Report

Columbia Slough Sediment Study

Whitaker Slough between River Mile 0 and 3.2.

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This report prepared by:

Oregon Department of Environmental Quality
2020 NW 4th Ave Suite #400
Portland, OR 97201
1-800-452-4011
www.oregon.gov/deq

Contact:
Jennifer Sutter
(503) 229-6148

Executive Summary

As part of DEQ's efforts to remove and remediate contaminated sediment in the north Portland waterway, the Columbia Slough, DEQ completed a sediment sampling study within a 3.2 mile reach – the Whitaker Slough. This effort is part of the larger effort to protect human health and reverse ecological impacts associated with contaminated sediment throughout the Columbia Slough. To implement this study, DEQ used two sampling approaches, incremental sampling and targeted composite sampling. The objectives of this study were to evaluate previous estimates of sediment ambient baseline concentrations and identify where hazardous substances are present at concentrations significantly exceeding those baseline concentrations.

Incremental sampling (IS) involves particular sample collection and preparation procedures, including collection and compositing of a large number of subsamples, to creating a homogeneous sediment sample that is representative of a large area. For the IS sampling, 50 sample increments were collected using a grid overlain on the entire 3.2 mile study reach. Material from the 50 locations was randomly combined into three replicates such that each of three samples contained sediment from 30 sample locations. Targeted, composite samples consisting of 5-8 subsamples were collected in the vicinity of public and private outfalls and areas of known contamination where elevated concentrations of hazardous substances were more likely to be present above ambient baseline levels. Targeted composite samples consisted of up to six subsample locations within the area of interest. Samples were analyzed for metals, pesticides, polychlorinated biphenyls (PCBs) (Aroclors and congeners), semi-volatile organic compounds, tributyltin, and polybrominated diphenyl ethers. Laboratory results indicate that the highest contaminant levels are found near the targeted locations and that the incremental samples provide a statistically robust indication of reach-wide sediment concentrations that can be used for establishing baseline levels.

IS samples were also used in conjunction with fish tissue data already collected in this area by the City of Portland in 2005 (BES and Geosyntec 2007), to consider bioaccumulation relationships that may exist between. However, no attempt is made in this report to estimate specific fish contaminant uptake factors applicable to Whitaker Slough. This is because paired data between the sediment and fish were too sparse, and reliable relationships adequate to develop predictions could not be established. However, relationships appear to be generally similar to those found in previous work conducted in the Lower Slough (DEQ 2011).

In addition to sediment chemistry tests, bioassays were conducted on sediment collected from nine locations in the study area. Comprehensive evaluation of the results of these tests did not reveal any clear correlation between toxicity and sediment contamination. As a result, no changes to existing toxicity screening levels are recommended at this time for the Whitaker Slough. It is noted, however that the longer term bioassays (20/28-day) appear to be more sensitive than the shorter term tests (10-day) performed in the Lower Slough study.

The contaminants with the greatest exceedances of risk-based and baseline concentrations in this section of the Slough were metals and PAHs. While significant levels of PCBs are present in Johnson Lake, which is directly connected to the Whitaker Slough, the elevated concentrations appear to be primarily confined to the lake itself. Remedial action, consisting of thin-layer capping of Johnson Lake sediments is expected to be completed in the spring 2012. Priority cleanup areas were identified by estimating which areas would need to be remediated to reduce the weighted average concentrations of lead, copper, and benzo(a) pyrene in Whitaker Slough sediment to baseline levels. The cleanup priority of one of the areas identified, based on benzo(a)pyrene concentrations, was reduced because the bioassay performed on the sample did not indicate toxicity. In addition, the location of the lone sample with elevated PCBs and a location where the bioassay indicates toxicity but the contaminant concentrations are relatively low were identified as priority areas for remediation. Three general priority cleanup areas were identified using these criteria.

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1.0 INTRODUCTION

In 2008/2009 DEQ initiated a process through which parties whose sites were determined to have likely contributed to contamination in Columbia Slough sediments could settle their liability for this contamination by paying into an account set up by DEQ. DEQ would use the money collected in this account to complete environmental investigation and cleanup in the portion of the Slough impacted by the associated sites. Some of the parties taking advantage of this process are located in the Whitaker Slough. They include Portland Willamette and Owens Brockway Glass Container. DEQ used some of the settlement money to design and implement a sediment investigation in this area. This report describes the study, documents results, provides analysis and conclusions, and identifies next steps.

1.1 Report Organization

This report is organized as follows:

- Section 1 provides a brief overview of the project and objectives.
- Section 2 describes the Columbia Slough Watershed with more detailed information on the focus area of this study.
- Section 3 summarizes sample collection methods, analytical procedures, and the data quality review.
- Section 4 presents the analytical and bioassay results for samples and provides some comparisons to ambient and risk-based levels.
- Section 5 summarizes data from other investigations in the Whitaker Slough to provide a comprehensive picture of the available data and where additional data may be needed.
- Section 6 presents the study conclusions.
- Section 7 outlines the additional work that may be needed to identify source control needs and develop a sediment remedy for the Whitaker Slough.

1.2 Study Objectives

The Record of Decision (ROD) for the Columbia Slough specified three primary tasks: 1) source control, 2) sediment cleanup, and 3) long-term monitoring to evaluate the effectiveness of natural recovery at reducing sediment contamination to risk-based levels. This study will characterize the nature and extent of hazardous substances in sediments in a portion of the Whitaker Slough to identify areas of sediment contamination that may warrant cleanup. The data will also support evaluating the effectiveness of source control efforts and identifying areas where additional source control may be warranted.

1.2.1 Complete Source Control Evaluation

DEQ and the City of Portland developed the Columbia Slough Sediment Watershed Action Plan in 2005 (currently being updated), which identified priority areas for investigation within the Slough. Whitaker Slough in the Cully Neighborhood was identified as one of five areas with elevated sediment concentrations and high total suspended solids (TSS) in stormwater runoff, particularly from Outfalls #77 and 77A. The DEQ sampling effort intends to support the Columbia Slough Watershed Action Plan by identifying outfalls associated with higher concentrations of contaminants of concern. Further source control evaluation may be needed at these locations, and further investigation may be needed to inform actions to address existing contaminants.

1.2.2 Define Sediment Cleanup Areas

The cleanup goal for sediment in the Columbia Slough is the higher of established baseline concentrations (concentrations reflecting area-wide levels below which active cleanup may not be feasible due to potential recontamination) or risk-based levels. The incremental sample (IS) data collected in this study will provide a more defensible, area-specific, and up-to-date representation of baseline concentrations in the Whitaker slough (see Section 3 below).

The study will identify "hot spot" zones; defined as those areas where sediment concentrations are more than an order of magnitude above the corresponding risk-based screening level or where they exceed baseline concentration for the target reach whichever is higher. These are areas where additional point and non-point source control measures for storm water discharge or contaminated bank soils may be needed and active cleanup of sediment may be evaluated. If hot spot zones are found, it is likely that further investigation of the depth and full extent of contamination will be required in order to develop cleanup options. Toxicity test results will be considered in determining the priority of the hot spot zones. The use of City of Portland outfall names throughout the report should not be interpreted as an indication that City of Portland outfalls are necessarily the primary source of contamination discussed but are used for ease of reference.

2.0 AREA BACKGROUND

The Columbia Slough Watershed drains approximately 32,700 acres of land (see Figure 1). Portland's city limits end at approximately NE 185th Avenue on the east, but the watershed includes Fairview Lake and Fairview Creek, and portions of Troutdale, Fairview, Gresham, Maywood Park, Wood Village, and unincorporated Multnomah County. The Watershed historically contained a vast system of side channels, streams, ponds, lakes, and wetlands that covered the floodplain of the Columbia River between the mouths of the Willamette and Sandy Rivers. High water seasonally inundated the floodplain, cutting new channels and depositing sediment. Native Americans used these waterways and the uplands for fishing, hunting, and gathering food. Fishing continues in this area.

Over the years, the watershed and waterway have been drastically altered. Beginning in 1918, levees were built and wetlands were drained and filled to provide flood protection and allow for development. The waterway was channelized, and dozens of streams were diverted from natural channels to underground pipes. Today, the Columbia Slough comprises a 19-mile main channel that parallels the Columbia River, as well as approximately 12 additional miles of secondary waterways. Other remaining major surface water features include Fairview Creek, Fairview Lake, and Smith and Bybee Lakes. Floodplain development has resulted in an extensively managed surface water system that includes levees, pumps, and other water control structures. The levee system has greatly changed the historic floodplain and reduced the area available to floodwaters.

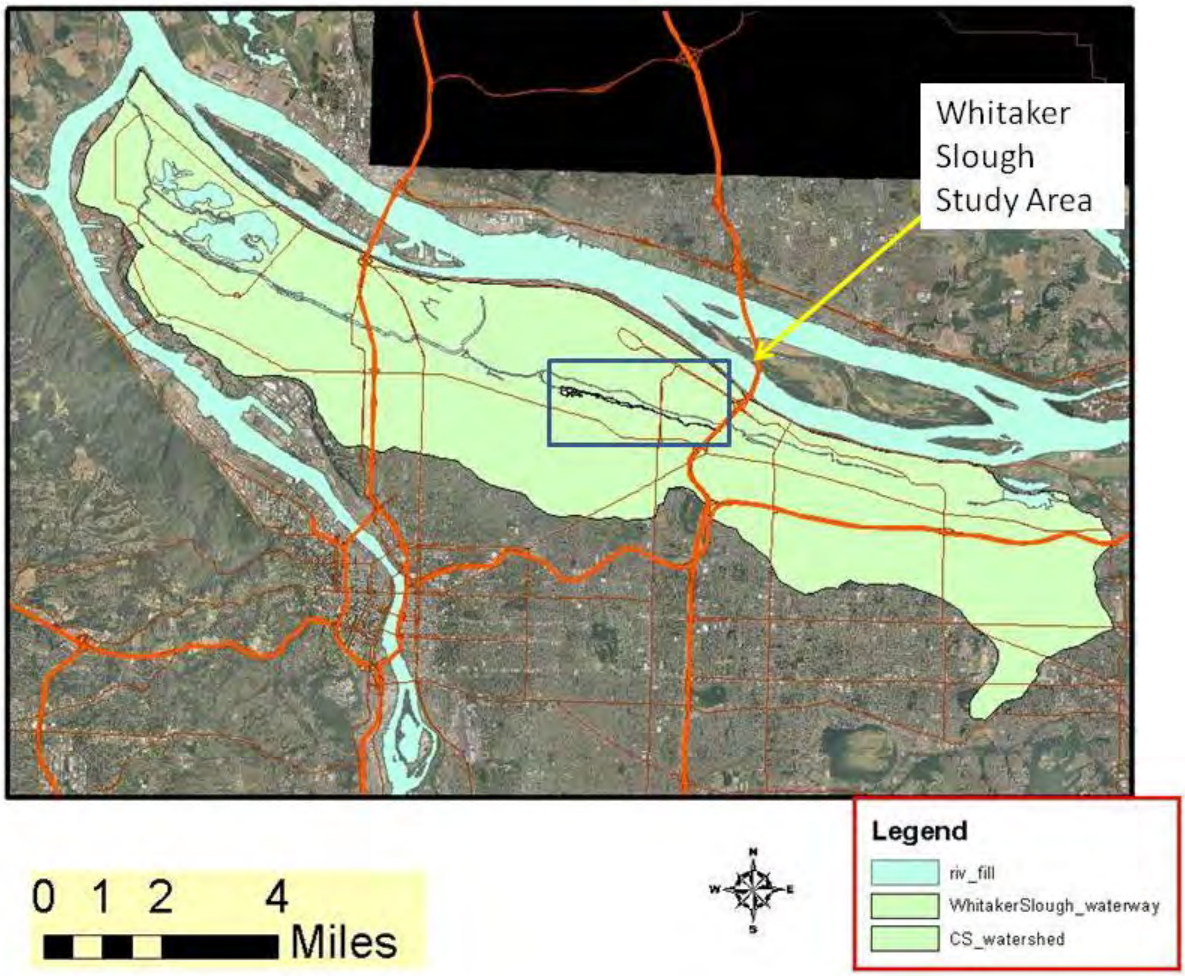

Figure 1 Columbia Slough Watershed; Portland, Oregon

The Columbia Slough Watershed includes virtually every type of land use: residential neighborhoods, commercial and industrial development, agriculture, Portland International Airport (PDX), interstate highways, railroad corridors, 54 schools, and large open spaces. Much of Portland's industrial and commercial land is located within the Watershed. In addition to

industrial development in the area north of Columbia Boulevard and the Rivergate area, land is preserved for industrial uses in the Columbia South Shore area between NE 82nd and NE 185th Avenues north of Sandy Boulevard.

The Slough is divided into three sections, based on hydraulic characteristics:

- The **Upper Slough** starts at the mouth of Fairview Lake on the east and flows west to the mid-dike levee at NE 142nd Avenue. It receives water from Fairview Lake, Fairview Creek, Wilkes Creek, stormwater outfalls, natural springs, groundwater, and overland flow.

- The **Middle Slough** extends from the mid-dike levee near NE 142nd Avenue to the Pen 2 levee near NE 18th Avenue. It includes a substantial southern arm complex of sloughs and lakes, including Prison Pond, Mays Lake, Johnson Lake, Whitaker Slough, Whitaker Ponds, and Buffalo Slough. The Middle Slough receives water from the Upper Slough, stormwater outfalls, natural springs, overland flow, and groundwater. Pumps are used to move water from the Upper and Middle Slough to the Lower Slough.

- The **Lower Slough** starts at the Pen 2 levee, near NE 18th Avenue, and extends approximately 8.5 miles to the Willamette River. The lowlands of the Lower Slough Watershed are subject to flooding because they are not protected by levees. Water flow and levels in the Lower Slough are affected primarily by the Columbia River and Willamette River stage and the ocean tides, as well as by pumping. During high tide, the Columbia and Willamette Rivers create a backwater effect that complicates flow patterns.

During the Columbia Slough Screening Level Risk Assessment performed in 1994, virtually every sediment sample analyzed contained one or more contaminants at concentrations exceeding conservative screening levels based on impacts to aquatic life and fish consumers. Sediment contaminants of concern include metals, pesticides, polyaromatic hydrocarbons (PAHs), phthalates, and polychlorinated biphenyls (PCBs).

DEQ's Water Quality program has established a Total Maximum Daily Load (TMDL) for the Columbia Slough and a fish consumption health advisory has been issued by the Department of Health. The TMDL, part of the Clean Water Act, includes DDT/DDE, dioxin, lead, and PCBs reduction strategies for the water column. Oregon Department of Health has issued a health advisory discouraging the consumption of fish in the Slough because of high PCB levels. In 2009, DEQ completed a study similar to this one for the priority area located at the eastern end of the Lower Slough (DEQ, 2011).

