectives established for this project in the sampling plan (Blakley and Wittmann, 2004) were met (Appendix C, Table C-1), with the following exceptions:

- Grain size. Precision objective (RSD ≤ 20 %) was not met for the gravel size class.
- Total sulfides. Matrix spike recovery objective could not be evaluated because the analyte concentration already in the sample used was higher than the spike concentration. Because of the high sulfide concentrations, all samples were diluted before analysis. The dilution factors ranged from 50 to 200.
- Ammonia. Reported concentration in the method blank (< 600 µg/kg) was inconsistent with the objective criterion (< 100 µg/kg).

Data quality assessments, based on the reporting laboratories' quality assurance procedures and criteria, are provided in the Case Narratives (Appendix F). No data quality qualifier flags were attached to any of the sample measurements for sulfide or ammonia.

Bioassays

The three tests – amphipod, larval bivalve, and Microtox® – met acceptability criteria for control performance.

There were no deviations to the test protocol in any of the tests, with the exception of the extension of sediment settling time from 4 hours to 24 hours prior to the addition of bivalve larvae. The extended settling time was provided to reduce the risk of artifactual toxicity associated with the physical effects of settling suspended particulate interfering with the conclusion of the test.

Results of reference toxicant tests conducted with the test organisms are provided in Appendix C, Table C-2. Results of these tests fell within the acceptable range of mean ± two standard deviations for historical data generated by the testing laboratory. These data indicate that the test organisms were of an appropriate sensitivity.

Field Duplicate

Although a blind field duplicate sample was included in the original study design (Blakley and Wittmann, 2004), this sample is treated as an independent station (BBY11), rather than a duplicate at BBY10 as originally intended, because the sample was collected off-station. This occurred because of difficulties in obtaining acceptable grabs at the original location and the need to reposition the research vessel as it drifted in strong winds towards shallow water. Because no bioassay testing was originally planned for the field duplicate, bioassay results are not available for BBY11.

Results

Data from this October 2004 study are available electronically from Ecology's Environmental Information Management System database at www.ecy.wa.gov/eim/ and is entered in the SEDQUAL database (www.ecy.wa.gov/programs/tcp/smu/sedqualfirst.htm).

Physical Characteristics of Sediments

There was a general similarity in sediment characteristics throughout the study area, with silt and clay size classes predominating at the sampling stations (Table 3). However there was some spatial variation in sediment characteristics. Sand was more abundant in samples taken closer to the shoreline (BBY08, BBY10, and BBY11), while clay was the largest size fraction at the most northerly sampling station (BBY01). The reference station (CR02) in Carr Inlet differed from the Post Point sampling stations in having more silt and less clay.

Total organic carbon (TOC) content did not vary greatly at the sites (2.3 – 2.9% TOC) and was higher than the Carr Inlet reference station sample (1.3%).

Table 3. Sediment Sample Grain Size, Percent Solids, and TOC Content.

Station ID	Lab ID	% Solids	TOC (%)	Grain Size (%)			
				Gravel	Sand	Silt	Clay
CR02 (reference)	414092	44.8	1.3	0.0	11.3	73.8	14.9
BBY01	444080	35.9	2.5	0.1	17.1	38.7	44.2
BBY02	444081	36.6	2.5	0.1	18.6	40.8	40.7
BBY03	444082	28.2	2.3	0.0	12.1	46.7	41.1
BBY04	444083	30.8	2.5	0.3	7.0	51.5	41.2
BBY05	444084	31.5	2.5	0.2	16.1	50.4	33.5
BBY06	444086	31.1*	2.5	0.5	12.3	47.0	40.2
BBY07	444087	33.5	2.5	0.1	17.1	44.0	39.0
BBY08	444088	34.1	2.9	0.3	30	39.7	30.0
BBY09	444089	41.8	2.7	--	--	--	--
BBY10	444090	40.4*	2.3	0.5	28.6	36.7	34.3
BBY11	444092	--	2.3	0.1	29.1	36.5	34.3

* Mean of two laboratory replicates.
-- Not analyzed due to limited sample volume from this station.

Water Column Profiles

Dissolved oxygen concentrations showed little variation with depth and were about 7 mg/L at all stations (Appendix D). Temperature and salinity profiles similarly showed little variation with depth, except for a small reduction in salinity in the upper 5 m at station BBY01.

The water column pH ranged from 7.5 to 8.3 at the surface (Appendix A). There was a similar range (7.6 to 8.2) in measurements taken at the bottom.

Chemical Concentrations

Sulfides and Ammonia

Total sulfide concentrations ranged from 862 to 2,620 mg/Kg dry weight (dw). Ammonia ranged from 15.8 to 33.0 mg/Kg dw (Table 4). The reference station had a lower sulfide concentration (425 mg/Kg dw) than any of the Post Point stations. Data for the reference station are taken from the concurrent Ostrich Bay study analyses (Blakley, 2005) which did not include ammonia in the study plan.

Table 4. Total Sulfide Concentrations.

Station ID	Sulfides (mg/Kg dw)	Ammonia-N (mg NH_4-N/Kg dw)
CR02	425	--
BBY01	862	15.8
BBY02	900	22.5
BBY03	1,570	56.8
BBY04	2,010	25.9
BBY05	2,620	43.7
BBY06	1,810	28.4
BBY07	1,310	19.4
BBY08	1,570	29.7
BBY09	1,730	20.4
BBY10	2,300*	30.0*
BBY11	1,330	33.0

* Laboratory triplicate mean.

Bioassays

Washington State's Sediment Management Standards (Chapter 173-204 WAC) establish two levels for sediment quality, the *Sediment Quality Standards* (SQS) and the *Cleanup Screening Levels* (CSL).

- CSLs are "minor adverse effects" levels, used as upper regulatory levels for source control and as minimum cleanup levels. Sediment Management Standards set criteria for CSLs based on bioassay testing and also set 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.
- SQSs 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, Sediment Management Standards 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)

Four of the ten stations tested in this 2004 study exceeded (did not meet) the Microtox SQS and one of these stations also exceeded the amphipod CSL (Table 5). There were no exceedances for any of the three endpoints in the larval bivalve bioassay.

Table 5. Summary of Bioassay Testing Results. (See Appendix E for complete data.)

Station	Amphipod (*Ampelisca*)	Bivalve (*Mytilus*)			Microtox		Overall Station Status
	Mortality	Survival	% Normal Larvae	% Normal Surviving Larvae	5 min	15 min	SQS or CSL†
BBY01	17%	86.6%	89.9%	77.5%	101%	103%	Pass
BBY02	25%	88.7%	88.8%	79.2%	100%	100%	Pass
BBY03	31%	77.9%	88.7%	69.1%	100%	101%	Pass
BBY04	25%	79.4%	88.1%	69.9%	98%	99%	Pass
BBY05	15%	90.8%	88.5%	80.3%	**30%***	**41%***	SQS
BBY06	26%	84.3%	87.4%	73.7%	102%	112%	Pass
BBY07	21%	88.2%	89.7%	79.0%	103%	112%	Pass
BBY08	21%	85.5%	89.4%	76.6%	**63%***	**69%***	SQS
BBY09	**47%****	77.7%	92.2%	71.6%	**16%***	**17%***	CSL
BBY10	28%	79.3%	88.6%	70.3%	**19%***	**25%***	SQS
CR02 (Reference)	20%	76.5%	91.0%	69.6%	na	na	na

† SQS or CSL station exceedance. A station with two or more SQS exceedances is assigned a CSL exceedance under the Sediment Management Standards (WAC 173-204-520(1)(d) and (3)(d)).
* SQS bioassay exceedance (bold)
** CSL bioassay exceedance (bold)
na not applicable

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Discussion

Figure 3 summarizes the key results from this October 2004 investigation. Elevated sulfide concentrations (over 1,000 mg/kg) were found throughout the area bounded by the Post Point Wastewater Treatment Plant outfalls and the Harris Avenue Shipyard. There is no numerical standard for sulfide in the Washington State Sediment Management Standards (WAC 173-204). For comparison, sediments at the Taylor Avenue Dock, about 0.3 mile northeast of the study area, had a range of 4.6 – 320 mg/kg sulfides (data for nine stations sampled in 1999, from Ecology's SEDQUAL database). Ammonia concentrations for this 2004 study had a range of 15.8 – 56.8 mg NH_4-N/kg dw, compared with <1.3 – 30 mg/kg for the nine Taylor Avenue Dock stations in 1999.

The two most northerly stations (BBY01 and BBY02) had the lowest sulfide concentrations (862 and 900 mg/kg dw). A similar pattern is evident for the ammonia concentration data. These sulfide concentrations are elevated relative to the reference station CR02 (425 mg/kg dw) and the Taylor Avenue Dock stations in 1999, suggesting that the northern extent of the sulfide footprint was not located in this 2004 study.

Sediment sulfide concentrations from this study are generally consistent with data from previous investigations at Post Point (Figure 4). For example, the high concentration at BBY05 (2,620 mg/kg) near the Harris Avenue Shipyard is comparable to values previously reported at some stations in this vicinity.

In general, the bioassay exceedances of regulatory criteria do not show a strong relationship to sulfide or ammonia concentrations. The larval bivalve bioassay had no exceedances at any station, and the amphipod bioassay had only one exceedance, although not at any of the stations with the highest concentrations of sulfide or ammonia.

Microtox bioassay SQS exceedances tended to occur at higher sulfide concentrations, as found in previous sampling conducted by Anchor (Figure 5). There is a statistically significant relationship between Microtox pass/fail results (scored as a dichotomous variable) and sulfide concentration, at the 95% confidence level (Table 6). A logistic regression comparison of Microtox results with ammonia concentrations was not statistically significant.

Comparison of the Microtox results from this study and Anchor (2004) suggests a difference in sensitivity to sulfide concentrations (Figure 6). SQS exceedances occurred at lower sulfide concentrations in this study than in the Anchor study. The basis for this difference is unknown.

In addition, there were no instances where bioassay results exceeded the CSL for any three stations identified within a station cluster, as described in WAC 173-204-500 through 173-204-590.

Table 6. Logistic Regression Analyses for Microtox SQS Exceedances.

Model		Analysis of Deviance				
Parameter	Value	Source	Deviance	Df	P-value	Pseudo-R^2
Data from this October 2004 study						
Sulfide	-0.00337864	Model	4.18236	1	**0.0408**	0.3107
Constant	6.26435	Residual	9.27788	8	0.3194	
		Total	13.4602	9		
Ammonia	-0.020129	Model	0.136259	1	0.7120 (ns)	0.0123
Constant	0.9988	Residual	13.324	8	0.1012	
		Total	13.4602	9		
Data from Anchor (2004)						
Sulfide	-0.000663764	Model	3.90228	1	**0.0482**	0.4093
Constant	2.74368	Residual	5.63243	7	0.5833	
		Total	9.53471	8		

Analyses show results of fitting a logistic regression model to describe the relationship between Microtox SQS exceedances and the independent variable. The equation of the fitted model is

$F = e^{\theta}/(1+e^{\theta})$

where

F = Microtox score (1 = pass, 0 = fail)
$\theta = V_X X + V_C$

V_X = parameter value for sulfide or ammonia

X = sulfide or ammonia concentration

V_C = parameter value for the constant in the regression

P-value of <0.05 in the Analysis of Deviance table (bold) indicates that there is a statistically significant relationship between the variables at the 95% confidence level. Pseudo-R^2 is similar to the usual R^2 statistic, and calculated as (Model deviance)/(Total deviance). Df = degrees of freedom.

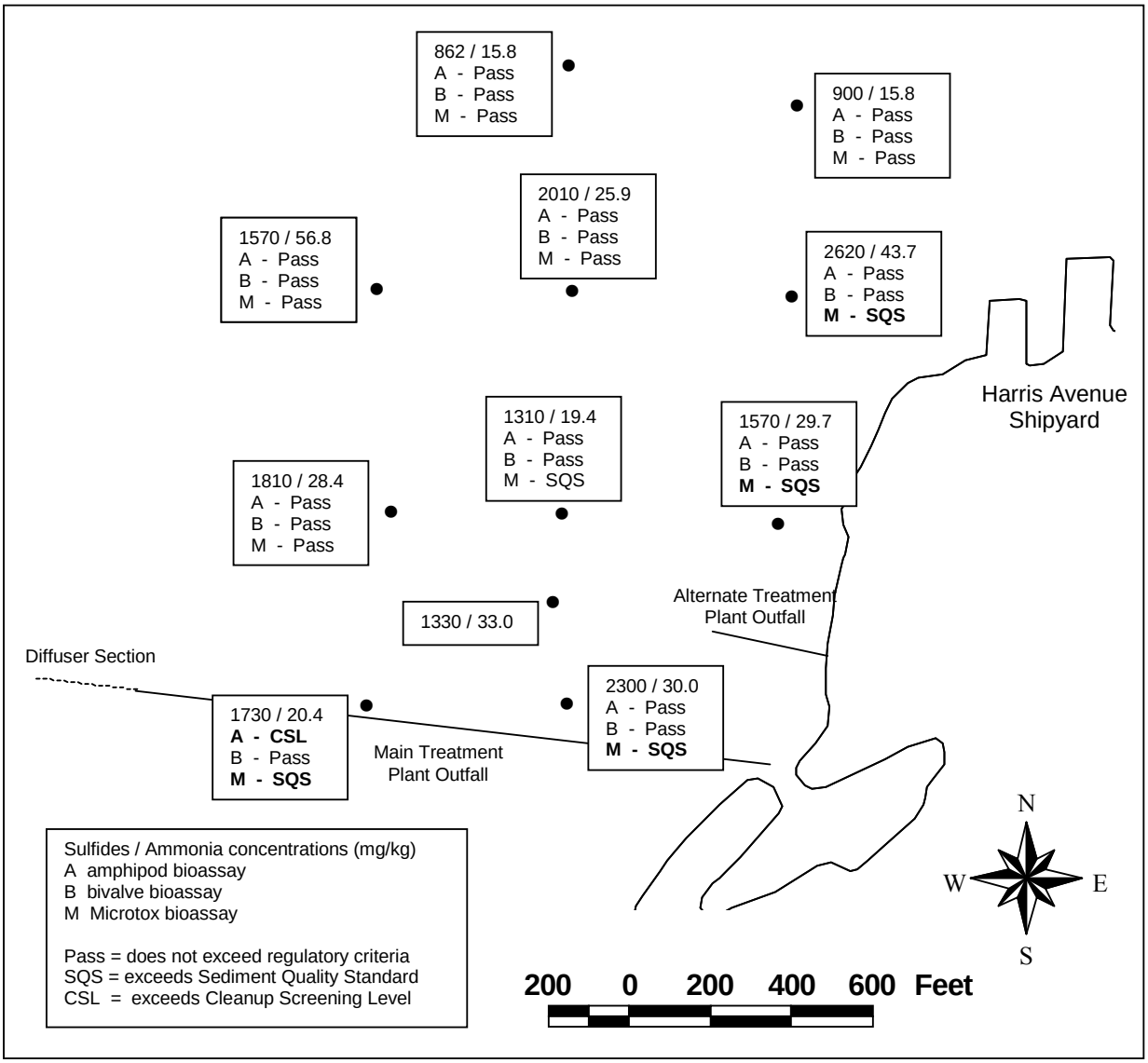

Figure 3. Sulfide, Ammonia, and Bioassay Results.

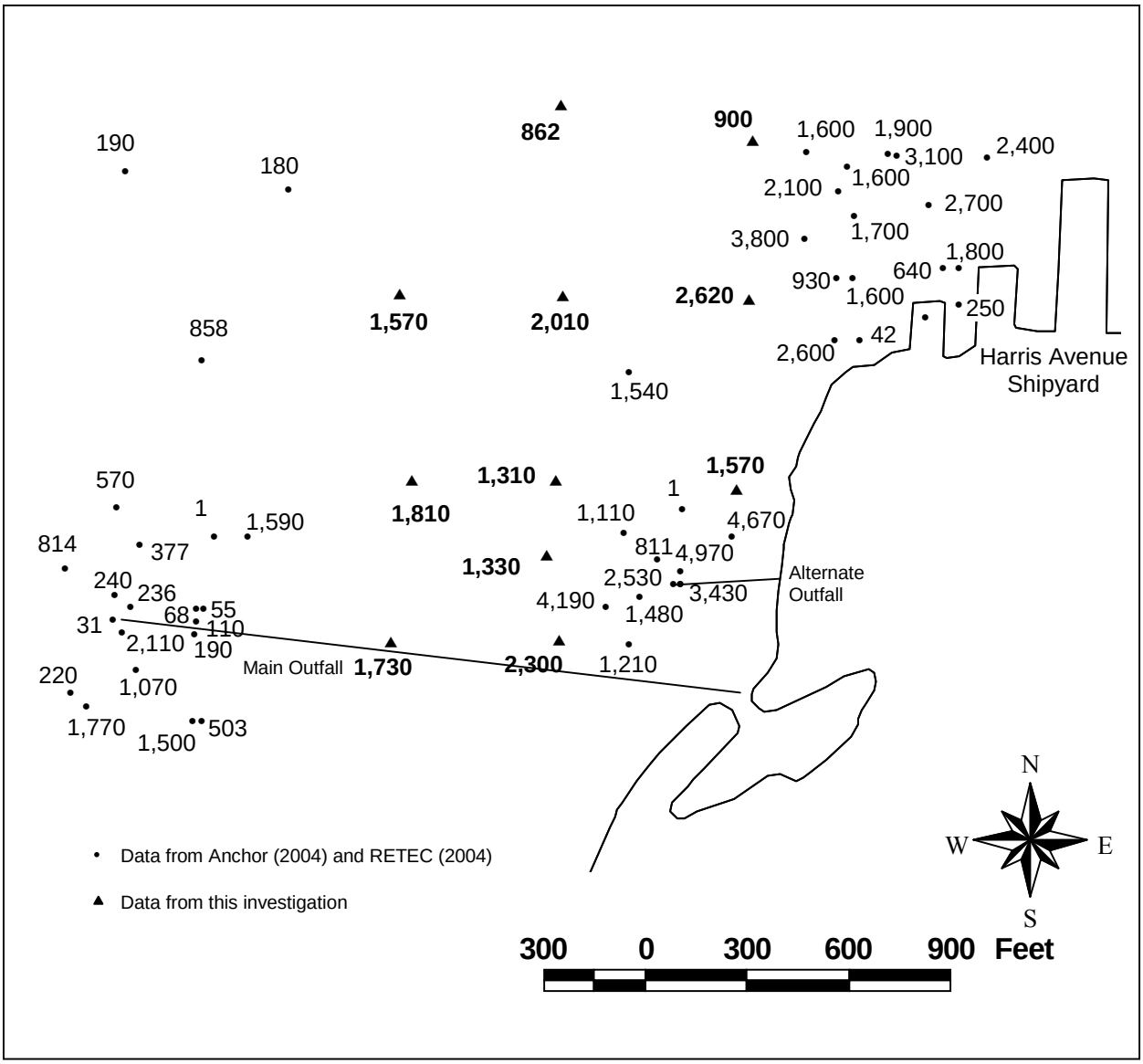

Figure 4. Sulfide Concentrations (mg/Kg dw) from This Study and Previous Investigations.

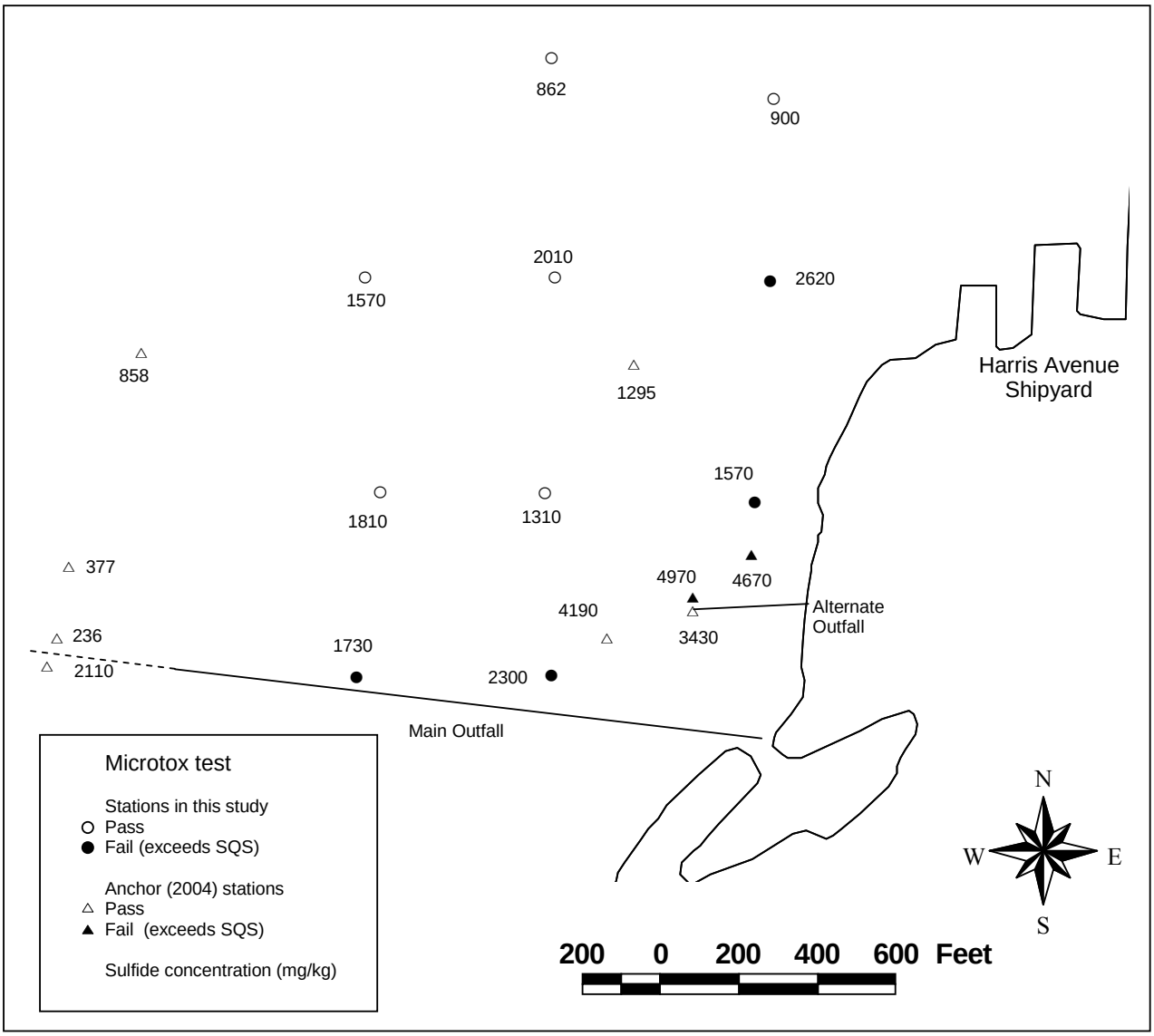

Figure 5. Summary of Microtox Bioassay Results and Sulfide Concentrations from This Study and from Anchor (2004) Report.