2.1 Project Area

The project area is located within an arm of the Middle Slough of the Columbia Slough watershed, specifically, the lower section of Whitaker Slough between the mouth and highway I-205. Data collected prior to this study indicate that the sediments in this area have relatively low

concentrations of PCBs, but consistently elevated levels of pesticides, with several areas showing elevated lead, chromium, and copper. The highest concentrations of pesticides have been detected east of I-205 (outside the current study area), in an area referred to as the Marx-Whitaker subbasin, where runoff from farms has impacted the sediments. The Marx-Whitaker subbasin is another priority area in the Slough and efforts are underway to address the agricultural runoff and associated impacts.

The Whitaker Slough is located east of the Peninsula 2 (Pen2) levee and water flow is highly regulated by the Multnomah County Drainage District. Anadromous fish are not able to pass the Pen2 levee, but carp and other warm water fish are found above the levee. Johnson Lake is not included in the sample area as it is being addressed in an individual cleanup remedy.

Figure 2 Whitaker Slough near Alderwood Rd

2.2 Contaminant Sources of Concern

Contaminated bank areas and discharges from outfalls, both public and private are thought to be the major contributors to sediment contamination in the Slough.

2.2.1 Outfalls

City of Portland (COP) and Oregon Department of Transportation (ODOT) outfalls tend to drain larger areas than private outfalls and tracking down particular contaminant sources can be more complicated. There are nine COP outfalls and one ODOT outfall within the study area. City stormwater outfalls were generally routed to Whitaker Slough beginning in the 1960s and 1970s.

The City of Portland used a Total Suspended Solid (TSS) Grid Model to help identify priority outfalls for source control. This model identified OF77 and AAL621 (labeled as CLWD) as high priority under this criterion based on modeled discharge of 12 – 18 pounds of total suspended solids per acre of drainage area. OF74 and OF77A, also in the study area, were considered to have moderate levels of TSS discharge, falling in the range of 6 – 12 lbs per acre. These locations are labeled as 'GRID identified outfall' on Figure 3.

The Grid Model study, along with outfall diameter and potential sources contributing to discharge from the outfall contributed to the selection of targeted outfalls.

In addition to the City and ODOT outfalls, there are over 60 private outfalls in the sampling area which individually drain smaller areas generally confined to a particular private property. When combined, private outfalls account for approximately 70% of the Whitaker Slough drainage area.

Available resources were insufficient to sample all outfalls in the study area. Consequently, DEQ staff met with City of Portland BES staff to determine additional target sites of interest based on 1200COLS Stormwater Discharge Permits or other industrial facilities with discharges to private outfalls. Five outfalls were identified:

- Metro Metals
- Waste Management Oregon(WMOR)
- Pro Truck Lines(PTL)
- Oregon Tractor(ORT)
- Oregon Fresh Farms(OFF)

The latter four outfalls listed above were chosen for targeted sampling. Metro Metals outfall is being addressed under an individual work plan. See Figure 3 for project area and all outfalls in the Middle Slough reach. See Figure 9 for final targeted sampling locations.

The need for additional site discovery in this portion of the Whitaker Slough will be evaluated using the 2011 sampling data.

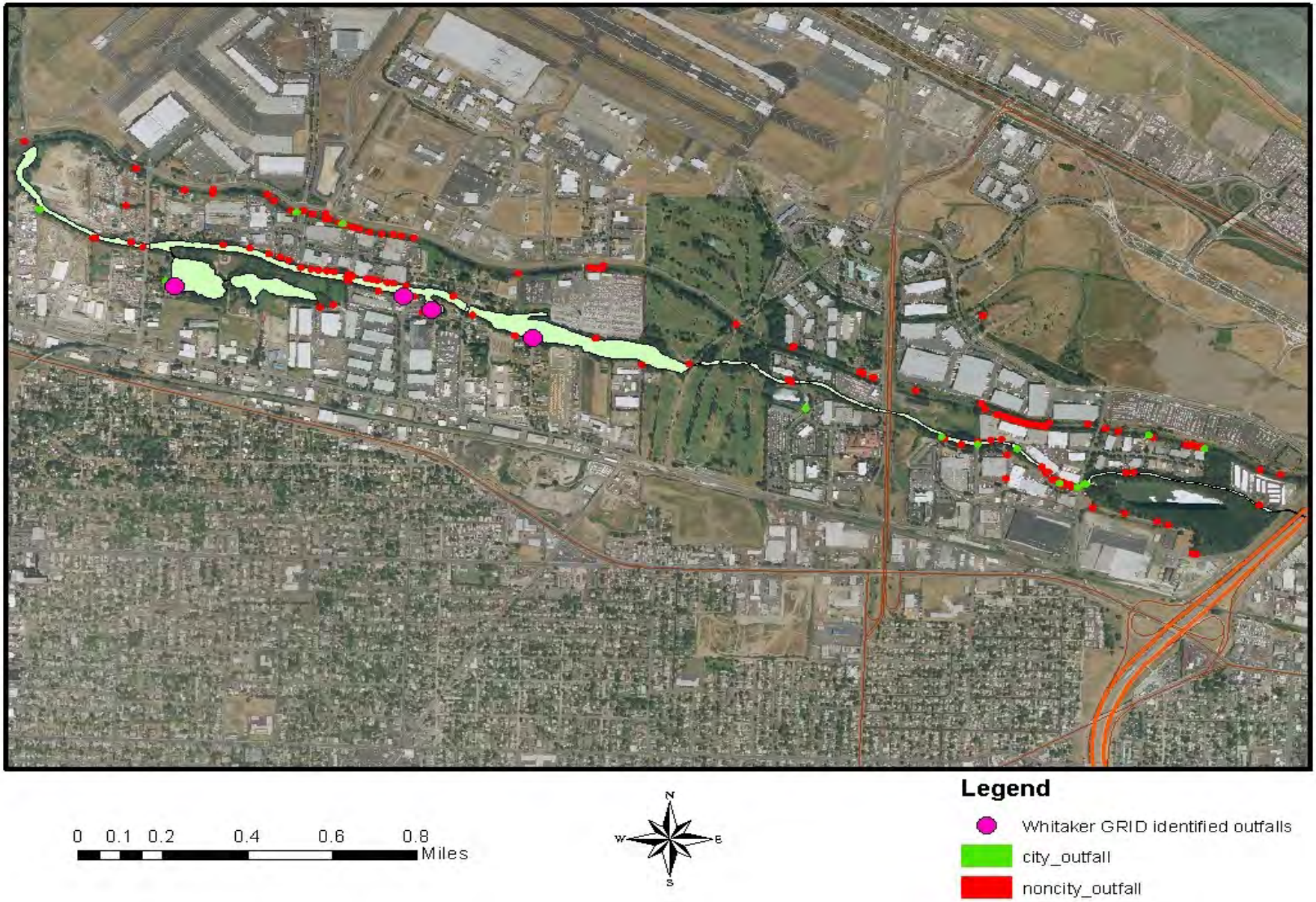

Figure 3 Map of Project Area and Outfalls

2.2.2 DEQ Cleanup Sites

Over twenty-five cleanup sites listed in DEQ's database drain to the Whitaker Slough study area. Contaminants of concern at these sites include PCBs, PAHs, metals, pesticides and petroleum hydrocarbons. Based on these contaminants of concern, DEQ chose three cleanup sites with private outfalls for targeted sampling, including Halton, Nuway Oil, and Portland Willamette. Figures 4 and 5 show all cleanup site locations.

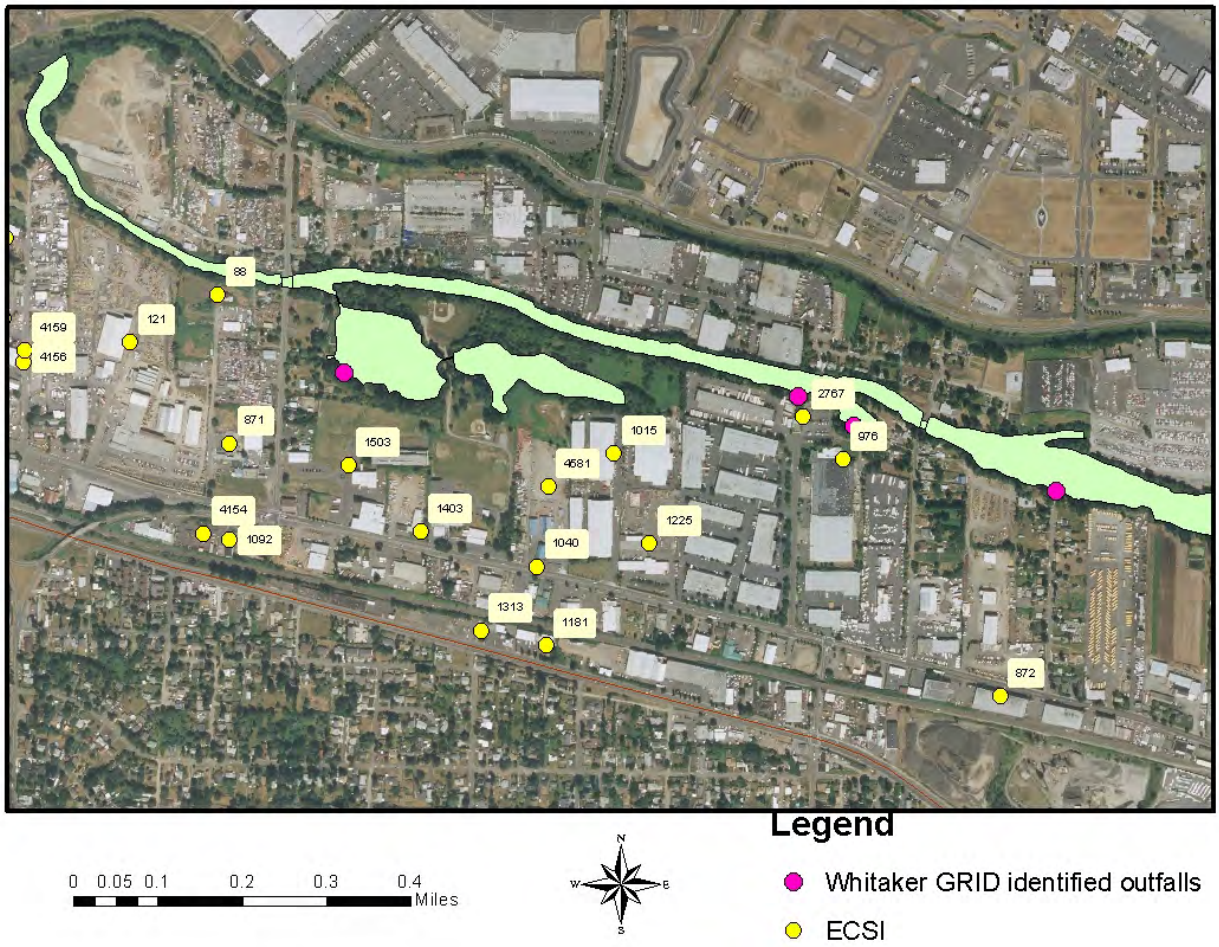

Figure 4 Whitaker Slough ECSI Sites: West End

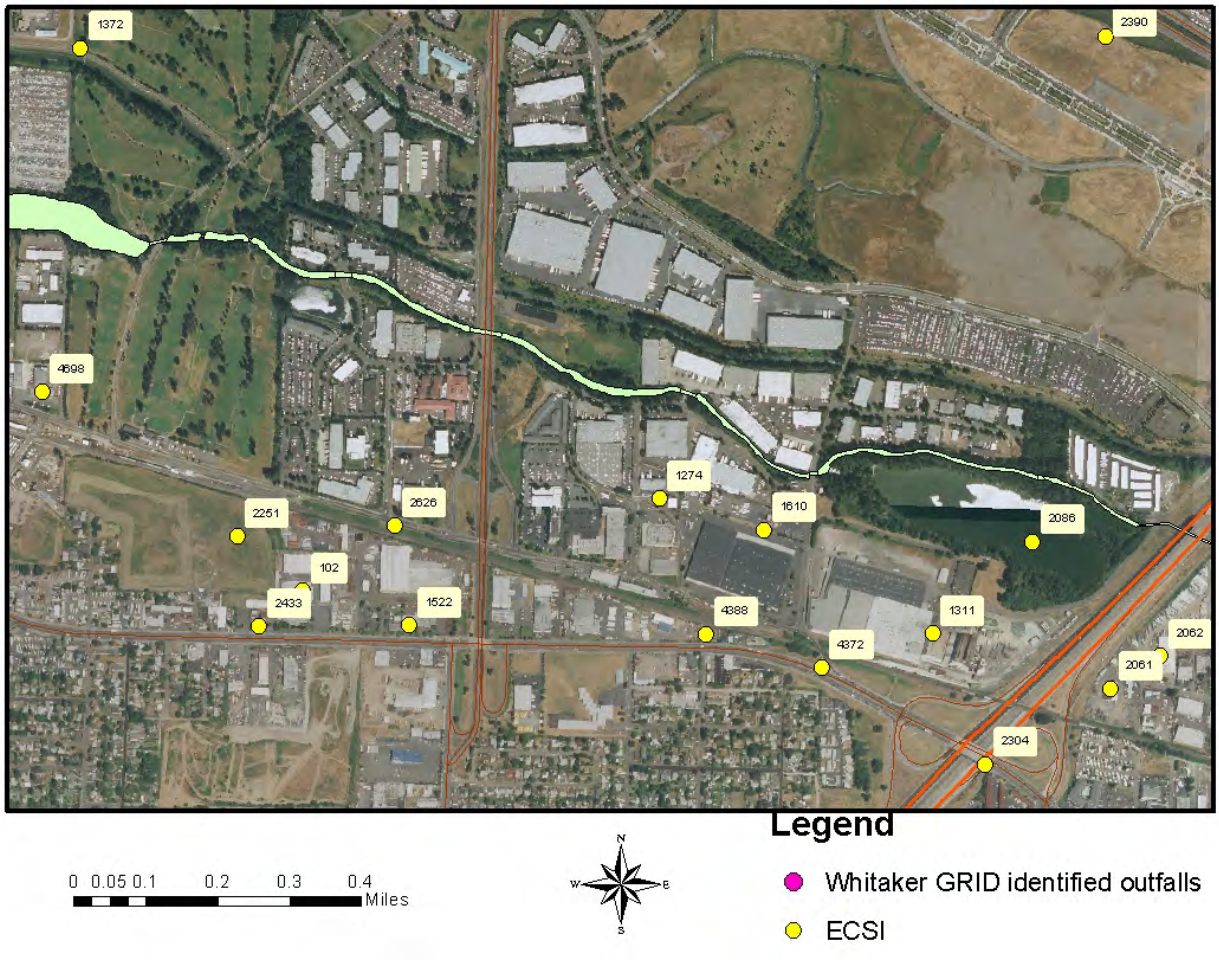

Figure 5 Whitaker Slough ECSI Sites East End

DEQ is working to ensure that source control measures are implemented where needed at these sites and anticipates that major sources will be managed by 2013. A detailed list of all cleanup sites and current status is available at http://www.deq.state.or.us/lq/cu/nwr/columbiaslough/CSCleanupSites.pdf.