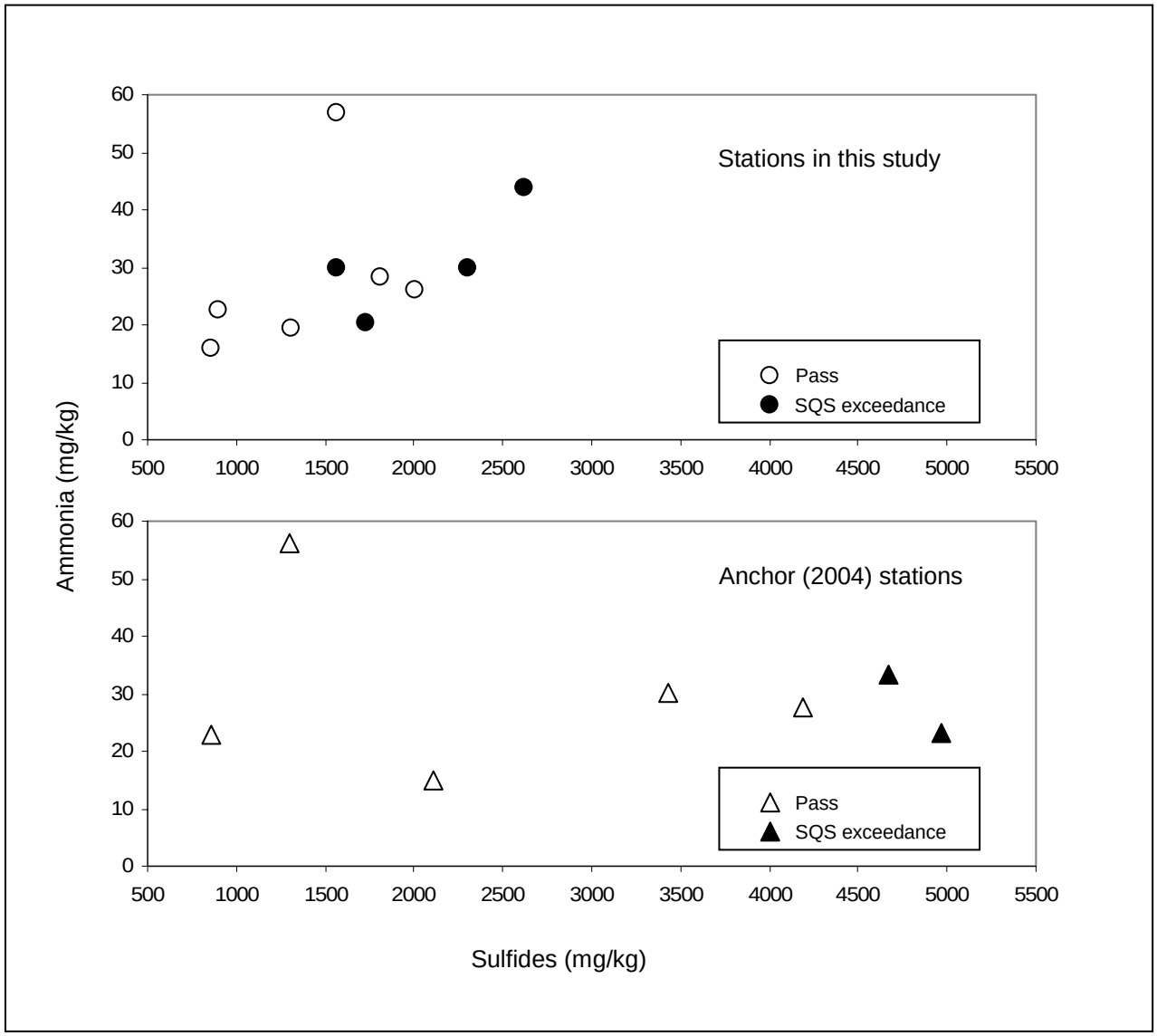

Figure 6. Microtox Bioassay Results in Relation to Sulfides and Ammonia Concentrations from This Study and from Anchor (2004) Data.

Conclusions

Elevated sulfide concentrations previously reported from sediment sampling around the two Post Point Wastewater Treatment Plant outfalls, and the Harris Avenue Shipyard, are part of a larger area of elevated sulfide levels in sediment at Post Point. Further sampling would be required to determine the northerly extent of the sulfide footprint.

Of the three sediment bioassays included in this October 2004 study, only Microtox exhibited some evidence of sulfide toxicity. Similar results were obtained in previous testing of sediments from the vicinity of the two outfalls (Anchor, 2004). In those tests, none of the samples failed the 48-hour acute larval bivalve (*Mytilus galloprovincialis*) bioassay, and only one of the nine samples failed the acute 10-day amphipod (*Eohaustorius estuarius*) bioassay. The Microtox results showed an association with sulfide levels (Figure 6 and Table 6), although only two of the nine stations failed comparison with regulatory criteria.

No evidence of sulfide toxicity was found in Microtox testing of samples from Ostrich Bay (Blakley, 2005), and there was little evidence of sulfide toxicity from testing with three other bioassays. These consisted of the acute 10-day amphipod (*Ampelisca abdita*) bioassay, the 20-day chronic juvenile polychaete (*Neanthes*) bioassay, and the 48-hour acute larval bivalve (*Mytilus galloprovincialis*) bioassay.

Despite these results, sulfide may be more harmful to benthic invertebrate communities than bioassay tests suggest (Wang and Chapman, 1999). This is particularly the case if density stratification of the water column occurs during summer months, and oxygen depletion of deeper water imposes additional stresses on these communities. Although stratification was not observed in this study (conducted in October), it has been previously reported from Bellingham Bay in August, with dissolved oxygen levels less than 3 mg/L at depth (Newton et al., 2002).

Oxygen depletion can also lead to higher sulfide levels, due to the activity of some anaerobic bacteria. In sulfate-reducing bacteria, the anaerobic decomposition of organic matter is coupled with the reduction of sulfate from seawater to sulfide. As an alternative to bioassay tests, Wang and Chapman suggest assessing the in-situ abundance of sulfide-sensitive benthic invertebrate species.

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Appendices

A. Sampling Station Location Information

B. Bioassay Test Descriptions

C. Data Quality Assessment

D. CTD Results

E. Bioassay Test Results

F. Case Narratives

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Appendix A. Sampling Station Location Information

Table A-1. Field Log Notes.

Station	Latitude Degrees decimal minutes[a]	Longitude	Grab #	Depth[b] (m)	Date	Time	Penetration (cm)	pH Surface	pH Bottom	Comments
BBY08	122º 30.940	48º 43.216	1	10.2	10/25/04	12:20	15	7.93	7.70	Grey silt (1 cm), black silt underneath
			2	10.3	10/25/04	12:43	16			Same as above, also sulfide odor
			3	9.9	10/25/04	12:58	16			Same, wood, leaf debris
BBY05	122º 30.935	48º 43.308	1	15.1	10/25/04	13:05	17	7.80	7.94	2 mm light grey layer, black underneath, silty sand
			2	15.7	10/25/04	13:10	13			Same
			3	16.0	10/25/04	13:17	16			Same
BBY02	122º 30.935	48º 43.385	1	17.5	10/25/04	14:48	--	7.53	--	No grab (door open)
			2	17.7	10/25/04	14:55	16			Thin light brown layer on black silty sand. Shell material. Worms.
			3	17.8	10/25/04	15:13	15			" " worm
			4	17.8	10/25/04	15:28	--			No grab (wood)
			5	18.0	10/25/04	15:33	17			Same as #2
BBY01	122º 31.076	48º 43.399	1	20.6	10/25/04	16:26	16	7.77	7.62	Brown silty sand layer over black (5 mm). No odor. Worms. Shells.
			2	20.9	10/25/04	16:41	16			" "
			3	20.3	10/25/04	16:52	15			Leafy debris, shells, worms. Same as last two.
BBY04	122º 31.070	48º 43.308	1	19.0	10/26/04	09:31	17	7.97	8.05	2 mm light brown, black silt under. Slight sulfur smell, worms.
			2	18.6	10/26/04	09:41	16			One door open, collected seds from one side only/same description as #1
			3	18.4	10/26/04	09:48	17			Same as #1 plus woody debris
BBY03	122º 31.190	48º 43.306	1	21.6	10/26/04	10:18	17	8.00	7.91	Same as BBY04 but dark grey instead of black.
			2	22.0	10/26/04	10:29	16			Sulfur smell
			3	22.3	10/26/04	10:38	--			Over penetration – didn't use.
			4	22.3	10/26/04	10:44	16			Same but more black
BBY06	122º 31.177	48º 43.217	1	20.3	10/26/04	11:13	17	8.09	7.97	Same as BBY04 / sandy silt not quite black / sulfur smell
			2	21.4	10/26/04	11:26	--			Overfilled – didn't use. No grab.
			3	20.7	10/26/04	11:33	17			Same as #1
			4	20.8	10/26/04	11:44	17			Same. Shells.
BBY07	122º 31.073	48º 43.138	1	16.9	10/26/04	12:54	17	8.03	8.17	Very thin light brown layer. Black under – sandy silt. Shells.
			2	17.5	10/26/04	13:10	17			Same, more worms
			3	16.1	10/26/04	13:20	15			Same, shell debris
BBY09	122º 31.190	48º 43.138	1	12.3	10/26/04	14:00	--	8.26	8.07	No grab -- sandy
			2	7.2	10/26/04	14:06	17			1-2 mm light brown, organic matter, shells, dark grey lower layer. Strong sulfide odor.
			3	13.4	10/26/04	14:17	--			No grab.
			4	15.1	10/26/04	14:24	--			No grab.
			5	14.7	10/26/04	14:33	8			Not enough material.
			6	16.9	10/26/04	14:42	--			Abandoned due to bad weather.
BBY10	122º 31.067	48º 43.141	1	10.8	10/26/04	15:05	14	7.85	--	Black sandy silt, some vegetation. Shells.
			2	12.3	10/26/04	15:25	14			Black – no light brown layer on top – sulfide smell.
			3	2.7	10/26/04	15:35	--			No grab.
			4	2.9	10/26/04	15:43	--			No grab.
BBY11	122º 31.077	48º 43.182	1	12.5	10/26/04	15:46	15	--	--	Light brown top layer, black under. Shells.

a NAD27 b Depths are not tide-adjusted

Appendix B. Bioassay Test Descriptions

Table B-1. Bioassay Descriptions and Test Criteria.

Bioassay test	**Amphipod**: A 10-day acute sediment toxicity test that assesses mortality of the amphipod, *Ampelisca abdita*.
Method	EPA (1994) and PSEP (1995)
No. replicates/sample	5
Endpoints	Mortality
Performance criteria	The control sediment shall have less than ten percent mortality over the test period. The reference sediment shall have less than twenty-five percent mortality. WAC 173-204-315(2).
Decision criteria	The test sediment has a higher (statistically significant, t test, $p \leq 0.05$) mean mortality than the reference sediment, and the test sediment mean mortality exceeds twenty-five percent, on an absolute basis. SQS exceedance. WAC 173-204-320(3). The test sediment has a higher (statistically significant, t test, $p \leq 0.05$) mean mortality than the reference sediment, and the test sediment mean mortality is greater than a value represented by the reference sediment mean mortality plus thirty percent. CSL exceedance. WAC 173-204-520(3).