2.3 Previous Sampling Investigations

Several other sediment sampling efforts have been completed in the Whitaker Slough as part of specific site investigations and as part of the City's long-term monitoring. This data is summarized in Section 5 and has been incorporated into the Slough-wide data base to provide a larger dataset for evaluating data gaps and identifying "hot-spot" areas.

3.0 SAMPLE DESIGN AND STRATEGY

The general sampling strategy included two sample designs: an incremental sampling (IS) strategy to determine average sediment concentrations throughout the lower Whitaker Slough study reach and targeted samples in locations of suspected contamination within the study area.

The IS provides a reliable, defensible, and cost-effective method to determine average concentrations within the reach. The size of a decision unit for an IS sampling grid depends on the purpose of the data and how it will be used. The purpose of the lower Whitaker Slough decision unit is to generate a baseline sediment concentration for this segment of the Whitaker Slough and an average exposure concentration for the typical three mile home range of carp. The Whitaker Slough east of I-205 is not included as it is known to contain higher concentrations of pesticides and represents a distinct unit based on sediment concentrations. The baseline sediment concentrations can then be used to assess the feasibility of active cleanup measures within the reach and may help determine bioaccumulation rates in fish. The sample design was chosen by DEQ staff after researching available methods and discussing with DEQ chemists, toxicologists, Columbia Slough project managers, and program managers.

3.1 Collection and Field Activities

Field activities were carried out in accordance with the Sampling and Analysis Plan *Whitaker Slough Sediment Investigation; ECSI#1283;* document number DEQ10-LQ-0069-SAP which referenced the Quality Assurance Project Plan, *Columbia Slough Outfall 59-65 Sediment Study* (DEQ, 2009); document number DEQ09-LQ-0046-QAPP. Deviations from the 2009 QAPP are described in the report where appropriate. Sediment was analyzed for a variety of chemicals at all locations and bioassays were performed at selected locations, typically major outfalls. Additionally, sample collection procedures and analyses were matched to previous City of Portland studies when applicable. Preservation and labeling followed laboratory guidelines.

A Nationwide Permit for Survey Activities (NWP-2009-439) from the Army Corps of Engineers was obtained to collect sediment within the waters of the United States. An Oregon Department of State Lands dredge/fill permit was not required for the project. Multnomah County Drainage District provided logistical support including Slough access and boat storage. DEQ Laboratory and Environmental Assessment Division provided sampling equipment for field collection.

3.2 Sediment Sample Location Selection

Sample locations were selected based on the two sampling strategies: IS and targeted composites at suspected source locations. See Appendix A for detailed sample location maps. Sites were located with a Garmin handheld GPS, with an average accuracy of +/- 15 feet. While all efforts were made to collect the sediment at mapped locations, some site locations deviated due to safety concerns or outfall deposition areas that differed from office estimates. The majority of the sites were within 15 feet or less of the intended sample point. The exceptions were due to log jams near outfall 73A and Oregon Tractor (ORT). In addition, outfall 77 and the 82nd Ave outfall samples were moved because sediments in the estimated outfall settling areas were further from the outfall than expected. Appendix B describes actual locations of all sample increments.

Incremental Sampling Locations: The IS strategy was designed to integrate sediment information from throughout the 2.5 mile length of this Slough reach. The Whitaker Ponds and

other water bodies outside the Whitaker Slough proper were excluded, to get a better representation of the Whitaker Slough. Based on the DEQ09-LQ-0046-QAPP sampling design, a random start triangular grid, was laid over the Whitaker Slough, however this portion of the slough was too narrow in width to support a triangular grid. Consequently, the grid points were evenly spaced across the east/west length of the slough and the placement north/south was randomized to provide coverage for the entire width of the slough. The upper 10 cm of sediment from the 50 locations was randomly combined such that each of three samples (designated A, B, and C), contained sediment from 30 of the 50 different locations shown in Figure 8.

Targeted Samples: The targeted sampling strategy involved a small array of composite sampling points immediately upstream and downstream of 20 public and private outfalls (Figure 9). The number and location of individual sample points in each composite were based on outfall size. Sediment was collected from up to eight locations in deposition areas of large diameter outfalls and no fewer than 6 locations for smaller outfalls. The goal was to collect samples of the upper 10 cm of sediment; however macrophyte mats on the sediment bottom impeded dredge depth at some collection points. All sediment samples were collected from the surface to between 7-10 cm deep.

Figure 6 Sample in stainless steel bowl

Figure 7 Log jam near Oregon Tractor Outfall

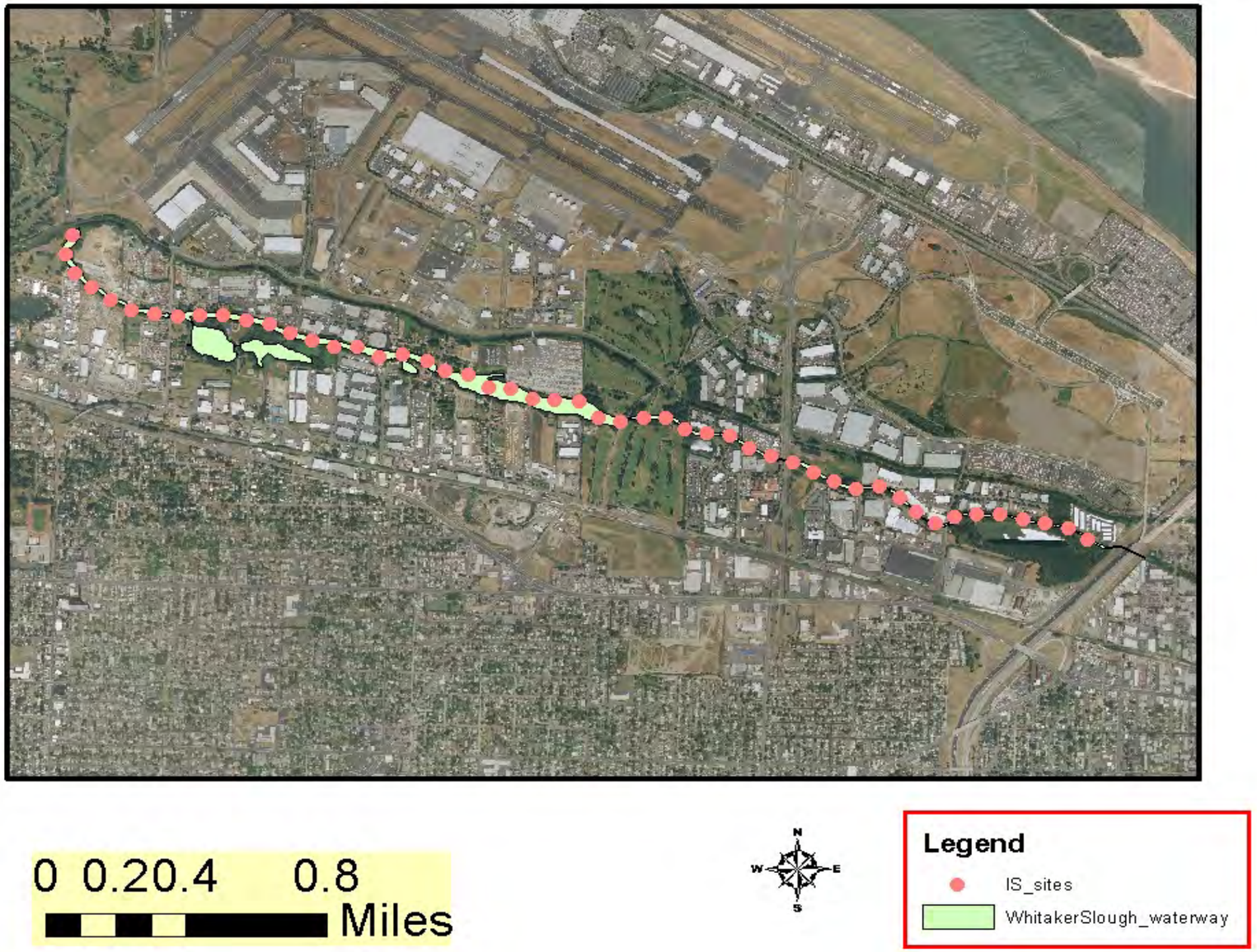

Figure 8 Increment Sample Map

DEQ 2011 Sample Locations

Figure 9 Targeted Sample Map

3.3 Sampling Procedure

All samples were collected during a two week period in January 2011 during high water levels. The DEQ crew used an electric powered boat or wading to gain access to the sites. Samples were collected using an Ekmann Dredge at deep water sites or by stainless steel spoon or clam gun at shallow sites. Sampling equipment was rinsed and washed between sites. Once samples were collected and labeled, they were placed on ice for preservation and transport to the laboratory.

Incremental Sampling: At each increment point, 50 g of sediment, collected as described above, was weighed with a digital scale. The sediment was then placed in the appropriate triplicate glass jar. The sediment was later dried and homogenized at the laboratory.

Figure 10 Placing increment sample on scale

Targeted Samples: Each sample consisted of six to eight composited subsamples. The total sediment mass required varied between 1000 g for chemical analyses only and 4000 g for bioassay and chemical analyses. Sample volume from each composite point depended on the number of composite points and the analyses to be performed. The field crew placed the sediment in labeled glass jars for analysis and the samples were later homogenized by the contract lab. Targeted samples were not dried. Glass jars were separately filled for chemical analyses and bioassays from the same sample points. Field information was collected at each site including sample depth, sediment color, presence of woody debris, observation of oil sheen, and other information (see Appendix B).

3.4 Analytical Methods

Sediment samples were sent to Pace Analytical, Inc in Seattle for chemical analysis. Bioassay samples were sent to Northwestern Aquatic Sciences (NAS), based in Newport, Oregon.

3.4.1 Chemical Analyses

The chemical analyses chosen reflect legacy and current-use compounds found in Columbia Slough sediment. Previous studies were examined for historical comparisons. Tributyltin (TBT) and polybrominated diphenyl ethers (PBDEs) are new compounds not previously tested in Columbia Slough sediment studies until DEQs 2009 Lower Slough study. Tributyltin (TBT) is a biocide effective against a broad range of organisms used in many products. It is primarily used as an antifoulant paint additive on ship and boat hulls, docks, fishnets, and buoys to discourage the growth of marine organisms such as barnacles, bacteria, tubeworms, mussels and algae, though its use on small boats was prohibited in 1988. PBDEs have been used in a wide array of products as a flame retardant.

Metals, PCB Aroclors, pesticides, semi-volatile organic compounds (SVOCs), total organic carbon (TOC) and grain size were analyzed in all samples. IS samples were also analyzed for PBDEs, PCB Congeners, TBT and pesticides using the high resolution method 1699. TBT analysis was performed only on a sample from an outfall with known boat repair activities within the pipeshed. Bioassays were performed on sediment from selected sites, typically larger diameter outfalls. See Table 1 for the list of analyses performed on each sample.

Once all IS samples were collected, the laboratory prepared the sediment for chemical analysis. For the IS samples this included drying, homogenization, sieving (<2mm), and sub-sampling. Some volatilization of semi-volatile organics and mercury may occur during this process; however, volatilization is not expected to be substantial. Samples were then frozen to prolong holding time. The analytical methods used can be found in Table 2.

3.4.2 Bioassay Analysis

Two freshwater sediment toxicity tests were performed on 10 sediment samples:

1) 20-day *Chironomus dilutes* bioassay and

2) 28-day *Hyalella azteca* bioassay.

These tests deviate from the 10-day duration bioassay tests performed on samples collected in DEQs 2009 Lower Slough study. The longer duration tests are intended to provide a better indication of chronic toxicity than the shorter-term bioassay tests. Bioassay samples were collected at 10 locations (see Figure 12), primarily larger outfalls or areas of known elevated concentration. See Appendix A for the list of sites.

Bioassay methods were based on the ASTM 2001 method and EPA method # 100.1 and 100.5. Samples were held on ice and shipped to NAS twice a week. Samples were sent via UPS to

Newport packed on ice. Once received at NAS, sample sediment was homogenized and split for the two analyses.

Figure 11 Sampling Equipment

Figure 12 Whitaker Slough Bioassay Locations

Table 1 Sampling and Analytical Methods

Sampling and Analytical Methods

Analysis	**Method**	**Laboratory**
Metals by ICPMS, Total Recoverable	EPA 6010\6020\7000	Pace Analytical, Inc
Total Organic Carbon	EPA 9060	Pace Analytical, Inc
Grain size	ASTM 422	Pace Analytical, Inc
Polychlorinated Biphenyls(PCBs)	EPA 1668B	Pace Analytical, Inc
PCB Aroclors	EPA 8082	Pace Analytical, Inc
Pesticides	EPA 1699 & EPA 8081	Pace Analytical, Inc
Semi-volatile Organics	EPA 8270CModified List	Pace Analytical, Inc
Total Petroleum Hydrocarbons	NWTPH Dx with silica gel	Pace Analytical, Inc.
Tributyl Tin(TBT)	Krone	Pace Analytical, Inc
PBDE	EPA 1614	Pace Analytical, Inc
Bioassay: 20 day *Chironomous dilutes* Toxicity Test	NAS-XXX-CT4c	Northwest Aquatic Science
Bioassay: 28 day *Hyalella azteca* Toxicity Test	NAS-XXX-HA4c	Northwest Aquatic Science

From document DEQ10-LQ-0069-SAP

Table 2: Summary of sediment sampling locations, sample types, and expected number of increments or composites.

Sample ID	Sample Type	Site	Outfall	Metals	Pesticide 8081	Pesticide (1699)	PCB- Aroclor	PCB Congener	SVOC/PAH	grain size	toc/solids	TBT	PBDE	TPH	bioassay	Increment/ Composite number
WSIS-1	Incremental	Whitaker Slough Area wide Incremental Sample Triplicate 1(between mouth and I-205 freeway)	NA	X	X	X	X	X	X	X	X	X	X	X		30
WSIS-2	Incremental	Whitaker Slough Area wide Incremental Sample Triplicate 2 (between mouth and I-205 freeway)	NA	X	X	X	X	X	X	X	X	X	X	X		30
WSIS-3	Incremental	Whitaker Slough Area wide Incremental Sample Triplicate 3 (between mouth and I-205 freeway)	NA	X	X	X	X	X	X	X	X	X	X	X		30
WS-73A	Composite	Whitaker Slough at City of Portland Outfall 73A/Halton	73A	X	X		X		X	X	X	X		X	X	6
WS-HALT	Composite	Whitaker Slough Halton Outfall	*CS028;030;020*	X	X		X	X	X	X	X			X	X	6
WS-NWEB	Composite	Whitaker Slough at NuWay East Bank	*N/A*	X	X		X	X	X	X	X			X		6
WS-NWds	Composite	Whitaker Slough at Nuway downstream	*N/A*	X	X		X	X	X	X	X			X		6
WS-489	Composite	Whitaker Slough at 47th Ave	CS-489	X	X		X	X	X	X	X			X		6
WS-74	Composite	Whitaker Ponds at City of Portland Outfall 74	74	X	X		X		X	X	X			X		6
WS-WMOR	Composite	Whitaker Slough at Waste Management of OR	CS048;049;354	X	X		X		X	X	X			X		6

Sample ID	Sample Type	Site	Outfall	Metals	Pesticide 8081	Pesticide (1699)	PCB- Aroclor	PCB Congener	SVOC/PAH	grain size	toc/solids	TBT	PBDE	TPH	bioassay	Increment/ Composite number
WS-PTL	Composite	Whitaker Slough at Pro Truck Lines	CS052;053;054; 376;574	X	X		X		X	X	X					5
WS-77	Composite	Whitaker Slough at City of Portland Outfall 77	77	X	X		X		X	X	X			X	X	6
WS-77A/PW	Composite	Whitaker Slough at City of Portland Outfall 77A & Portland Willamette Outfall	77A; CS-267	X	X		X		X	X	X			X	X	8
WS-77A/PW QA	Composite QA	Whitaker Slough at City of Portland Outfall 77A & Portland Willamette Outfall	77A; CS-267	X	X		X		X	X	X			X	X	8
WS-PW2	Composite	Portland/Willamette Inlet #2	CS-266	X	X		X		X	X	X			X	X	6
WS-ORT	Composite	Whitaker Slough at Oregon Tractor	CS-355	X	X		X		X	X	X			X		6
WS-OFFarm	Composite	Whitaker Slough at Oregon Fresh Farms	N/A	X	X		X		X	X	X				X	6
WS-CLWD	Composite	Whitaker Slough at Colwood Ave	AAL621	X	X		X		X	X	X			X		6
WS-GlfC	Composite	Whitaker Slough at Colwood Golf Course	N/A	X	X		X		X	X	X					6
WS-78	Composite	Whitaker Slough at City of Portland Outfall 78	78	X	X		X		X	X	X			X	X	6
WS-82ndAv	Composite	Whitaker Slough at 82nd Ave	Unk.	X	X		X		X	X	X			X		6
WS-80	Composite	Whitaker Slough at City of Portland Outfall 80	80	X	X		X		X	X	X					6

Sample ID	Sample Type	Site	Outfall	Metals	Pesticide 8081	Pesticide (1699)	PCB- Aroclor	PCB Congener	SVOC/PAH	grain size	toc/solids	TBT	PBDE	TPH	bioassay	Increment/ Composite number
WS-83	**Composite**	**Whitaker Slough at City of Portland 83**	**83**	**X**	**X**		**X**		**X**	**X**	**X**			**X**	**X**	**6**
WS-83-QA	**Composite**	**Whitaker Slough at City of Portland 83**	**83**	**X**	**X**		**X**		**X**	**X**	**X**			**X**		**6**
WS-84/85-	**Composite**	**Whitaker Slough at City of Portland Outfall 84/85**	**84/85**	**X**	**X**		**X**		**X**	**X**	**X**			**X**	**X**	**6**

All media will be sediment/soils

3.5 Data Usability

Sample collection and analyses followed all methods, quality control procedures and reporting as described in the Sampling and Analysis (DEQ10-LQ-0069-SAP, (DEQ, 2010) and associated documents, except as noted below. DEQ conducted a data validation check to ensure data acceptability. Below is a brief summary of data quality controls outlined in the SAP and areas where the project deviated from the SAP.

3.6 Summary of Quality Control

Three categories of quality control (QC) were used to assess data quality: sample design and methods, field sampling QC and analytical QC. Sampling designs were chosen to provide quality control for IS and targeted sampling.

Sample Design and Methods:
Integrated Samples: A triplicate sampling QC method, based on *'Draft Guidance on Multi-Increment Soil Sampling'* Alaska Department of Environmental Conservation, 2009) was used for the incremental sampling. The entire reach was our "decision unit" enabling determination of a reach-wide average or baseline concentration. This length was also appropriate for evaluating bioaccumulation as it is consistent with the average home range of carp. The IS procedure controls compositional heterogeneity and distributional heterogeneity, two major sources of error in sediment sampling. Grouping and segregation error is controlled by collecting multiple randomly located sample increments to address distributional heterogeneity. The collection of triplicate samples allows for the calculation of relative standard deviation (RSD=100* Standard Deviation/mean) which provides an indication of how well the IS sample represents the decision unit. All results under 30% RSD were considered representative of the decision unit. If the RSD is greater than 35% the data distribution becomes 'non-normal' and the confidence of the results is weakened.

Figure 13 Sample drying & waiting to be processed with IS analytical methods

Targeted Samples: Standard duplicate samples were collected at a rate of 10 percent of the outfall sites, in this case 2 sites: WS-OF77A and WS-OF83. Relative percent difference was calculated to determine precision/accuracy of results. Field duplicate precision was considered acceptable when RPD <50% for organics or RPD<35% for inorganics. The analytical quality control target included precision of 20% for all analytes. Accuracy limits varied, depending on laboratory methods. The reporting limit was requested to be the lower of the Limit of Quantitation or Columbia Slough Risk Based Screening Levels. In some cases, estimates were reported and used. Analytical instruments were maintained and inspected within manufacturer's guidelines.

Field Sampling QC:

Daily Activities Log: Daily Activities were recorded on Chain of Custody forms and Columbia Slough Sediment Field Forms, which include date/time, location changes, how sample was collected, sample depth, odor and color. Field notes are summarized in Appendix B. Sample depth was expected to be 10 cm, however 7 out of 22 targeted samples did not reach the 10 cm sample depth. The average depth for samples was 9 cm. It was noted that rockier/sandier sediments seemed to produce smaller depths. Wood debris and mats of macrophytes also limited sample depths.

Location**:** Locations were as outlined in the SAP, with the exceptions of outfall 73A and Oregon Tractor due to log jams near the outfalls. The new sampling locations were approximately 20 ft north of the original location. In addition, outfall 77 and 82nd Ave outfall locations were moved because sediments in the estimated outfall fine sediment settling areas were further from the outfall than expected. Updated locations can be found in Appendix B.

Minor tracking changes were noted on the field sheet, including crossed out bottle numbers and other minor typos.

Quality control in the field included decontamination of field sampling gear between sites, use of electric boat motor, and isolation of the sediment, whenever possible, to minimize cross contamination.

Analytical QC:

All analytical QA/QC was deemed acceptable, except for deviations noted below (Section 3.7). Quality Control included duplicates, matrix spikes, laboratory control standards/calibrations and equipment calibrations. Dilutions were needed for several analyses to minimize interferences. Duplicate sample precision and relative percent difference for the incremental samples are evaluated and discussed in Section 4.3.2.

Appropriate methods were used for all analyses, ensuring good comparability with other data. Analytical accuracy and precision were determined to be generally acceptable, with noted exceptions. Qualifiers were assigned to data points that exceeded project data criteria. All data was reported and considered representative of the samples collected, except as noted by qualifiers.

Bioassay quality control included water quality testing, replicates and a control sediment test. Test results were considered acceptable, as controls were above the minimum acceptable survival rate of 80% - *Hyalella* (92.5% average survival rate); *Chironomus* (92.5% average survival rate).

3.7 Deviations from Quality Assurance Project Plan

Targeted samples were homogenized but not dried before chemical analysis per standard laboratory procedures. Some target limits for PCBs and pesticides were not met due to excessive moisture content. PCB extractions were re-concentrated to reduce the method detection limits by approximately one-half. Pesticide samples with DDT detection limits above 10 ug/kg (a total of 3 samples) were re-analyzed using new sample material, as the lab was unable to re-concentrate the original sample extractions. The reworked data is used in the report for the following samples:

Table 3 Sample Rework Information

Sample:	Parameter	Value used
All targeted samples	PCB aroclors	Re-extraction from original sample
WS-PTL, WS-77A/PW, WS-CLWD	Pesticide	Original sample and new sample averaged. If concentration was found in only one of the samples, that value is reported.

Some estimates were used after careful consideration by the project managers. For example some values were estimated to the method detection limit rather than using the method reporting limit.

Targeted Samples: Field duplicate samples used the criteria listed in the EPA PA/SI document (DEQ05-LQ-069-QAPP) rather than the QA criteria listed in DEQ09-LQ-0046-QAPP. The new QA targets are:

Analyte	QA Criteria
Inorganic	RPD +/- 35% for concentrations > 5X the MRL, or Absolute difference ≤ MRL for average concentrations ≤ MRL
Organic	RPD +/- 50% for concentrations > 5X the MRL, or Absolute difference ≤ 2X MRL for average concentrations ≤ MRL

Outfall 77A duplicate review determined that 87% of analyses met acceptable criteria. Many duplicates for PAH compounds did not meet the 50% precision limit. The Outfall 83 duplicate passed 75% of the precision limits. Again, PAH compounds did not meet the 50% precision limit. Since the incremental samples passed for most QA/QC checks, DEQ concluded that laboratory methods produced acceptable results and that variability in other duplicate checks was due to a heterogeneous environment. This variability is expected in a diverse environment, based on previous studies within the slough (City of Portland 2009). Appendix E contains a complete review of targeted sample quality assurance.

Incremental Samples: A clerical error while sampling resulted in placement of multiple sediment increments in incorrect triplicate jars; however, the error was caught and the number of increments per triplicate was not affected. The error is not expected to impact the results as the original triplicate designation was random. Appendix B shows the intended and actual triplicate increments.

For the IS samples, all results under 30% relative standard deviation (RSD) were considered representative of the decision unit. The QA criteria for a representative sample were met for 78% of the analytes supporting their use in developing baseline concentrations for this segment. Total cadmium, 3 phthalates, dibenz(a,h)anthracene, 2,4'-DDT and many PCB congeners did not pass the RSD evaluation. One PCB congener triplicate result was at least 2x higher than the other two triplicates, suggesting one of the increments was located at an unidentified localized pocket of PCBs. The PCB aroclors are representative of the decision unit and the average of the replicates will be used for comparison against the targeted samples. The other substances are not risk-drivers in this section of the slough and, although there is less certainty in the result, the average of the replicates can be considered estimates for the average conditions across the decision unit with little impact on subsequent environmental decisions. Appendix E contains a complete list of incremental sample RSD values.

Table 4 Incremental Sample Relative Standard Deviation (RSD) Failures-above 30%

Chemical	Relative Standard Deviation (RSD) %
Cadmium	42
bis(2-Ethylhexyl)phthalate	41

Chemical	Relative Standard Deviation (RSD) %
Butylbenzylphthalate	32
Di-n-butylphthalate	39
Dibenz(a,h)anthracene	36
Tributyltin	42
2,4'-DDT	39
cis-Heptachlor Epoxide	53
Heptachlor	42
Hexachlorobutadiene	74
Mirex	36
PCB Congeners	76(average)
Total PBDE	64

Results met the project completeness goal of 100% for targeted samples, after some collection locations were moved by the field crew because of obstacles (i.e. log jams). Some samples of PCBs and pesticides were reanalyzed to meet project target goals. The incremental sampling met the project completeness goal of 100%. Project managers believe the dataset is useable and meets the goals outlined in the Whitaker Slough Sediment Study. Future data users must evaluate whether this data is acceptable for their project's data quality objectives.

4.0 SAMPLE RESULTS

Sample results are summarized in the following sections. IS results are presented first as they are used in subsequent data comparisons.

4.1 Increment Samples Method

The IS data shows low variability between the three replicates for selected analytes. The QA criteria for a representative sample (results under 30 percent RSD) were met for 76 percent of the analytes.

Table 5 Increment Sample Summary – Representative Results

	2011 Whitaker Slough IS summary					Previous Slough baseline values	Lower Slough baseline values
Analyte	**IS A**	**IS B**	**IS C**	**Relative Standard Deviation(%)[2]**	**2011 IS Mean**		
Organics (ug/kg)							
Aroclor 1260	28	19.6	15.6	30	21	24	18.7
Dieldrin	1.12	1.66	1.58	20	1.45	1	0.7
DDE	5.66	7.48	6.59	13.8	6.58	6.1	6.31
DDD	4.05	5.78	3.72	24.5	4.52	7	3.7
DDT	0.862	0.957	1.03	8.9	0.95	2.5	0.47
Benzo(a)pyrene	34	37	45	14.2	39	90	109.8
Dibenz(a,h)anthracene	9.5	7.9	15.3	35.7	10.9	60	113
Metals (mg/kg)							
Cadmium	0.48	0.29	0.21	42.5	0.3	1.9	0.9
Copper	40	42	52	14.4	44	54	37.5
Lead	69	77	75	5.7	73	90	41.3
Zinc	165	186	192	7.8	181	314	244

2. Relative Standard Deviation (RSD) measures how widely spread the data points are and is used to determine precision. It is also the absolute value of the coefficient of variation. An RSD of less than 30% indicates a representative sample.

The results presented in Table 5 show that the IS samples were relatively consistent between replicates indicating the method was successful in reducing sediment sample heterogeneities.

For comparison, Slough-wide baseline values (DEQ 2002) calculated using the sediment data collected throughout the entire Slough in 1994/1995 (Parametrix, 1995) are also shown. Surprisingly, the historical data generated baseline concentrations for the organics shown that are very consistent with the IS averages determined in this study. Metals concentrations are consistently lower, but on the same order of magnitude as the historically determined baseline

values. This may indicate some improvement resulting from source control and natural recovery.

The IS data set for the Whitaker Slough reflects more recent data with a higher level of confidence and is more representative of ambient concentrations in the Whitaker Slough. Consequently, the average concentration values for the IS data in the Whitaker Slough will replace the baseline values previously developed for the entire Columbia Slough. As expected, the average concentrations (IS data) for some SVOCs, PCBs and pesticides are above DEQ bioaccumulative risk-based sediment screening levels (DEQ 2007). As outlined in the 2005 Columbia Slough ROD, active remediation of sediment in the Slough to concentrations below baseline is likely to be infeasible due to potential for recontamination. However, a combination of active remediation of sediment exceeding baseline concentrations, source control, and natural recovery is expected to be effective in eventually reaching risk-based cleanup levels.

Baseline concentrations in the Lower Slough are similar to those in the Whitaker Slough with a couple of exceptions. PAH concentrations are significantly higher in the Lower Slough, possibly reflecting a relatively large quantity of runoff from roadways. Lead concentrations are higher in the Whitaker Slough which may be a remnant of the impacts from the NuWay site as well as the metals source area at the Portland Willamette/Outfall 77A site. PCB concentrations are somewhat ambiguous between these two reaches as total aroclor concentrations in the Whitaker Slough are about half the level in the Lower Slough, but total congener levels are over 4 times higher. Pesticide concentrations are surprisingly consistent between the two reaches however dieldren is about twice as high in the Whitaker Slough as in the Lower Slough.