Bioassay test	**Bivalve larval development**: A 48-hr sediment toxicity test that assesses abnormal development and mortality of mussel larvae (*Mytilus galloprovincialis*).
Method	PSEP (1995) and ASTM (1989)
No. replicates/sample	5
Endpoints	Developmental abnormality and mortality
Performance criteria	The seawater control sample shall have less than thirty percent combined abnormality and mortality (i.e., a seventy percent normal survivorship at time-final). WAC 173-204-315(2).
Decision criteria	The test sediment has a mean survivorship of normal larvae that is less (statistically significant, t test, $p \leq 0.05$) than the mean normal survivorship in the reference sediment, and the test sediment mean normal survivorship is less than eighty-five percent of the mean normal survivorship in the reference sediment (i.e., the test sediment has a mean combined abnormality and mortality that is greater than fifteen percent relative to time-final in the reference sediment). SQS exceedance. WAC 173-204-320(3). The test sediment has a mean survivorship of normal larvae that is less (statistically significant, t test, $p \leq 0.05$) than the mean normal survivorship in the reference sediment, and the test sediment mean normal survivorship is less than seventy percent of the mean normal survivorship in the reference sediment (i.e., the test sediment has a mean combined abnormality and mortality that is greater than thirty percent relative to time-final in the reference sediment). WAC 173-204-520(3).

Bioassay test	**Microtox®** 100 percent sediment porewater extract test: A rapid (15-min) method of assessing toxicity in aqueous media by utilizing the bioluminescent properties of the marine bacteria *Vibrio fischeri*. The test method assumes that light emitted by the bacteria can be used as an accurate assessment of the overall biological condition of the bacteria exposed to chemical compounds and mixtures. Light emitted by the bacteria exposed to potentially toxic samples is compared to light emitted to unexposed bacterial controls. Differences in luminescence are therefore deemed an indication of relative toxicity.
Method	Ecology Protocol
Reference	Ecology, 2003
No. replicates/sample	5
Endpoints	Light output (bioluminescence) after 5 min and 15 min exposure to test sample
Decision criteria	The mean light output of the highest concentration of the test sediment is less than eighty percent of the mean light output of the reference sediment, and the two means are statistically different from each other (t test, $p \leq 0.05$). SQS exceedance. WAC 173-204-320(3).

SQS - Sediment Quality Standard

CSL – Cleanup Screening Level

Appendix C. Data Quality Assessment

Table C-1: Quality Control Samples, Evaluation Criteria, and Assessment.

	Method Blank		Analytical Replicates[1]		Laboratory Control Sample[2]		Matrix Spike and Matrix Spike Duplicate	
Parameter	Number	Evaluation	Number	Evaluation	Number	Evaluation	Number	Evaluation
Grain Size	--		1 triplicate analysis[3]	Method Quality Objective: RSD ≤ 20 %[3] *Objective was met for all grain sizes except gravel*	--		--	
Total Organic Carbon (TOC)	1/batch	Analyte concentration < PQL[4] *Objective was met (concentration < 0.10%)*	1 triplicate analysis[3]	RSD ≤ 20 %[3] *Objective was met (RSD < 1%)*	--		--	
Total Sulfides	1/batch	Analyte concentration < PQL[4] *Objective was met (concentration < 10 mg/kg)*	1 triplicate analysis[3]	RSD ≤ 20 %[3] *Objective was met (RSD < 10%)*	1/batch	135-65% recovery[5] *Objective was met*	1 (MS only)	135-65% recovery[5] *Not evaluated. Analyte concentration in sample exceeded added spike concentration.*
Ammonia	1/batch	Analyte concentration < 100 µg/kg[4] *Concentration < 600 µg/kg)*	1 triplicate analysis[3]	RSD ≤ 20 %[3] *Objective was met (RSD < 2%)*	1/batch	135-65% recovery[5] *Objective was met*	1 (MS only)	135-65% recovery[5] *Objective was met*

RPD - Relative percent difference; RSD - Relative standard deviation; MS – Matrix spike

[1] Synonymous with Laboratory Replicates or, if applicable, Laboratory Duplicates.

[2] 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.

[3] Source: Sediment Sampling and Analysis Plan Appendix (Ecology, 2003), Table 13.

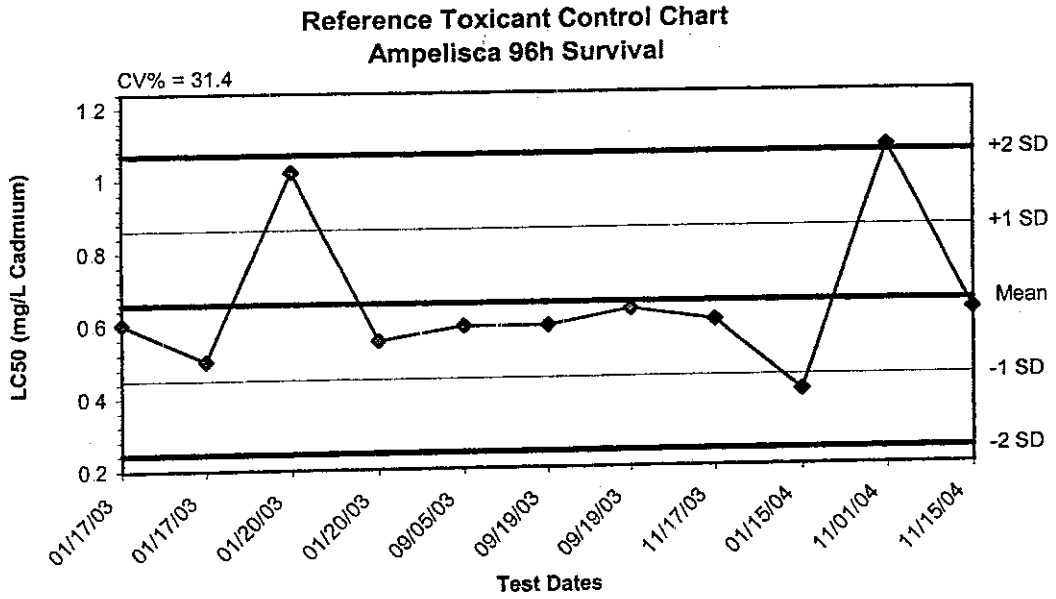
[4] Source: Sediment Sampling and Analysis Plan Appendix (Ecology, 2003), Table 11.
Recommended Practical Quantitation Limits (PQLs) for many analytes are provided in Table 5. Alternatively, the Method Detection Limit (MDL) may be used for this evaluation.
The PQL is also known as the EQL (Estimated Quantitation Limit).

[5] Source: Sediment Sampling and Analysis Plan Appendix (Ecology, 2003), Table 13.

Table C-2. Bioassay Reference Toxicant Test Results.

Species	Endpoint	Toxicant	Current result	Acceptable range (Mean ± 2SD)
A. abdita	Survival	Cadmium	0.63 mg/L	0.24 ± 1.07 mg/L
M. galloprovincialis	Normality	Copper	10.6 µg/L	8.6 – 16.1 µg/L
Microtox	Light reduction	Phenol	13.2 mg/L	4.3 ± 44.9 mg/L

SD – standard deviation



Dates	Values	Mean	-1 SD	-2 SD	+1 SD	+2 SD
01/17/03	0 6029	0 6560	0 4499	0 2437	0 8622	1 0683
01/17/03	0.5022	0 6560	0 4499	0.2437	0 8622	1 0683
01/20/03	1 0198	0 6560	0 4499	0.2437	0 8622	1 0683
01/20/03	0.5537	0.6560	0 4499	0 2437	0.8622	1.0683
09/05/03	0.5918	0 6560	0 4499	0.2437	0.8622	1.0683
09/19/03	0.5918	0.6560	0.4499	0 2437	0.8622	1.0683
09/19/03	0 6343	0 6560	0 4499	0.2437	0 8622	1.0683
11/17/03	0.6018	0.6560	0 4499	0 2437	0.8622	1.0683
01/15/04	0.4067	0.6560	0.4499	0.2437	0 8622	1 0683
11/01/04	1 0816	0 6560	0 4499	0 2437	0.8622	1.0683
11/15/04	0.6295	0.6560	0.4499	0.2437	0.8622	1.0683

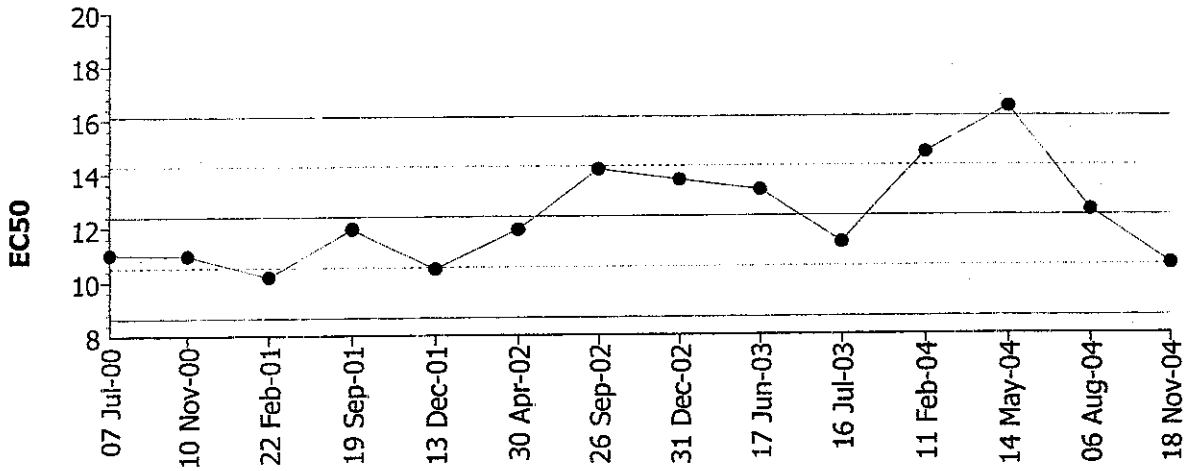
Figure C-1. Amphipod Bioassay Reference Toxicant Control Chart.

CETIS QC Chart

Report Date: 01 Dec-04 3:14 PM

Bivalve Larval Survival and Development Test — **Nautilus Environmental WA**

Test Type: Development-Survival | **Organism:** Mytilus species (Mussel) | **Material:** Copper chloride
Protocol: All Protocols | **Endpoint:** Proportion Normal | **Source:** Reference Toxicant-REF



Mean:	12 3852	**Count:**	14	**-1s Warning Limit:**	10 5151	**-2s Action Limit:**	8 64488
Sigma:	1 87017	**CV:**	15 10%	**+1s Warning Limit:**	14 2554	**+2s Action Limit:**	16 1256

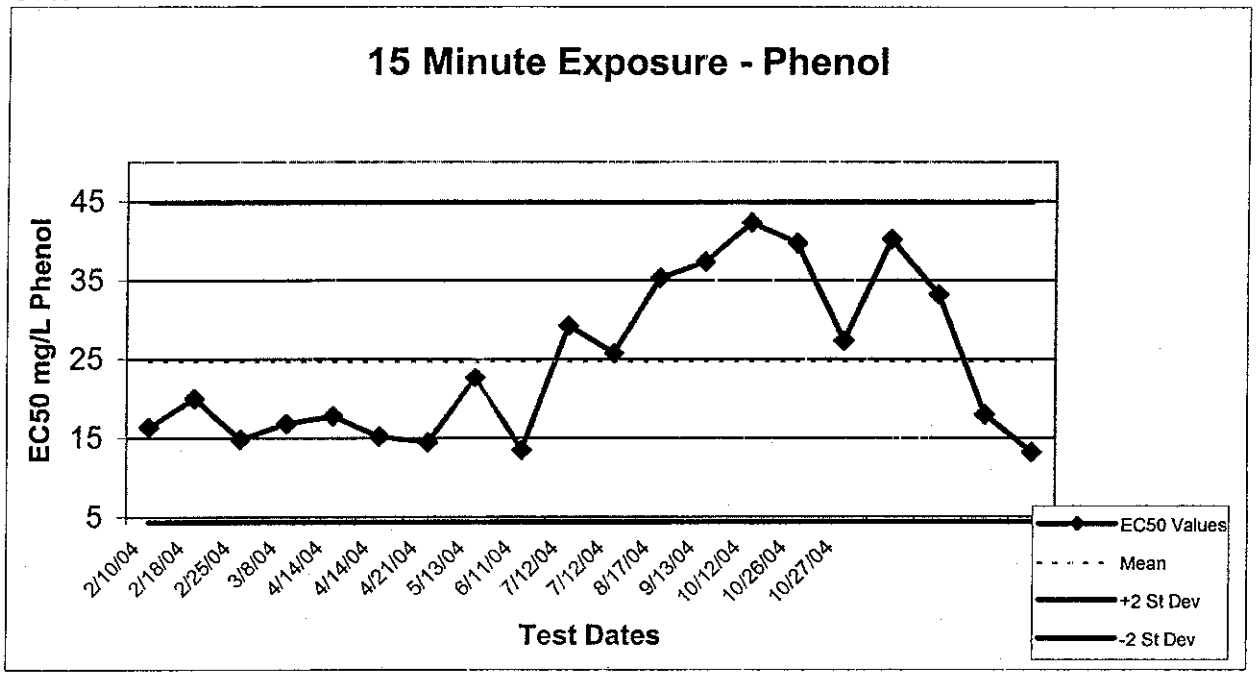
Quality Control Data

Point	Year	Month	Day	Data	Delta	Sigma	Warning	Action	Link	Analysis
1	2000	Jul	7	11 02289	-1 36233	-0 72845			06-2383-7231	15-8811-1925
2		Nov	10	10 95940	-1 42582	-0 76240			12-6715-4553	18-4408-2018
3	2001	Feb	22	10 17384	-2 21138	-1 18245	(-)		02-6026-4121	06-4875-1326
4		Sep	19	11 92993	-0 45529	-0 24345			06-0180-7815	07-6640-0477
5		Dec	13	10 45845	-1 92677	-1 03026	(-)		13-7973-3597	01-4641-0907
6	2002	Apr	30	11 89147	-0 49375	-0 26401			04-8237-8024	10-5534-2698
7		Sep	26	14 13118	1 74596	0 93359			06-1825-3281	11-5781-8920
8		Dec	31	13 73626	1 35104	0 72242			06-6952-1362	05-7226-1150
9	2003	Jun	17	13 34938	0 96416	0 51555			07-1875-9608	16-8768-6208
10		Jul	16	11 38739	-0 99783	-0 53355			08-1671-4723	17-4934-0332
11	2004	Feb	11	14 75596	2 37074	1 26766	(+)		08-8663-3521	09-8272-1438
12		May	14	16 47587	4 09065	2 18732	(+)	(+)	08-4172-1305	09-6138-3355
13		Aug	6	12 56354	0 17832	0 09535			13-9512-6563	04-0302-0220
14		Nov	18	10 55745	-1 82777	-0 97733			07-3088-1491	18-6894-4700

Figure C-2. Larval Bivalve Bioassay Reference Toxicant Control Chart.

Reference Toxicant Control Chart
Microtox 15-Minute Exposure

CV% = 41.2



Date	Time	EC50 %	EC50 mg/L Phenol [a]	Mean	StDev	-2 SD	+2 SD
2/10/04	1549	16.0	16.3	24.6	10.14	4.3	44.9
2/18/04	1522	19.6	20.0	24.6	10.1	4.3	44.9
2/25/04	1505	14.5	14.8	24.6	10.1	4.3	44.9
3/8/04	1310	16.4	16.8	24.6	10.1	4.3	44.9
4/14/04	1325	17.4	17.7	24.6	10.1	4.3	44.9
4/14/04	1513	14.9	15.1	24.6	10.1	4.3	44.9
4/21/04	1419	14.1	14.4	24.6	10.1	4.3	44.9
5/13/04	1717	22.2	22.6	24.6	10.1	4.3	44.9
6/11/04	1625	13.2	13.5	24.6	10.1	4.3	44.9
7/12/04	1344	28.6	29.2	24.6	10.1	4.3	44.9
7/12/04	1426	25.2	25.7	24.6	10.1	4.3	44.9
8/17/04	1759	34.6	35.3	24.6	10.1	4.3	44.9
9/13/04	1155	36.6	37.3	24.6	10.1	4.3	44.9
10/12/04	1239	41.4	42.3	24.6	10.1	4.3	44.9
10/26/04	1500	38.9	39.7	24.6	10.1	4.3	44.9
10/27/04	1531	26.7	27.3	24.6	10.1	4.3	44.9
12/3/04	1416	39.4	40.2	24.6	10.1	4.3	44.9
12/6/04	1057	32.5	33.2	24.6	10.1	4.3	44.9
12/15/04	1447	17.6	18.0	24.6	10.1	4.3	44.9
12/20/04	1606	12.9	13.2	24.6	10.1	4.3	44.9

a - Highest concentration of Phenol is 102 mg/L

Figure C-3. Microtox Bioassay Reference Toxicant Control Chart.

Appendix D. CTD Results

Table D-1. Edited data from the CTD (Conductivity-Temperature-Depth) recorder.

Station	Temperature [ITS-90, deg C]	Scan Count	Depth [salt water, m], lat = 48	Salinity [PSU]	Oxygen, Beckman/YSI [mg/l]	Descent Rate [m/s]	Number of scans per bin
BBY08	10.5	166	0.5	28.81	7.54	0.099	16
	10.5	176	1	28.81	7.49	0.398	3
	10.5	177	1.5	28.84	7.45	0.4	3
	10.5	180	2	28.87	7.44	0.386	3
	10.5	182	2.5	29.0	7.42	0.397	2
	10.5	185	3	29.04	7.37	0.398	3
	10.5	187	3.5	29.11	7.34	0.379	2
	10.5	190	4	29.16	7.35	0.438	3
	10.5	192	4.5	29.19	7.36	0.892	1
	10.5	193	5	29.19	7.26	0.856	1
	10.5	194	5.5	29.20	7.26	0.604	2
	10.5	198	6	29.22	7.27	0.197	5
	10.5	203	6.5	29.24	7.25	0.28	4
	10.5	206	7	29.25	7.24	0.404	2
	10.5	208	7.5	29.26	7.23	0.363	3
	10.5	211	8	29.27	7.20	0.41	2
	10.5	213	8.5	29.28	7.18	0.36	3
	10.5	216	9	29.29	7.14	0.416	3
	10.5	246	9.5	29.31	7.15	-0.03	50
BBY05	10.6	396	0.5	29.07	7.50	0.106	14
	10.6	405	1	29.06	6.85	0.339	3
	10.6	408	1.5	29.06	6.79	0.394	3
	10.6	410	2	29.06	6.86	0.367	3
	10.6	414	2.5	29.07	6.89	0.398	2
	10.6	415	3	29.07	6.91	0.404	3
	10.6	418	3.5	29.08	6.95	0.316	3
	10.6	421	4	29.09	6.98	0.402	3
	10.6	423	4.5	29.09	7.02	0.74	1
	10.6	424	5	29.08	7.02	0.797	1
	10.6	426	5.5	29.08	7.04	0.512	3
	10.6	430	6	29.08	7.05	0.21	5
	10.6	435	6.5	29.13	7.08	0.314	4
	10.6	437	7	29.16	7.07	0.295	3
	10.6	441	7.5	29.19	7.05	0.475	2
	10.6	442	8	29.21	7.06	0.438	2
	10.6	446	8.5	29.25	7.10	0.261	4
	10.5	449	9	29.26	7.09	0.438	2
	10.5	452	9.5	29.30	7.13	0.32	4

Station	Temperature [ITS-90, deg C]	Scan Count	Depth [salt water, m], lat = 48	Salinity [PSU]	Oxygen, Beckman/YSI [mg/l]	Descent Rate [m/s]	Number of scans per bin
	10.5	454	10	29.33	7.12	0.312	3
	10.5	458	11	29.36	7.10	0.35	3
	10.5	460	11	29.36	7.08	0.615	1
	10.5	463	12	29.37	7.08	0.335	4
	10.5	465	12	29.37	7.08	0.505	2
	10.5	468	13	29.37	7.05	0.251	4
	10.5	471	13	29.38	7.05	0.403	2
	10.5	476	14	29.38	7.02	0.144	4
	10.5	501	14	29.38	7.04	0.05	17
	10.5	519	15	29.38	7.03	0.032	15
	10.5	534	15	29.38	7.02	-0.08	2
BBY02	10.6	199	0.5	28.94	7.31	0.071	14
	10.6	213	1	28.94	7.39	0.86	1
	10.6	210	1.5	28.94	7.36	0.255	5
	10.6	213	2	28.94	7.35	0.291	4
	10.6	217	2.5	28.94	7.33	0.382	2
	10.6	220	3	28.94	7.35	0.313	4
	10.6	223	3.5	28.95	7.35	0.313	3
	10.6	226	4	28.94	7.35	0.35	3
	10.6	228	4.5	28.94	7.35	0.664	2
	10.6	230	5	28.95	7.35	0.669	1
	10.6	231	5.5	28.95	7.34	0.428	3
	10.6	236	6	28.96	7.34	0.181	6
BBY01	10.2	420	0.5	27.07	8.38	0.047	13
	10.2	429	1	27.14	8.30	0.431	3
	10.2	431	1.5	27.35	8.24	0.384	3
	10.3	433	2	27.64	8.14	0.454	2
	10.4	436	2.5	27.97	8.02	0.425	3
	10.4	438	3	28.16	7.92	0.53	1
	10.5	440	3.5	28.32	7.83	0.351	4
	10.5	444	4	28.49	7.73	0.632	1
	10.5	445	4.5	28.51	7.67	0.577	3
	10.5	447	5	28.56	7.56	0.677	1
	10.5	448	5.5	28.57	7.53	0.691	1
	10.6	451	6	28.72	7.47	0.266	5
	10.6	456	6.5	28.96	7.47	0.267	4
	10.6	459	7	29.01	7.49	0.376	3
	10.5	461	7.5	29.03	7.45	0.44	2
	10.5	464	8	29.04	7.30	0.372	2
	10.5	466	8.5	29.05	7.15	0.363	3
	10.6	470	9	29.12	7.06	0.358	3
	10.6	472	9.5	29.19	7.11	0.469	2

Station	Temperature [ITS-90, deg C]	Scan Count	Depth [salt water, m], lat = 48	Salinity [PSU]	Oxygen, Beckman/YSI [mg/l]	Descent Rate [m/s]	Number of scans per bin
	10.6	474	10	29.23	7.16	0.36	4
	10.6	477	11	29.26	7.20	0.443	2
	10.6	479	11	29.28	7.23	0.432	2
	10.6	482	12	29.28	7.24	0.412	3
	10.5	484	12	29.30	7.22	0.385	2
	10.5	487	13	29.33	7.17	0.371	3
	10.5	490	13	29.34	7.16	0.324	3
	10.5	493	14	29.34	7.14	0.422	2
	10.5	495	14	29.39	7.12	0.39	3
	10.5	498	15	29.40	7.07	0.429	2
	10.5	500	15	29.43	7.05	0.349	3
	10.5	503	16	29.44	7.03	0.385	3
	10.5	506	16	29.45	7.01	0.41	2
	10.5	508	17	29.45	7.00	0.354	3
	10.5	511	17	29.46	6.96	0.475	3
	10.5	513	18	29.46	6.88	0.48	1
	10.5	515	18	29.47	6.75	0.458	3
	10.4	517	19	29.50	6.67	0.434	2
	10.4	520	19	29.57	6.54	0.251	3
	10.4	523	20	29.61	6.46	0.315	4
	10.4	526	20	29.64	6.36	0.397	2
	10.4	529	21	29.66	6.32	0.335	3
	10.4	578	21	29.69	6.25	0.063	117
BBY04	10.4	441	0.5	28.78	7.54	0.036	16
	10.4	452	1	28.90	7.67	0.363	3
	10.4	453	1.5	28.95	7.65	0.442	3
	10.4	455	2	28.99	7.52	0.372	3
	10.4	458	2.5	29.03	7.25	0.422	2
	10.4	460	3	29.06	7.06	0.475	2
	10.5	463	3.5	29.16	6.91	0.388	3
	10.5	465	4	29.35	6.83	0.6	2
	10.5	467	4.5	29.42	6.82	0.828	1
	10.5	468	5	29.48	6.82	0.876	1
	10.5	469	5.5	29.53	6.82	0.699	1
	10.4	472	6	29.64	6.90	0.247	5
	10.4	476	6.5	29.70	6.94	0.355	3
	10.4	479	7	29.71	6.94	0.358	3
	10.4	481	7.5	29.71	6.92	0.502	2
	10.4	483	8	29.72	6.91	0.562	1
	10.4	485	8.5	29.72	6.91	0.435	3
	10.4	488	9	29.72	6.92	0.448	2
	10.4	490	9.5	29.72	6.92	0.481	2
	10.4	492	10	29.72	6.92	0.432	3
	10.4	494	11	29.72	6.90	0.457	2