4.2 Targeted Samples

The sediment chemistry results for targeted sites were elevated in comparison to the average IS concentrations in the Whitaker Slough study area. The following sections discuss contaminants of concern for the Whitaker Slough and summarize detection characteristics at the targeted source areas. Appendix C provides details on all analytes.

4.2.1. Detection Rates for Analyte Classes

Naturally occurring metals were detected in nearly all samples, ranging from 100 percent for common metals to 45 percent for less common metals, such as antimony. The most common PAHs were found in nearly all samples. Pesticides were analyzed using two methods. The standard lower resolution Method 8081 used for targeted samples detected some analytes, including DDE and alpha-chlordane. Method 1699, a higher resolution method used for the IS triplicates, detected low concentrations of numerous pesticides, including dieldrin, DDT, DDE and DDD. TBT was detected in one sample collected in an area of known boat construction activities.

PCB aroclors were found in 55% of targeted samples. PCB congeners were found at higher concentrations than PCB aroclors in the IS sample. Method 1668A is a high resolution

chromatographic method that has the capability to resolve independent peaks from most of the 209 possible congeners. The exception is those congeners that, due to similarity in chemical properties, elute from the chromatographic column at the same time. This effect is referred to as co-elution. With this exception, it is possible to explicitly quantify each unique PCB molecule in a sample at detection limits in the picogram per gram range (pg/g). By comparison, the aroclor method attempts to identify a mixture of many PCB congeners at lower resolution, based on the patterns observed in the particular aroclor mixture. The presence of a subset of specific characteristic chromatographic peaks in the mixture, are compared to a commercial aroclor standard. If these peaks are sufficiently similar, it is identified as that aroclor. Once the identification is made, the aroclor is quantified based on the subset of characteristic peaks. Because the aroclor method requires more judgment and has lower resolution, the congener method is considered to be a more accurate and complete representation of total PCBs.

The reason for this apparent discrepancy in estimates of total PCBs between Aroclor method 8082 and congener method 1668A is unknown, but our current hypothesis is that weathered PCBs in sediment may have reduced concentrations of less chlorinated congeners. These processes tend to reduce the relative abundance of less chlorinated congeners and congeners that are not substituted in the ortho position, where spatial arrangement of the atoms limits degradation. Over time, this weathering results in environmental mixtures that are dissimilar for the original aroclors. This dissimilarity increases the likelihood that an aroclor will not be detected in a sample or will be detected at lower concentrations than the total PCB congener sum would suggest. We did not observe this effect in the Lower Slough sampling where the estimate of total PCBs by both methods was more comparable (DEQ 2011).

Currently, toxicity of PCBs is estimated based on estimates of either totals, or as 12 specific congeners that are most similar in structure to 2,3,7,8- tetrachlorodibenzodioxin (TCDD). This similarity is thought to enable these PCB congeners to act in a “dioxin-like” manner. Therefore, their toxicity is indexed relative to TCDD to derive a PCB toxicity equivalent (i.e., TEQ). Thus, the two common measures of toxicity are totals, usually as Aroclor, and TEQ. Most individual congeners are not known to be dioxin like and do not have published toxicity estimates. However, the total PCBs can be accurately quantified as the sum of all congeners and this concentration compared to a total PCB toxicity measure. While this is uncertain due to the fact that toxicity of the total PCB was estimated based on an Aroclor standard, the total congener sum may be considered an acceptable estimate for total PCB to be used in the comparison. Moreover, the congener method will provide a more accurate quantification of PCBs.

4.2.2. Common Contaminants at Targeted Sites

Contaminants of concern (COCs) were selected based on their toxicity and frequency of detection throughout the reach. Standard plots were generated to display the data for the targeted sites relative to the IS mean (reach average or baseline) and the Columbia Slough Source Control Screening values. Targeted site location acronyms (x axis) are defined in Table 2.

Metals

Chromium: Targeted chromium values for the reach were below risk-based values in the upper portion of Whitaker Slough. 57% of the targeted sites were above the source control (risk-based) Screening level and the average concentration of chromium in targeted areas was 75 ppm. The highest chromium result was at Portland Willamette-a known area of metals sediment contamination.

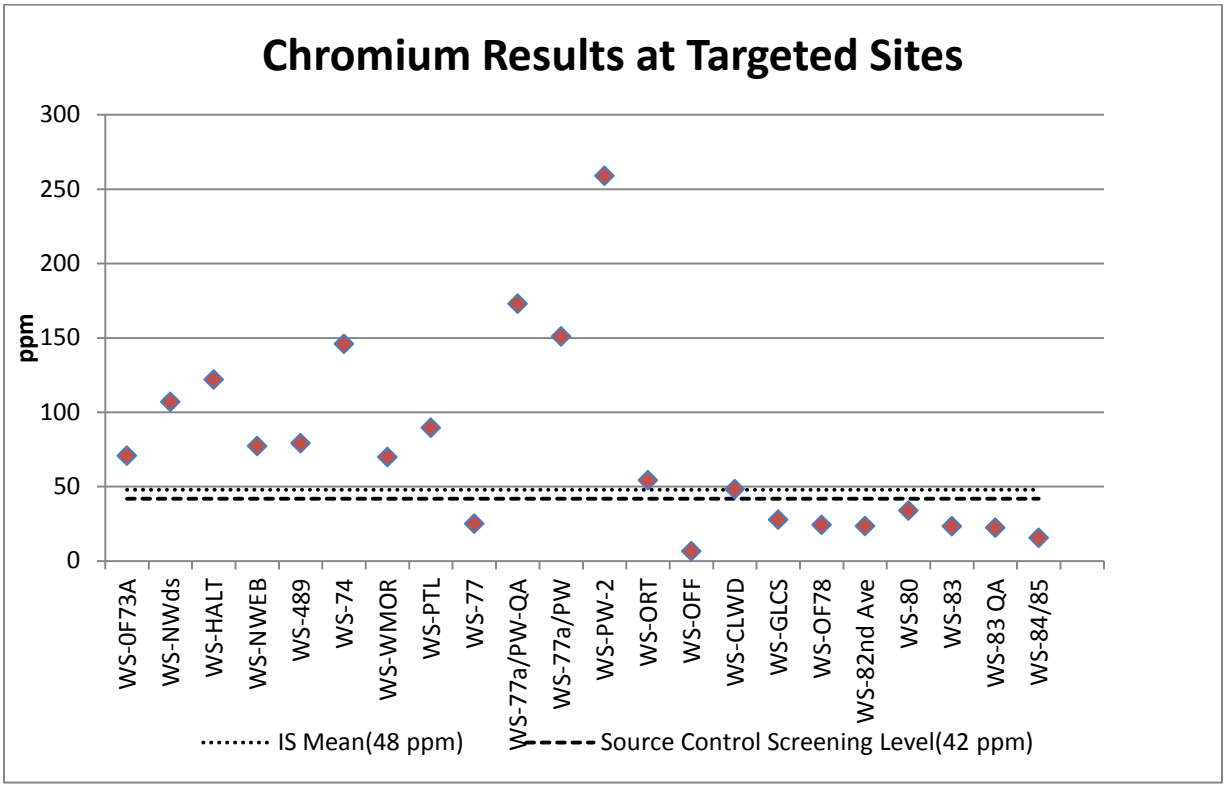

Figure 14 Chromium Values for Targeted Samples Chromium Values for Targeted Samples

Copper: 57% of targeted sites in the Whitaker Slough were above the source control screening level for copper. The Outfall 74 value (1,570 mg/kg) was omitted from the graph due to its magnitude. Outfalls PW and 77A are located in an area known to have metals contamination (apparently associated with both Portland Willamette and City outfall discharges). The IS mean was slightly higher than the source control screening level.

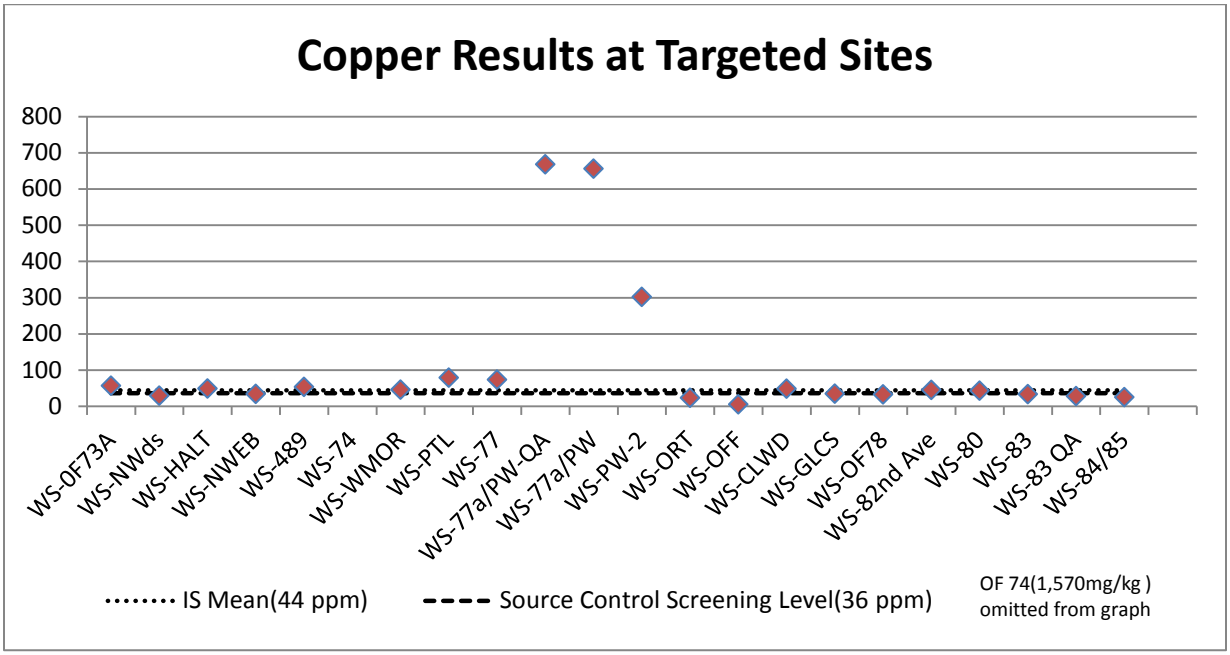

Figure 15 Copper Values for Targeted Samples

Lead: Except for one site, lead was found at all targeted sites above the source control screening level. Lead was above the IS average for 62% of sites. WS-Halt, WS-PW and WS-77A/PW are in or adjacent to areas of known high lead concentrations (based on previous sampling in the area) in Whitaker Slough Sediments.

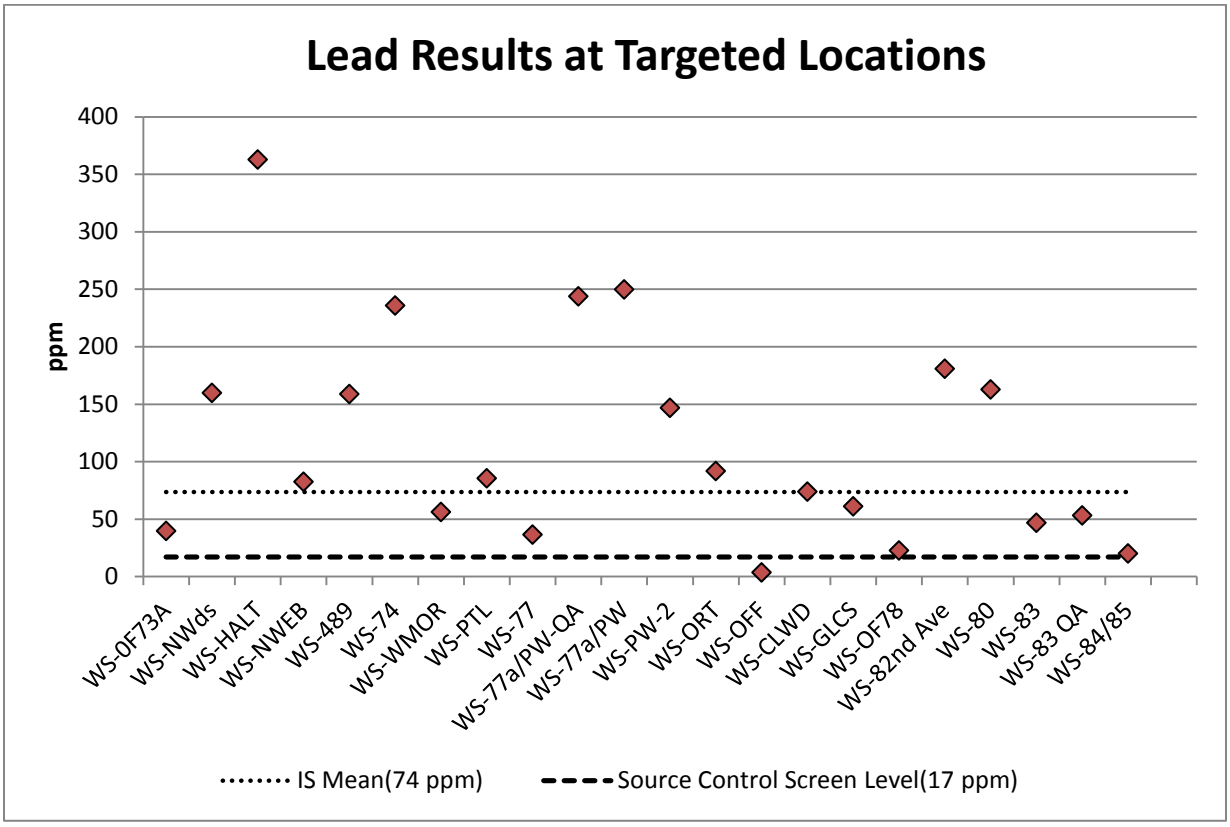

Figure 16 Lead Values for Targeted Samples

Nickel: Nickel results were below the source control screen level for all targeted values except the WS-PW and WS-77A/PW area of known metal contamination and OF 74 in Whitaker Pond. The IS value is below the source control/risk-based value for nickel.