Station	Temperature [ITS-90, deg C]	Scan Count	Depth [salt water, m], lat = 48	Salinity [PSU]	Oxygen, Beckman/YSI [mg/l]	Descent Rate [m/s]	Number of scans per bin
	10.4	496	11	29.72	6.90	0.533	2
	10.4	498	12	29.72	6.91	0.503	2
	10.4	500	12	29.72	6.91	0.469	2
	10.4	502	13	29.72	6.90	0.448	2
	10.4	505	13	29.73	6.87	0.412	3
	10.4	507	14	29.73	6.83	0.455	2
	10.4	510	14	29.73	6.79	0.489	2
	10.4	511	15	29.73	6.78	0.488	2
	10.4	514	15	29.74	6.79	0.386	3
	10.4	517	16	29.74	6.78	0.622	1
	10.4	518	16	29.74	6.76	0.43	3
	10.4	522	17	29.74	6.72	0.217	7
	10.4	600	17	29.76	6.65	-0.07	73
BBY06	10.4	362	0.5	28.78	7.68	0.07	16
	10.4	372	1	28.77	7.72	0.414	3
	10.4	374	1.5	28.80	7.65	0.412	3
	10.4	376	2	28.88	7.60	0.348	4
	10.4	379	2.5	29.01	7.53	0.404	2
	10.4	381	3	29.07	7.39	0.418	2
	10.4	384	3.5	29.11	7.15	0.343	3
	10.5	387	4	29.15	7.09	0.397	3
	10.5	389	4.5	29.23	7.09	0.621	2
	10.5	391	5	29.27	7.06	0.709	1
	10.5	392	5.5	29.32	7.02	0.6	1
	10.5	396	6	29.39	6.96	0.218	7
	10.5	401	6.5	29.43	6.92	0.266	3
	10.5	404	7	29.47	6.92	0.311	3
	10.5	408	7.5	29.49	6.92	0.362	3
	10.5	410	8	29.50	6.84	0.454	2
	10.5	413	8.5	29.52	6.76	0.318	4
	10.5	416	9	29.54	6.73	0.372	3
	10.5	418	9.5	29.56	6.71	0.386	2
	10.5	421	10	29.56	6.71	0.32	4
CR2	14.6	338	1	29.97	9.09	0.219	4
	14.5	345	1.5	29.99	8.75	0.338	4
	14.5	347	2	29.99	8.32	0.289	4
	14.4	351	2.5	30.00	7.65	0.25	4
	14.3	355	3	30.01	6.85	0.303	3
	14.2	359	3.5	30.04	6.70	0.257	4
	14.2	363	4	30.04	6.45	0.299	4
	14.2	365	4.5	30.04	6.00	0.515	2
	14.1	367	5	30.05	5.72	0.577	1

Station	Temperature [ITS-90, deg C]	Scan Count	Depth [salt water, m], lat = 48	Salinity [PSU]	Oxygen, Beckman/YSI [mg/l]	Descent Rate [m/s]	Number of scans per bin
	14.1	369	5.5	30.06	5.33	0.39	3
	13.9	374	6	30.10	5.00	0.17	7
	13.8	380	6.5	30.11	4.90	0.236	4
	13.8	384	7	30.13	4.84	0.251	4
	13.8	388	7.5	30.13	4.51	0.323	4
	13.8	390	8	30.14	4.31	0.354	2
	13.7	394	8.5	30.14	4.09	0.276	4
	13.7	397	9	30.14	4.14	0.334	3
	13.7	400	9.5	30.14	4.45	0.331	3
	13.7	404	10	30.14	4.71	0.247	4
	13.7	407	11	30.15	4.83	0.324	3
	13.7	410	11	30.16	4.84	0.369	3
	13.6	413	12	30.15	4.82	0.347	3
	13.6	416	12	30.15	4.74	0.297	3
	13.6	419	13	30.15	4.61	0.309	4
	13.6	423	13	30.15	4.51	0.306	3
	13.6	426	14	30.15	4.32	0.285	3
	13.6	430	14	30.15	4.23	0.357	3
	13.6	432	15	30.15	4.22	0.332	3
	13.6	436	15	30.15	4.21	0.244	4
	13.6	441	16	30.15	4.26	-0.159	2

Appendix E. Bioassay Test Results

Table E-1. 10-day Amphipod Survival (*Ampelisca abdita*), Bellingham Bay Sediments - Test Initiated November 12, 2004

Lab ID Site ID	Replicate	Number Survived	% Survival	Mean % Survival	Standard Deviation
Control	1	16	80	90.0	11.7
	2	19	95		
	3	15	75		
	4	20	100		
	5	20	100		
414092 CR02	1	19	95	81.0	8.9
	2	16	80		
	3	14	70		
	4	16	80		
	5	16	80		
444080 BBY01	1	17	85	83.0	9.1
	2	14	70		
	3	19	95		
	4	17	85		
	5	16	80		
444081 BBY02	1	15	75	75.0	7.9
	2	17	85		
	3	14	70		
	4	13	65		
	5	16	80		
444082 BBY03	1	8	40	69.0	17.5
	2	14	70		
	3	17	85		
	4	14	70		
	5	16	80		
444083 BBY04	1	12	60	75.0	14.1
	2	18	90		
	3	17	85		
	4	12	60		
	5	16	80		
444084 BBY05	1	16	80	85.0	7.9
	2	18	90		
	3	19	95		
	4	15	75		
	5	17	85		
444086 BBY06	1	15	75	74.0	2.2
	2	15	75		
	3	15	75		
	4	14	70		
	5	15	75		
444087 BBY07	1	14	70	79.0	8.9
	2	16	80		
	3	18	90		
	4	17	85		
	5	14	70		
444088 BBY08	1	18	90	79.0	7.4
	2	16	80		
	3	16	80		
	4	14	70		
	5	15	75		
444089 BBY09	1	0	0	53.0	30.5
	2	11	55		
	3	13	65		
	4	14	70		
	5	15	75		
444090 BBY10	1	12	60	72.0	15.2
	2	16	80		
	3	19	95		
	4	13	65		
	5	12	60		

Table E-2. 48-Hr Bivalve Larval Development Test (*Mytilus galloprovincialis*), Bellingham Bay Sediments - Test Initiated November 17, 2004

Lab ID Site ID	Rep	Initial Density	Number Survived	Proportion Survived	Mean Prop. Survived	Standard Deviation	Number Normal	Prop. Normal	Mean Prop. Normal	Standard Deviation	Combined Prop. Surv./Normal	Mean Combined Prop. Surv./Normal	Standard Deviation
Control	1	292	221	0.757	**0.876**	**0.107**	204	0.923	**0.873**	**0.035**	0.699	**0.764**	**0.093**
	2		260	0.890			230	0.885			0.788		
	3		267	0.914			230	0.861			0.788		
	4		300	1.027			261	0.870			0.894		
	5		231	0.791			191	0.827			0.654		
414092 Ref CR02	1		210	0.719	**0.765**	**0.139**	184	0.876	**0.910**	**0.027**	0.630	**0.696**	**0.127**
	2		263	0.901			237	0.901			0.812		
	3		162	0.555			152	0.938			0.521		
	4		256	0.877			240	0.938			0.822		
	5		226	0.774			203	0.898			0.695		
444080 BBY01	1		262	0.897	**0.866**	**0.120**	225	0.859	**0.899**	**0.058**	0.771	**0.775**	**0.095**
	2		266	0.911			239	0.898			0.818		
	3		245	0.839			206	0.841			0.705		
	4		198	0.678			196	0.990			0.671		
	5		293	1.003			266	0.908			0.911		
444081 BBY02	1		302	1.034	**0.887**	**0.191**	275	0.911	**0.888**	**0.034**	0.942	**0.792**	**0.193**
	2		282	0.966			253	0.897			0.866		
	3		167	0.572			142	0.850			0.486		
	4		297	1.017			275	0.926			0.942		
	5		247	0.846			211	0.854			0.723		
444082 BBY03	1		225	0.771	**0.779**	**0.052**	207	0.920	**0.887**	**0.025**	0.709	**0.691**	**0.054**
	2		242	0.829			215	0.888			0.736		
	3		243	0.832			217	0.893			0.743		
	4		220	0.753			187	0.850			0.640		
	5		207	0.709			183	0.884			0.627		
444083 BBY04	1		218	0.747	**0.794**	**0.061**	202	0.927	**0.881**	**0.028**	0.692	**0.699**	**0.052**
	2		208	0.712			179	0.861			0.613		
	3		244	0.836			217	0.889			0.743		
	4		249	0.853			215	0.863			0.736		
	5		240	0.822			208	0.867			0.712		
444084 BBY05	1		277	0.949	**0.908**	**0.123**	244	0.881	**0.885**	**0.013**	0.836	**0.803**	**0.110**
	2		302	1.034			272	0.901			0.932		
	3		285	0.976			249	0.874			0.853		
	4		251	0.860			219	0.873			0.750		
	5		210	0.719			188	0.895			0.644		
444086 BBY06	1		254	0.870	**0.843**	**0.053**	222	0.874	**0.874**	**0.013**	0.760	**0.737**	**0.049**
	2		266	0.911			230	0.865			0.788		
	3		232	0.795			202	0.871			0.692		
	4		229	0.784			198	0.865			0.678		
	5		250	0.856			224	0.896			0.767		
444087 BBY07	1		240	0.822	**0.882**	**0.109**	219	0.913	**0.897**	**0.019**	0.750	**0.790**	**0.088**
	2		306	1.048			270	0.882			0.925		
	3		272	0.932			243	0.893			0.832		
	4		226	0.774			208	0.920			0.712		
	5		243	0.832			213	0.877			0.729		
444088 BBY08	1		226	0.774	**0.855**	**0.122**	204	0.903	**0.894**	**0.025**	0.699	**0.766**	**0.123**
	2		219	0.750			189	0.863			0.647		
	3		226	0.774			200	0.885			0.685		
	4		292	1.000			260	0.890			0.890		
	5		285	0.976			265	0.930			0.908		
444089 BBY09	1		243	0.832	**0.777**	**0.048**	232	0.955	**0.922**	**0.034**	0.795	**0.716**	**0.047**
	2		227	0.777			209	0.921			0.716		
	3		214	0.733			200	0.935			0.685		
	4		212	0.726			198	0.934			0.678		
	5		238	0.815			206	0.866			0.705		
444090 BBY10	1		294	1.007	**0.793**	**0.196**	257	0.874	**0.886**	**0.024**	0.880	**0.703**	**0.171**
	2		202	0.692			186	0.921			0.637		
	3		281	0.962			247	0.879			0.846		
	4		155	0.531			133	0.858			0.455		
	5		226	0.774			203	0.898			0.695		

Initial Density

Rep	Number Counted
1	289
2	274
3	286
4	295
5	316
Mean	**292**
St.Dev.	15.4
CV (%)	5.3

Table E-3a. Microtox 100 Percent Sediment Porewater Test, Bellingham Bay Sediments - Test Date: December 20, 2004

Lab ID / Site ID	Reading	Light Reading Replicate 1	2	3	4	5	Mean	92 (Ref) $T_{(mean)}/R_{(mean)}$	Control $T_{(mean)}/C_{(mean)}$	Change in light readings compared to initial control $I_{(t)(mean)}/I_{(0)C(mean)}$	Change in light readings compared to final control $I_{(t)(mean)}/I_{(t)C(mean)}$	Evaluation of initial light output $I_{(0)(mean)}/I_{(0)C(mean)}$
Control	$I_{(0)}$	96	99	89	107	95	97					
	$I_{(5)}$	99	104	95	114	97	102			1.05		
	$I_{(15)}$	101	107	97	116	101	104			1.07		
	$C_{(5)}$	1.03	1.05	1.07	1.07	1.02	1.05					
	$C_{(15)}$	1.05	1.08	1.09	1.08	1.06	1.07					
414092 Ref CR02	$I_{(0)}$	89	93	75	69	84	82					0.84
	$I_{(5)}$	97	98	80	73	90	88				0.86	
	$I_{(15)}$	98	102	82	75	91	90				0.86	
	$R_{(5)}$	1.09	1.05	1.07	1.06	1.07	1.07					
	$R_{(15)}$	1.10	1.10	1.09	1.09	1.08	1.09					
444080 BBY01	$I_{(0)}$	77	91	95	102	97	92					0.95
	$I_{(5)}$	82	100	102	110	105	100					
	$I_{(15)}$	85	102	106	115	110	104					
	$T_{(5)}$	1.06	1.10	1.07	1.08	1.08	1.08	1.01	1.03			
	$T_{(15)}$	1.10	1.12	1.12	1.13	1.13	1.12	1.03	1.04			
444081 BBY02	$I_{(0)}$	89	83	96	79	91	88					0.90
	$I_{(5)}$	95	88	102	84	98	93					
	$I_{(15)}$	97	91	105	87	100	96					
	$T_{(5)}$	1.07	1.06	1.06	1.06	1.08	1.07	1.00	1.02			
	$T_{(15)}$	1.09	1.10	1.09	1.10	1.10	1.10	1.00	1.02			
444082 BBY03	$I_{(0)}$	79	75	72	81	86	79					0.81
	$I_{(5)}$	84	81	76	85	92	84					
	$I_{(15)}$	87	83	80	89	95	87					
	$T_{(5)}$	1.06	1.08	1.06	1.05	1.07	1.06	1.00	1.02			
	$T_{(15)}$	1.10	1.11	1.11	1.10	1.10	1.10	1.01	1.03			
444083 BBY04	$I_{(0)}$	91	70	70	78	78	77					0.80
	$I_{(5)}$	95	70	75	83	83	81					
	$I_{(15)}$	101	73	77	85	85	84					
	$T_{(5)}$	1.04	1.00	1.07	1.06	1.06	1.05	0.98	1.00			
	$T_{(15)}$	1.11	1.04	1.10	1.09	1.09	1.09	0.99	1.01			

$I_{(0)}$ is the light reading after the initial five minute incubation period

$I_{(5)}$ is the light reading five minutes after $I_{(0)}$

$I_{(15)}$ is the light reading fifteen minutes after $I_{(0)}$

$C_{(t)}$, $R_{(t)}$, and $T_{(t)}$ are the changes in light readings from the initial reading in each sample container for the control, reference sediment and test sites.

Quality Control Steps:

1. Is control final mean output greater than 80% control initial mean output?

$I_{(5)}$: $F_{c(mean)}/I_{c(mean)}$=105%

$I_{(15)}$: $F_{c(mean)}/I_{c(mean)}$=107%

Control results are acceptable

2. Does the reference final mean exceed 80% of control final mean?

$I_{(5)}$: $F_{R(mean)}/F_{C(mean)}$=86%

$I_{(15)}$: $F_{R(mean)}/F_{C(mean)}$=86%

The reference site (92) is acceptable to use in statistical analyses.

3. Is the reference initial mean > 80% of control initial mean?

$I_{R(mean)}/I_{C(mean)}$=84%

Use reference initial readings to calculate change in light readings at $I_{(5)}$ and $I_{(15)}$ for reference site.

4. Are test initial mean values > 80% of control initial mean values?

80: $I_{T(mean)}/I_{C(mean)}$=95%, use site initial readings to calculate change in light readings.

81: $I_{T(mean)}/I_{C(mean)}$)=90%, use site initial readings to calculate change in light readings.

82: $I_{T(mean)}/I_{C(mean)}$=81%, use site initial readings to calculate change in light readings.

83: $I_{T(mean)}/I_{C(mean)}$)=80%, use site initial readings to calculate change in light readings.

Table E-3b. Microtox 100 Percent Sediment Porewater Test, Bellingham Bay Sediments - Test Date: December 20, 2004

Site	Light Reading Replicate							92 (Ref)	Control	Change in light readings compared to initial control	Change in light readings compared to final control	Evaluation of initial light output
	Reading	1	2	3	4	5	Mean	$T_{(mean)}/R_{(mean)}$	$T_{(mean)}/C_{(mean)}$	$I_{(t)(mean)}/I_{(0)C(mean)}$	$I_{(t)(mean)}/I_{(t)C(mean)}$	$I_{(0)(mean)}/I_{(0)C(mean)}$
Control	$I_{(0)}$	95	89	93	96	111	97					
	$I_{(5)}$	101	94	99	100	115	102			1.05		
	$I_{(15)}$	107	100	105	105	115	106			1.10		
	$C_{(5)}$	1.06	1.06	1.06	1.04	1.04	1.05					
	$C_{(15)}$	1.13	1.12	1.13	1.09	1.04	1.10					
414092 Ref CR02	$I_{(0)}$	96	81	91	94	103	93					0.96
	$I_{(5)}$	100	84	94	95	106	96				0.94	
	$I_{(15)}$	99	84	92	97	103	95				0.89	
	$R_{(5)}$	1.04	1.04	1.03	1.01	1.03	1.03					
	$R_{(15)}$	1.03	1.04	1.01	1.03	1.00	1.02					
444084 BBY05	$I_{(0)}$	32	33	32	32	35	33					0.34
	$I_{(5)}$	29	30	29	30	32	30					
	$I_{(15)}$	40	40	38	40	43	40					
	$T_{(5)}$	0.30	0.31	0.30	0.31	0.33	0.31	0.30	0.29			
	$T_{(15)}$	0.41	0.41	0.39	0.41	0.44	0.42	0.41	0.38			
444086 BBY06	$I_{(0)}$	78	83	86	83	71	80					0.83
	$I_{(5)}$	82	88	91	87	74	84					
	$I_{(15)}$	90	95	99	95	80	92					
	$T_{(5)}$	1.05	1.06	1.06	1.05	1.04	1.05	1.02	1.00			
	$T_{(15)}$	1.15	1.14	1.15	1.14	1.13	1.14	1.12	1.04			
444087 BBY07	$I_{(0)}$	89	85	80	88	86	86					0.88
	$I_{(5)}$	94	90	84	94	91	91					
	$I_{(15)}$	101	97	92	102	99	98					
	$T_{(5)}$	1.06	1.06	1.05	1.07	1.06	1.06	1.03	1.01			
	$T_{(15)}$	1.13	1.14	1.15	1.16	1.15	1.15	1.12	1.04			
444088 BBY08	$I_{(0)}$	54	66	54	57	76	61					0.63
	$I_{(5)}$	55	68	55	58	78	63					
	$I_{(15)}$	60	73	61	63	85	68					
	$T_{(5)}$	0.57	0.70	0.57	0.60	0.81	0.65	0.63	0.62			
	$T_{(15)}$	0.62	0.75	0.63	0.65	0.88	0.71	0.69	0.64			

$I_{(0)}$ is the light reading after the initial five minute incubation period

$I_{(5)}$ is the light reading five minutes after $I_{(0)}$

$I_{(15)}$ is the light reading fifteen minutes after $I_{(0)}$

$C_{(t)}$, $R_{(t)}$, and $T_{(t)}$ are the changes in light readings from the initial reading in each sample container for the control, reference sediment and test sites.

Quality Control Steps:

1. Is control final mean output greater than 80% control initial mean output?

$I_{(5)}$: $F_{c(mean)}/I_{c(mean)}$=105%

$I_{(15)}$: $F_{c(mean)}/I_{c(mean)}$=110%

Control results are acceptable

2. Does the reference final mean exceed 80% of control final mean?

$I_{(5)}$: $F_{R(mean)}/F_{C(mean)}$=94%

$I_{(15)}$: $F_{R(mean)}/F_{C(mean)}$=89%

The reference site (92) is acceptable to use in statistical analyses

3. Is the reference initial mean > 80% of control initial mean?

$I_{R(mean)}/I_{C(mean)}$=96%

Use reference initial readings to calculate change in light readings at $I_{(5)}$ and $I_{(15)}$ for reference site.

4. Are test initial mean values > 80% of control initial mean values?

84: $I_{T(mean)}/I_{C(mean)}$=34%, use control initial mean to calculate change in light readings.

86: $I_{T(mean)}/I_{C(mean)}$=83%, use site initial readings to calculate change in light readings.

87: $I_{T(mean)}/I_{C(mean)}$=88%, use site initial readings to calculate change in light readings.

88: $I_{T(mean)}/I_{C(mean)}$=63%, use control initial mean to calculate change in light readings.

Table E-3c. Microtox 100 Percent Sediment Porewater Test, Bellingham Bay Sediments - Test Date: December 20, 2004

Lab ID / Site ID	Reading	Light Reading Replicate 1	2	3	4	5	Mean	92 (Ref) $T_{(mean)}/R_{(mean)}$	Control $T_{(mean)}/C_{(mean)}$	Change in light readings compared to initial control $I_{(t)(mean)}/I_{(0)C(mean)}$	Change in light readings compared to final control $I_{(t)(mean)}/I_{(t)C(mean)}$	Evaluation of initial light output $I_{(0)(mean)}/I_{(0)C(mean)}$
Control	$I_{(0)}$	95	101	119	95	109	104					
	$I_{(5)}$	97	103	149	97	112	112			1.08		
	$I_{(15)}$	101	108	125	101	118	111			1.07		
	$C_{(5)}$	1.02	1.02	1.25	1.02	1.03	1.07					
	$C_{(15)}$	1.06	1.07	1.05	1.06	1.08	1.07					
414092 Ref CR02	$I_{(0)}$	103	98	102	98	107	102					0.98
	$I_{(5)}$	101	95	100	95	106	99				0.89	
	$I_{(15)}$	100	96	100	95	106	99				0.90	
	$R_{(5)}$	0.98	0.97	0.98	0.97	0.99	0.98					
	$R_{(15)}$	0.97	0.98	0.98	0.97	0.99	0.98					
444089 BBY09	$I_{(0)}$	22	21	22	23	20	22					0.21
	$I_{(5)}$	16	16	16	16	15	16					
	$I_{(15)}$	18	17	17	17	17	17					
	$T_{(5)}$	0.15	0.15	0.15	0.15	0.14	0.15	0.16	0.14			
	$T_{(15)}$	0.17	0.16	0.16	0.16	0.16	0.17	0.17	0.16			
444090 BBY10	$I_{(0)}$	4	29	23	23	24	21					0.20
	$I_{(5)}$	3	27	20	21	24	19					
	$I_{(15)}$	5	38	26	27	33	26					
	$T_{(5)}$	0.03	0.26	0.19	0.20	0.23	0.18	0.19	0.17			
	$T_{(15)}$	0.05	0.37	0.25	0.26	0.32	0.25	0.25	0.23			

$I_{(0)}$ is the light reading after the initial five minute incubation period

$I_{(5)}$ is the light reading five minutes after $I_{(0)}$

$I_{(15)}$ is the light reading fifteen minutes after $I_{(0)}$

$C_{(t)}$, $R_{(t)}$, and $T_{(t)}$ are the changes in light readings from the initial reading in each sample container for the control, reference sediment and test sites.