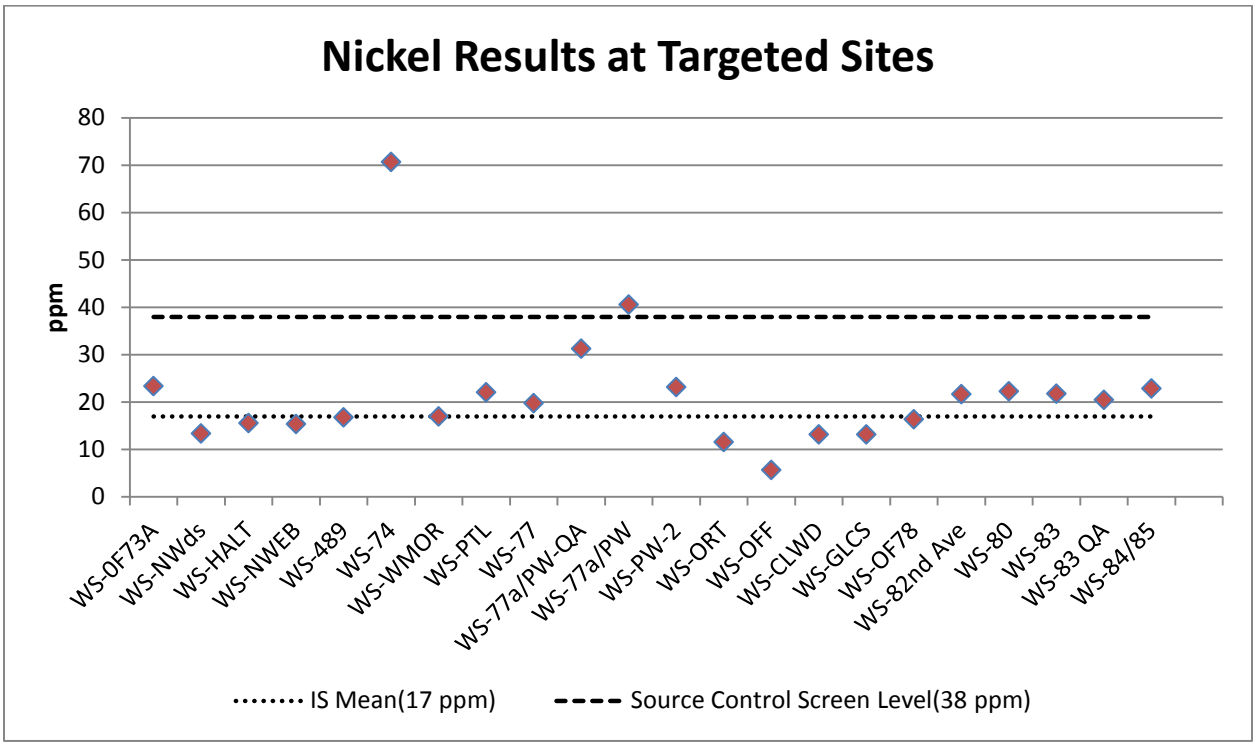

Figure 17 Nickel Values for Targeted Samples

Zinc: 81% of targeted sites were above the source control screening level. Targeted sites above the IS mean generally are areas of known metals contamination or have large areas of roadway runoff (82nd Ave & WS-489 outfalls).

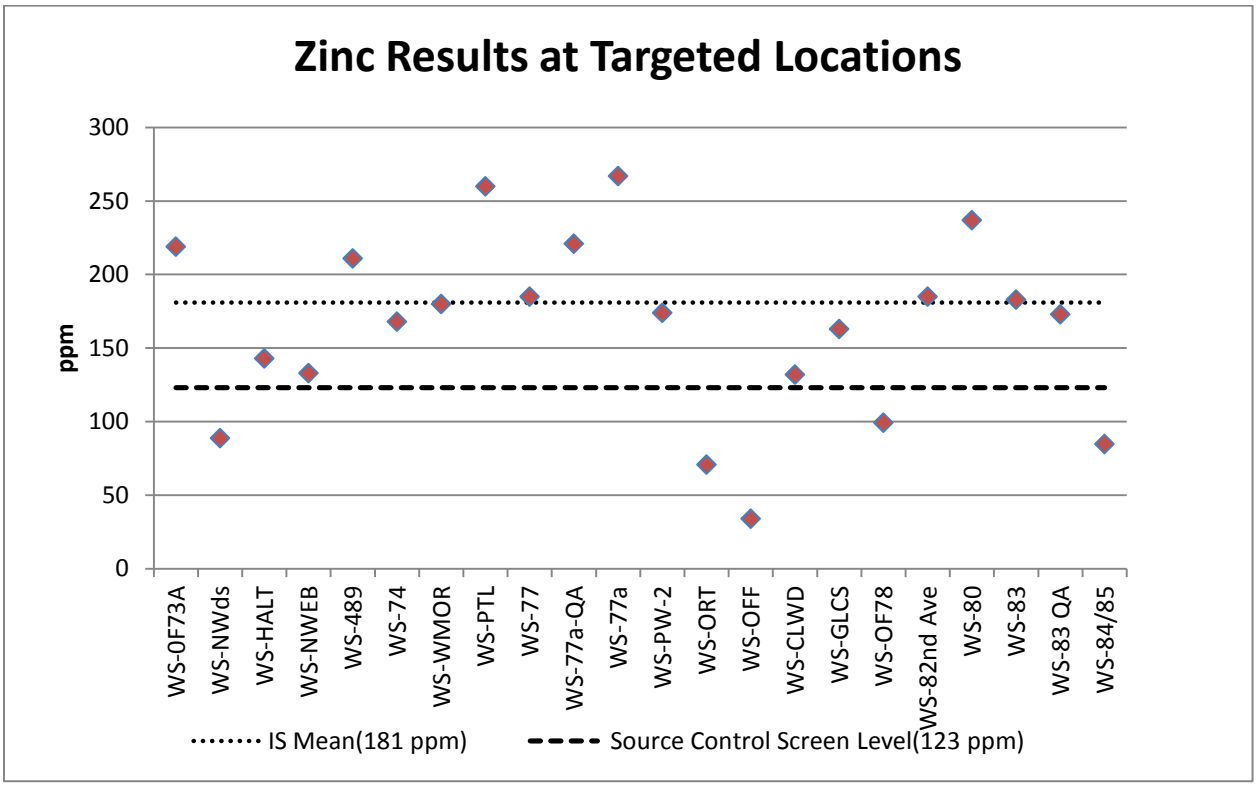

Figure 18 Zinc Values for Targeted Samples

Total Poly-Aromatic Hydrocarbons (PAHs)

Total PAH is the sum of the concentrations of all individual PAHs at each target site. For calculation simplicity, if an analyte was non-detect, the analytical detection limit was used in the calculation. A total PAH risk-based value has not been calculated. One targeted sample, WS 84/85(20,799 ppb) was omitted from the graph. 59% of target sites were above the Whitaker Slough IS mean.

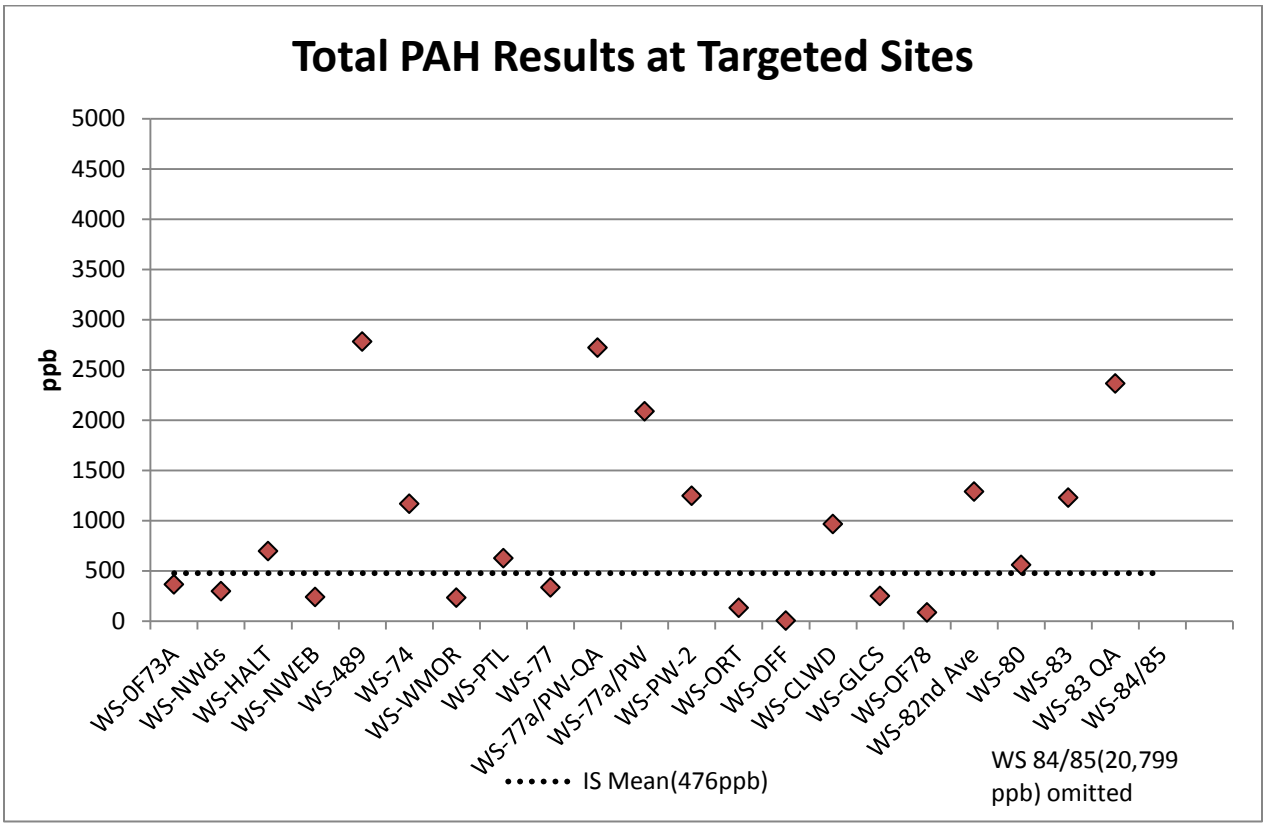

Figure 19 Total PAH Values for Targeted Samples

Pesticides:
Pesticides were generally found at targeted locations; however, method detection limits for some pesticides were above the detection limit, referenced in the 2007 Slough Screening Level Table, of 1 ppb and many of the pesticide results were estimated. The IS average for the reach was below the source control values for all pesticides except DDD, DDE and dieldrin. Note that the source control/risk-based values for pesticides are set at the typically achievable concentration of 1 ppb. The true risk-based values are below 1 ppb. Although pesticides were analyzed at all sites, only detected values are graphed in Figures 20 and 21.

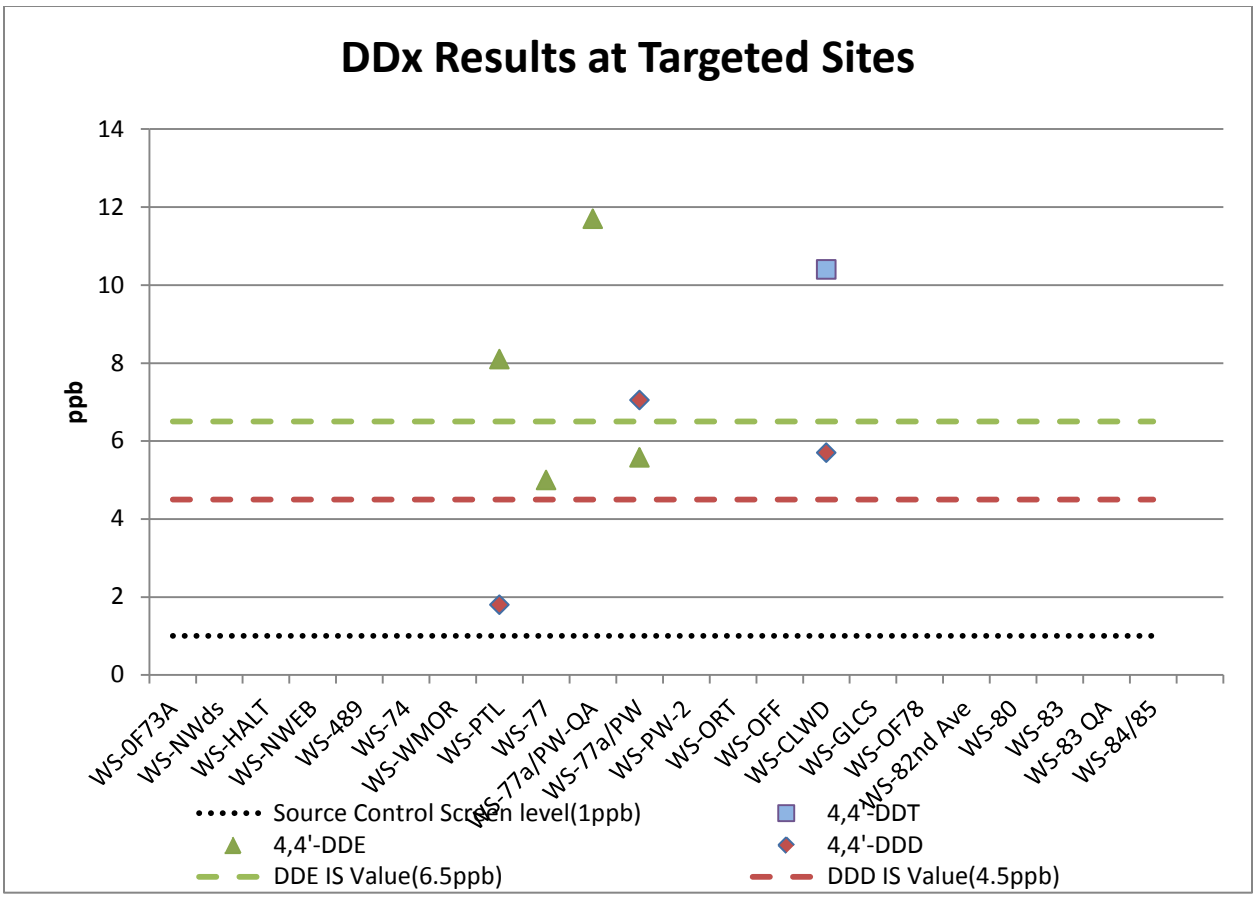

Figure 20 DDx Values for Targeted Samples

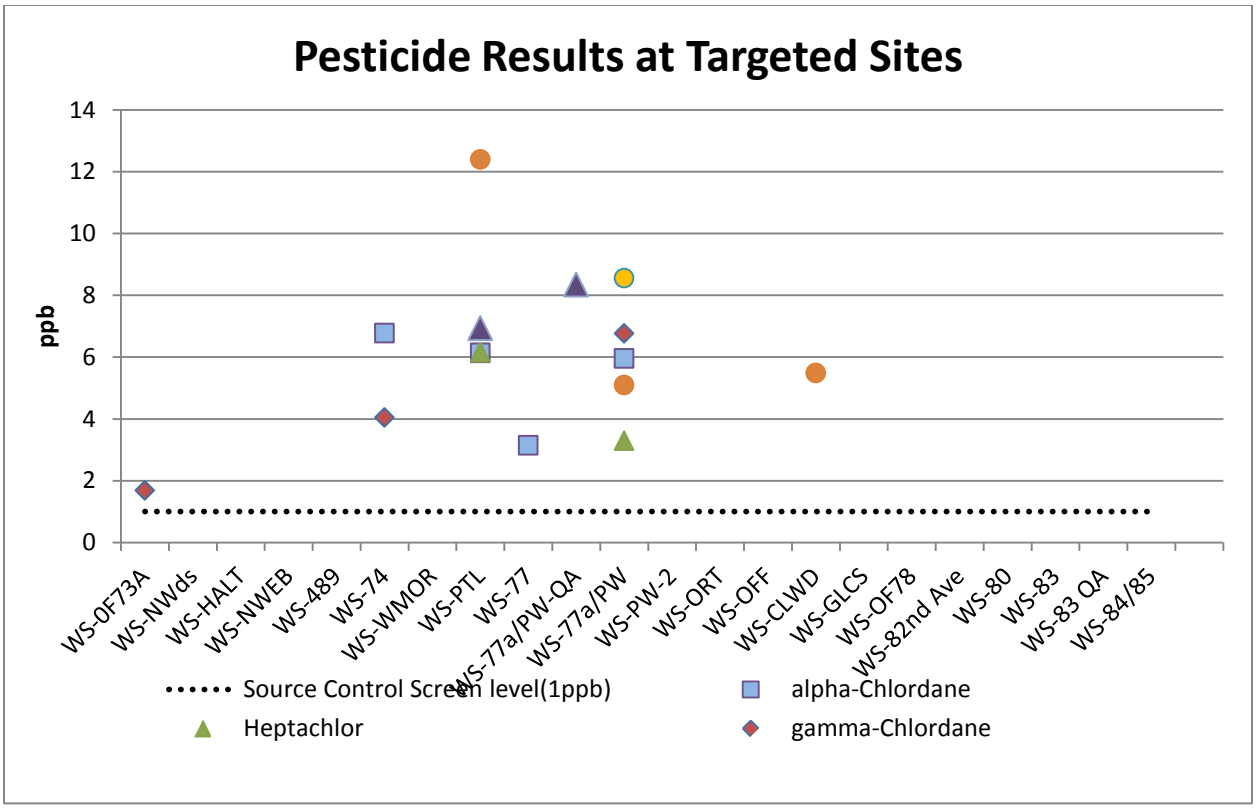

Figure 21 Pesticide Values for Targeted Samples

PCBs

PCB aroclors were found near the NuWay Oil cleanup site and at three of the four high priority outfalls for TSS. Higher concentrations of PCB congeners were detected than Aroclors. As discussed above, this is thought to result from weathering of the PCBs.