Quality Control Steps:

1. Is control final mean output greater than 80% control initial mean output?

$I_{(5)}$: $F_{c(mean)}/I_{c(mean)}$=108%

$I_{(15)}$: $F_{c(mean)}/I_{c(mean)}$=107%

Control results are acceptable

2. Does the reference final mean exceed 80% of control final mean?

$I_{(5)}$: $F_{R(mean)}/F_{C(mean)}$=89%

$I_{(15)}$: $F_{R(mean)}/F_{C(mean)}$=90%

The reference site (92) is acceptable to use in statistical analyses

3. Is the reference initial mean > 80% of control initial mean?

$I_{R(mean)}/I_{C(mean)}$=98%

Use reference initial readings to calculate change in light readings at $I_{(5)}$ and $I_{(15)}$ for reference site.

4. Are test initial mean values > 80% of control initial mean values?

89: $I_{T(mean)}/I_{C(mean)}$=21%, use control initial mean to calculate change in light readings.

90: $I_{T(mean)}/I_{C(mean)}$)=20%, use control initial mean to calculate change in light readings.

Table E-4. Bioassay Endpoint Evaluation

Bioassay Test	Station	Endpoint	Statistical Difference from Control	Statistical Difference from Reference	SQS Exceedance		CSL Exceedance		SQS Biological Criteria (Pass/Fail)	CSL Biological Criteria (Pass/Fail)
					Absolute Criterion Relative to Control	Absolute Criterion Relative to Reference	Absolute Criterion Relative to Control	Absolute Criterion Relative to Reference		
Amphipod		Survival	*t-test, p=0.05*		*Mortality > 25%*		*Mortality > 30%*			
	BBY01		No	NA	No	No	No	No	Pass	Pass
	BBY02		**Yes**	No	No	No	No	No	Pass	Pass
	BBY03		**Yes**	No	No	No	No	No	Pass	Pass
	BBY04		**Yes**	No	No	No	No	No	Pass	Pass
	BBY05		No	NA	No	No	No	No	Pass	Pass
	BBY06		**Yes**[1]	No[1]	No	No	No	No	Pass	Pass
	BBY07		No	No	No	No	No	No	Pass	Pass
	BBY08		No	No	No	No	No	No	Pass	Pass
	BBY09		**Yes**	No	**Yes**	**Yes**	**Yes**	No	**Fail**	**Fail**
	BBY10		No	No	No	No	No	No	Pass	Pass
	CR02		No	--	No	No	No	No		
Bivalve Larva		Survival of normal larvae	*t-test, p=0.05*		$(N_N/N_0)_{test} < (0.85)(N_N/N_0)_{control}$ $(N_N/N_0)_{test} < (0.85)(N_N/N_0)_{reference}$		$(N_N/N_0)_{test} < (0.70)(N_N/N_0)_{control}$ $(N_N/N_0)_{test} < (0.70)(N_N/N_0)_{reference}$			
	BBY01		NA	NA	No	No	No	No	Pass	Pass
	BBY02		NA	NA	No	No	No	No	Pass	Pass
	BBY03		No	No	No	No	No	No	Pass	Pass
	BBY04		No	NA	No	No	No	No	Pass	Pass
	BBY05		NA	NA	No	No	No	No	Pass	Pass
	BBY06		No	NA	No	No	No	No	Pass	Pass
	BBY07		NA	NA	No	No	No	No	Pass	Pass
	BBY08		NA	NA	No	No	No	No	Pass	Pass
	BBY09		No	NA	No	No	No	No	Pass	Pass
	BBY10		No	NA	No	No	No	No	Pass	Pass
	CR02		No	--	No	--	No	--		

Bioassay Test	Station	Endpoint	Statistical Difference from Control	Statistical Difference from Reference	SQS Exceedance		CSL Exceedance		SQS Biological Criteria (Pass/Fail)	CSL Biological Criteria (Pass/Fail)
					Absolute Criterion Relative to Control	Absolute Criterion Relative to Reference	Absolute Criterion Relative to Control	Absolute Criterion Relative to Reference		
Microtox - 5 min		Light output	*t-test, p=0.05*		*Test $_{mean}$ /Reference $_{mean}$ <0.8*		*Not applicable*			*Not applicable*
	BBY01		--	NA	--	No			Pass	
	BBY02		--	NA	--	No			Pass	
	BBY03		--	No	--	No			Pass	
	BBY04		--	No	--	No			Pass	
	BBY05		--	**Yes**	--	**Yes**			**Fail**	
	BBY06		--	NA	--	No			Pass	
	BBY07		--	NA	--	No			Pass	
	BBY08		--	**Yes**[1]	--	**Yes**			**Fail**	
	BBY09		--	**Yes**[1]	--	**Yes**			**Fail**	
	BBY10		--	**Yes**[1]	--	**Yes**			**Fail**	
Microtox - 15 min		Light output	*t-test, p=0.05*		*Test $_{mean}$ /Reference $_{mean}$ <0.8*		*Not applicable*			*Not applicable*
	BBY01		--	NA	--	No			Pass	
	BBY02		--	NA	--	No			Pass	
	BBY03		--	NA	--	No			Pass	
	BBY04		--	NA	--	No			Pass	
	BBY05		--	**Yes**	--	**Yes**			**Fail**	
	BBY06		--	NA	--	No			Pass	
	BBY07		--	NA	--	No			Pass	
	BBY08		--	**Yes**[1]	--	**Yes**			**Fail**	
	BBY09		--	**Yes**[1]	--	**Yes**			**Fail**	
	BBY10		--	**Yes**[1]	--	**Yes**			**Fail**	

[1] Welch's correction applied to unequal variance.

N_N = number normal larvae, N_0 = initial larval density. See Table E-2.

Appendix F. Case Narratives

State of Washington Department of Ecology
Manchester Environmental Laboratory
7411 Beach Drive East, Port Orchard WA. 98366

November 19, 2004

Project: Bellingham Bay

Samples: 44-4080-84, 4086-88, 4090, 4092

Laboratory: Analytical Resources, Inc.

By: Pam Covey

Case Summary

These ten sediment samples required Grain Size analyses using Puget Sound Estuary Protocol (PSEP) method. The samples were received at the Manchester Environmental Laboratory and taken to the contract lab on October 29, 2004 for Grain Size analyses.

The analyses were reviewed for qualitative and quantitative accuracy, validity and usefulness. One sample was analyzed in triplicate and was within QA requirements. The results are acceptable for use as reported.

State of Washington Department of Ecology
Manchester Environmental Laboratory
7411 Beach Dr E, Port Orchard, Washington 98366

Case Narrative
November 17, 2004

Subject: General Chemistry Bellingham Bay/Post Point

Project No: 186904

Officer: Nigel Blakely

By: Dean Momohara

Summary

The samples were analyzed by the following methods: Standard Methods 2540GC for percent solids and PSEP-TOC for total organic carbon (TOC).

All analyses requested were evaluated by established regulatory quality assurance guidelines.

Sample Information

Samples were received by Manchester Environmental Laboratory on 10/28/04. All coolers were received within the proper temperature range of 0°C - 6°C. All samples were received in good condition. Eleven (11) samples were received and assigned laboratory identification numbers 444080 – 444084, 444086 – 444090 and 444092.

Holding Times

All analyses were performed within established EPA holding times.

Calibration

Instrument calibrations and calibration checks were performed in accordance with the appropriate method. All initial and continuing calibration checks were within control limits. The calibration correlation coefficient for TOC was within the acceptance range of 1.000 - 0.995. Balances are professionally calibrated yearly and calibrated in-house daily. Oven temperatures were recorded before and after each analysis batch and were within acceptable limits.

Method Blanks

No analytically significant levels of analyte were detected in the method blanks associated with these samples.

Matrix Spikes

NA

Replicates

The TOC duplicate relative percent difference was within the acceptance range of 0% - 20%.

Laboratory Control Samples

The TOC laboratory control sample recovery was within the acceptance limits of 80% - 120%.

Other Quality Assurance Measures and Issues

All internal standard recoveries for TP analysis (ICPMS) were within acceptance limits.

U - The analyte was not detected at or above the reported result.
bold - The analyte was present in the sample. (Visual Aid to locate detected compounds on report sheet.)

Please call Dean Momohara at (360) 871-8808 to further discuss this project.

cc: Project File

Data Qualifier Codes

U	-	The analyte was not detected at or above the reported result.
J	-	The analyte was positively identified. The associated numerical result is an estimate.
UJ	-	The analyte was not detected at or above the reported estimated result.
REJ	-	The data are unusable for all purposes.
NAF	-	Not analyzed for.
N	-	For organic analytes there is evidence the analyte is present in this sample.
NJ	-	There is evidence that the analyte is present. The associated numerical result is an estimate.
NC	-	Not Calculated
E	-	The concentration exceeds the known calibration range.
bold	-	The analyte was present in the sample. (Visual Aid to locate detected compounds on report sheet.)

State of Washington Department of Ecology
Manchester Environmental Laboratory
7411 Beach Drive East, Port Orchard WA 98366

December 13, 2004

Project: Bellingham Bay

Samples: 44-4080- 4092

Laboratory: Columbia Analytical Services

By: Pam Covey

Case Summary

The samples were taken directly to Columbia Analytical by the Project Officer for Total Sulfide by PSEP 1986 and Ammonia by NH3-Plumb 1981. Total Solids by EPA 160.3 was analyzed and reported at no cost in conjunction with the other two analyses.

The samples were analyzed within acceptable holding time limits. The method blanks associated with the sample analyses have shown the process free from contamination. Difficulty was encountered with the spike recovery for the sulfide analyses. Please see narrative from Columbia Analytical for further information.

The results are acceptable for use as reported.

COLUMBIA ANALYTICAL SERVICES, INC.

Client:	Washington Department of Ecology	**Service Request No.:**	K2408545
Project:	Bellingham Bay	**Date Received:**	10/27/04
Sample Matrix:	Sediment		

CASE NARRATIVE

All analyses were performed consistent with the quality assurance program of Columbia Analytical Services, Inc (CAS) This report contains analytical results for samples designated for Tier III validation deliverables including summary forms and all of the associated raw data for each of the analyses When appropriate to the method, method blank results have been reported with each analytical test

Sample Receipt

Thirteen sediment samples were received for analysis at Columbia Analytical Services on 10/27/04. The samples were received in good condition and consistent with the accompanying chain of custody form. The samples were stored in a refrigerator at 4°C upon receipt at the laboratory

General Chemistry Parameters

Sulfide, Total by PSEP:
The control criteria for matrix spike recovery of Sulfide for sample BBY10/444090 is not applicable. The analyte concentration in the sample was significantly higher than the added spike concentration, preventing accurate evaluation of the spike recovery

No other anomalies associated with the analysis of these samples were observed

Approved by _____ **Date** 12/3/04