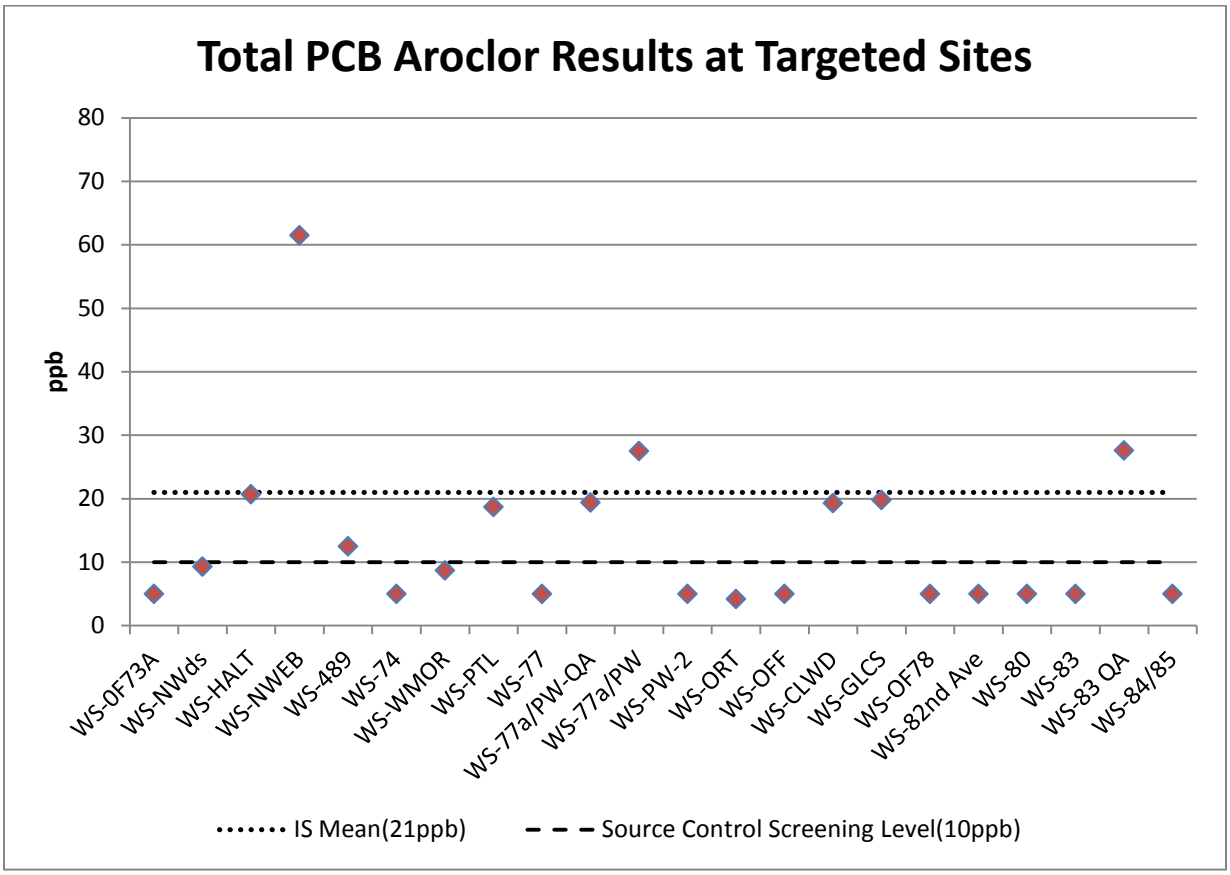

Figure 22 Total PCB Aroclor at Targeted Sites

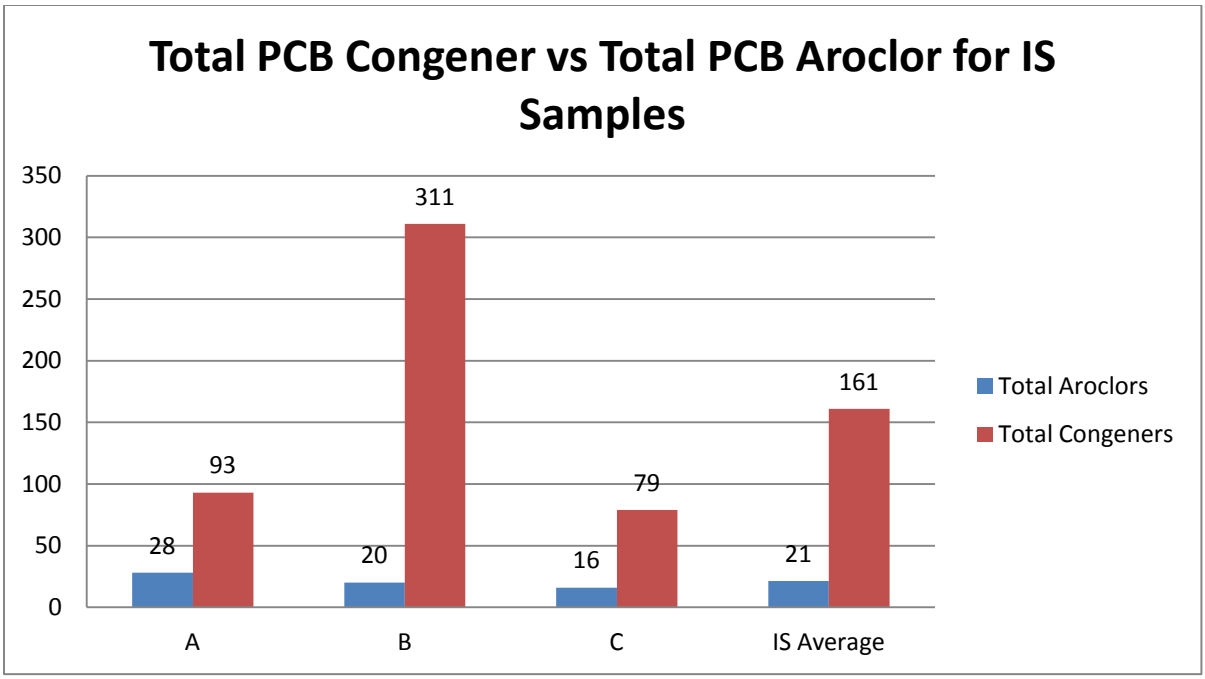

Figure 23 Total PCB Aroclor and Congener for Whitaker Slough IS Samples

4.3 Thiessen Polygon Weighted Averages

Another comparison of interest was completed by calculating the area-weighted average concentration for four compounds, total PCBs (Aroclors), lead, copper, and benzo(a)pyrene, using the discrete samples present in the Slough segment, including data collected in this study, the City of Portland 2006 study, Portland Willamette investigation, Johnson Lake investigation, NuWay investigation, and Multnomah County Drainage District sampling. These compounds were selected because they appeared to be representative of the contaminant groups contributing to the greatest exceedances of screening levels. The method involves creating polygons around each sample point that are sized based on proximity to the next closest sample points. The concentration at the sample point was assumed to apply to the entire polygon surrounding it. Weighted average surface sediment concentrations and corresponding IS average concentrations for these four compounds are presented in Table 6.

Table 6 Comparison of Theissen weighted average and IS average

Compound	Theissen-weighted Average	IS average
Total PCBs (Aroclors)	12.1 ppb	21.1 ppb
Lead	99.9 ppm	73.7 ppm
Copper	259.9 ppm	43.7 ppm
Benzo(a)Pyrene	71.6 ppb	38.5 ppb

With the exception of PCBs, the area-weighted concentrations are higher than the IS average consistent with the calculation in the Lower Slough and again, likely reflects the fact that discrete samples were targeted to release areas. The lower value for the weighted average PCB concentration indicates that the sampling strategy did not capture the source area for PCBs or there are not significant discrete sources of PCBs in this section of the Slough. It should also be noted that estimates of total PCBs differed substantially between the Aroclor method and the congener method. This is discussed in more detail in sections 4.3 and 6.1.

4.4 Bioassay Summary

Chronic bioassay tests were performed on sediment samples collected near target outfalls. Locations are shown on Figure 12 and described in Table 2. The toxicity tests were: the 28-day mortality and growth test with the amphipod *Hyallela azteca* and the 20-day mortality and growth test with the midge *Chironomus dilutus*. Details of these tests are documented in the laboratory reports from Northwest Aquatic Sciences (NAS 2011a,b). Bioassay results were evaluated by DEQ for statistical significance of the test sediment mean response relative to the control response, and for the magnitude of the test sediment response. Prior to interpreting the bioassay responses, the mean response of each of eight replicates was normalized to the control by dividing each of the mean test responses by the control response. The normalized data were

then evaluated for statistical significance and magnitude. Because bioassay response data does not generally meet parametric assumptions, non-parametric test procedures were used. The conclusions are summarized in Table 7.

Table 7 Bioassay Results at Whitaker Slough locations

	Hyallela azteca				*Chironomus dilutus*					
	Mortality		**Growth**		**Mortality**		**Growth**			
Site	Statistical Difference	Effect Level	Statistical Difference	Effect Level	Statistical Difference	Effect Level [a]	Statistical Difference	Effect Level [a]	Overall Interpretation	Cluster Number [e]
WS OFF73A	Yes	Severe	NA	Severe	Yes	Severe	NA	Severe	Toxic	3
WS HALT	Yes	Minor	Yes	Minor Effect	Yes	Severe	NA	Severe	Toxic	2
WS PW2	No	No Effect	No	No Effect	Yes	Severe	Yes	Severe	Toxic	2
WS 77A	No	No Effect	No [d]	No Effect	Yes	Severe	No	No effect	Toxic	2
WS 77A QA	Yes	Minor	No [d]	No Effect	Yes	Moderate	Yes	Moderate	Toxic	2
WS OF 77	Yes	Minor	No [d]	No Effect	Yes	Severe	No	No effect	Toxic	3
WS OFF	No	No Effect	No	No Effect	Yes	Severe	NA	Severe	Not Toxic [b]	1
WS OF 78	No	No Effect	No [d]	No Effect	Yes	Minor	No	No effect	Not Toxic	3
WS 83	No	Minor	No	No Effect	Yes	Severe	No	No effect	Not Toxic [c]	3
WS 8485	No	No Effect	No	No Effect	No	Moderate	No	No effect	Not Toxic	1

a - Based on 10-day test as surrogate.

b - Inconsistent response between *Hyallela* and *Chironomus* tests, and sample is chemically dissimilar from other samples. Result is ambiguous

c- No consistency between test endpoints for this sample within the Chironomus

d - Growth was better than control in these samples.

e- Hierarchical cluster analysis indicates that the samples separate or “cluster” into three distinct groups. See appendix I for explanation.

NA - Growth was not measured in some cases, due to mortality, preventing a test of significance.

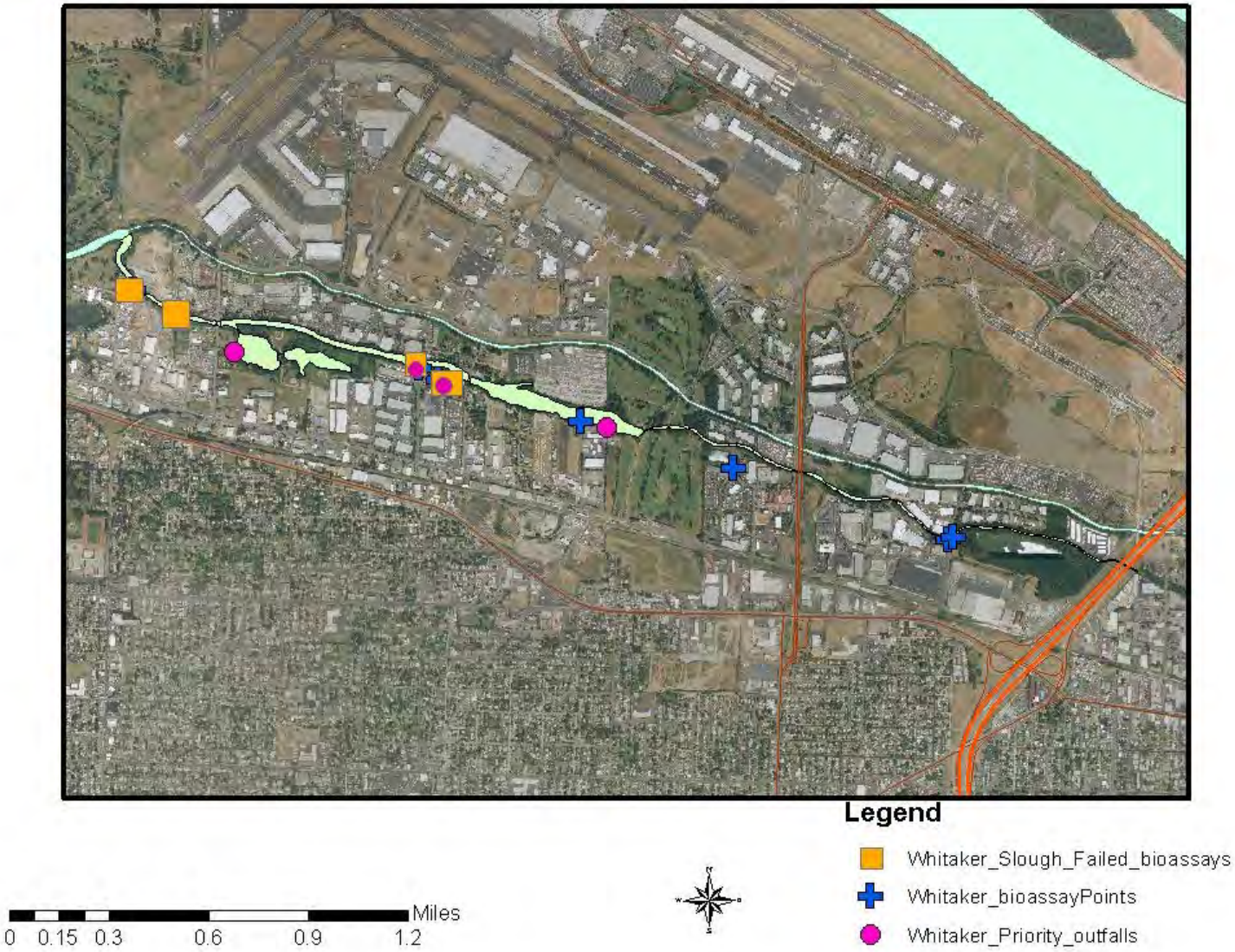

Figure 24 Whitaker Slough Failed Bioassays

For *Hyallela azteca*, effect size was evaluated using the reference envelope approach which was used to interpret Lower Willamette River sediment toxicity tests (EPA 2009). Sediment bioassays are usually interpreted using two criteria: 1) magnitude of effect, and 2) statistical significance. In order to assess what effect size is meaningful, one common approach for dredging projects is to use the Northwest Sediment evaluation framework. The effect sizes in that document are derived from experience with bioassays performed in a wide variety of environments throughout the Pacific Northwest. As an alternative, the reference envelope approach was developed as a method to interpret sediment bioassays performed in the Lower Willamette River, a location that is locally relevant to the Columbia Slough, a tributary of the Willamette River. In the development of the method a significant number of bioassays were performed within an area that could be used as a non-impacted local area reference location as well as in the known impacted area. The lower 5th percentile of responses were selected from this data set and used as the effect size criterion. This approach was also used here to provide a point of reference for effect size using a locally relevant data set.

For *Chironomus dilutus*, the 20-day test was not used in the same Lower Willamette River work; only the 10-day test was used. Therefore, the reference envelope criterion for the 10-day test was used as a guideline to assist with interpretation. The reference envelope was used to differentiate the effect size into three categories- no effect, minor effect, and severe effect. The results are presented in Table 7.

As shown in Table 7, the results were not completely consistent between test species and endpoints. However, these chronic tests do appear to be more sensitive than the shorter-term acute versions. DEQ used the bioassay data in an attempt to assess a correlation between contamination and/or sediment characteristics and bioassay results. The bioassay results appear to group into three 'clusters', based on differences in analytical chemistry. The details of this evaluation are summarized in Appendix I. While some trends in sediment chemistry can be discerned, no clear link between toxicity and contamination could be made.

Due to the inability to correlate toxicity to contaminant concentrations, toxicity screening levels for the Whitaker Slough have not been modified. Because of the higher level of sensitivity observed in the longer term toxicity tests, the results from the Lower Slough toxicity evaluation are being reconsidered.

4.4 Bioaccumulation Evaluation

Unlike DEQ's previous investigation in the Lower Slough, no attempt is made to estimate specific uptake factors between sediment and fish tissue in the Whitaker Slough for two reasons. First, data are sparse. Only 1 of 3 fish tissue samples associated with this reach was analyzed for PCB congeners. In addition, only PCB Aroclor 1254 was detected in the fish tissue samples and only PCB Aroclor 1260 was detected in the IS samples limiting the comparability. Secondly,

regression models attempted with the available data indicate high uncertainty and relatively poor regression diagnostics. This finding indicates that the assumptions required for regression are not met. Therefore, reliable estimates of uptake factors specific to the Whitaker Slough could not be derived. However, a brief presentation and discussion of these data are presented here to provide insight into patterns observed between the two media. Consistent with the evaluation completed for the lower Columbia Slough (DEQ 2011) the incrementally collected sediment data was related to the available fish collected by Portland BES in 2005(only 3 samples for the Whitaker Slough). Mean concentrations from the IS sediment was related to mean concentrations of pesticides in the three fish. For PCBs, data for only one fish was usable since only one fish had congener data and Aroclors were not consistent between fish and sediment. The base 10 logarithms were used to reduce the influence of extreme values and regressions and scatter plots were prepared.

Figure 24 shows the result for PCBs, and Figure 25 for pesticides.

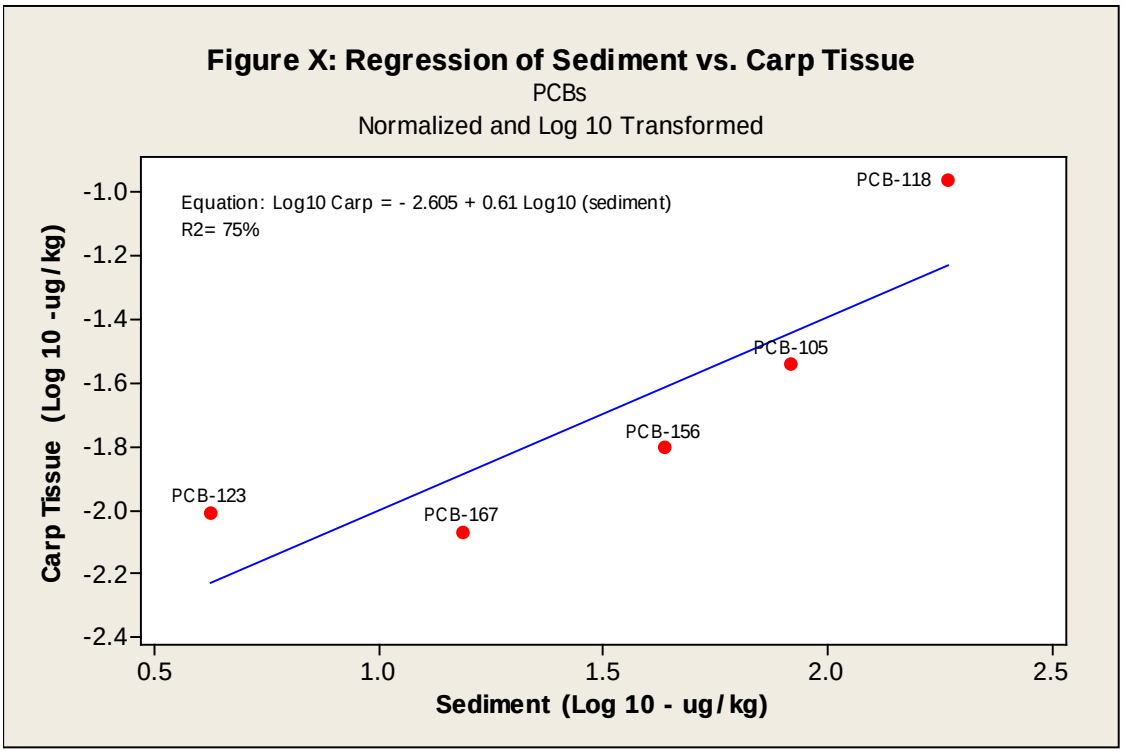

Figure 25 Regression of Sediment vs. Carp Tissue: PCBs

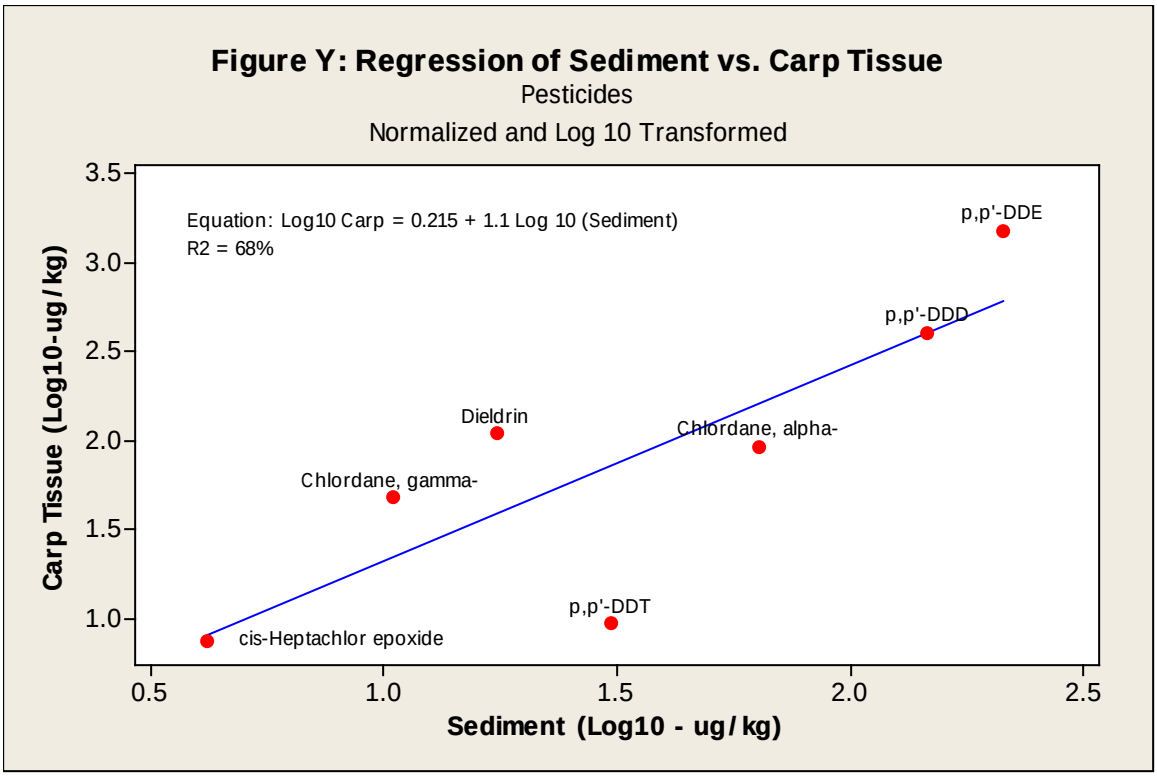

Figure 26 Regression of Sediment vs. Carp Tissue: Pesticides

Inspection of Figures 24 and 25 reveals the following general observations. The relationship between incrementally collected sediment data and fish tissue appears to remain valid in the Whitaker slough as it did in the Lower Slough (DEQ 2011). Notably, the PCB levels in fish tissue are lower and the pesticide levels are higher in the Whitaker Slough, relative to the Lower Slough. This is reflected in the differing intercepts in these regressions, relative to those prepared for the Lower Slough. Secondly, the slopes of these regressions are very similar to those prepared for the Lower Slough, indicating that the ratio between sediment organic carbon and fish lipid is likely the same between the two reaches regardless of the actual concentration differences. Moreover, where the analytes are in common between the two reaches, they appear in generally the same order. These results suggest that we are measuring a physical process that is consistent between locations (i.e., chemical partitioning).

In this case, insufficient data are available to establish site-specific uptake factors between the organic carbon pool and fish lipid. This is due to the following issues:

1) Limited and variable data in common between sediment and carp,
2) Difficulty in mathematically fitting an appropriate model to the available data

Concerning issue number 2, the method used is known as ordinary least squares regression (OLS). In order for this method to be used to create a model for prediction of new observations

with a degree of reliability, certain assumptions must be met. If these assumptions are not met, any prediction made using the method has unknown confidence and may be erroneous. Three common assumptions are that the data used fit a normal distribution, that the variance of each of the regression error terms is equal, (after minimizing the squared distance between the predictors and response) and thirdly, that the predictors (sediment concentrations) are unrelated to each other. There are other assumptions, but these three are the most commonly cited and they are listed here generally in order of relative importance. When assumptions are met, the model is able to provide an unbiased estimate of the mean response, given new predictor data with a specified level of confidence. When the assumptions are not met, regression predictions can be poor and there is no confidence that an unbiased estimate of the mean response can be obtained. In the case of the Whitaker Slough data, the results (not shown) indicate likely violations of all three assumptions, in addition to the relatively limited data.

Additionally, it is unclear if a linear relationship between media is the most appropriate. Based on Figure 25, it is also possible that a curvilinear relationship could be appropriate which would result in different uptake estimates at different concentration ranges.

Based on the considerations above, the existing Whitaker Slough fish tissue data set is insufficient to estimate a reliable uptake factor with confidence. However, this may be re-visited when additional IS-collected sediment data is available in other slough reaches, which may be compared to fish captured in those reaches. The Whitaker Slough data may then be incorporated with the broader, more complete data set throughout the slough, and more detailed and appropriate modeling methods applied.

5.0 ADDITIONAL SEDIMENT DATA IN THE WHITAKER SLOUGH

Data collected by other parties in the Whitaker Slough since 2000 are summarized below to present available recent sediment information in the Slough. The data is used in addition to the 2011 data to help characterize the sediment in Whitaker Slough. Sample locations are shown below in Figure 28.

5.1 Additional Sediment Investigations within the Whitaker Slough Study Area

5.1.1 Nu-Way Oil Co. Site

In 2002, sediment samples adjacent to the Nu-Way Oil Co. (ECSI#88) were collected to determine the extent of oil, lead and to a lesser extent PCB contamination in the Whitaker Slough from the Nu-Way Oil site. Petroleum hydrocarbon concentrations were found in slough sediments at concentrations up to 31,320 ppm. Concentrations of lead in Whitaker Slough sediments were found at concentrations up to 35,300 ppm. PCBs were found at 1.5 ppm in slough sediments. By 2009, most of the remedial action had been completed for the site, including dredging Whitaker Slough sediments and placement of a two foot soil cap in the upland contaminated area with engineered surface water drainage. Some contaminated areas of

the Whitaker Slough bank near the western edge of the property were not completely removed to avoid bank failure at the neighboring property (Halton), and damage to the stormwater infrastructure. Successive sampling events, including the 2011 sampling event, demonstrate that lead and PCB concentrations in this area have been substantially reduced. Currently, monitoring wells on the Nuway site do not indicate migration of TPH to the slough. The Halton site, which discharges stormwater in the Nuway remedial area, has not performed source control work and may be a source of lead and TPH to slough sediments.

In the Nuway Oil graphs below, both 2002 data points (pre-cleanup) and 2006 data points (post cleanup) located near the 2011 composite were averaged to produce the values below. Up to 10 historic data points were found within the 2011 composite sample areas, however not all data points included all three analyses. For example, only one sample of TPH was analyzed in the 2006 data set (Ecology and Environment, 2003 & 2008).

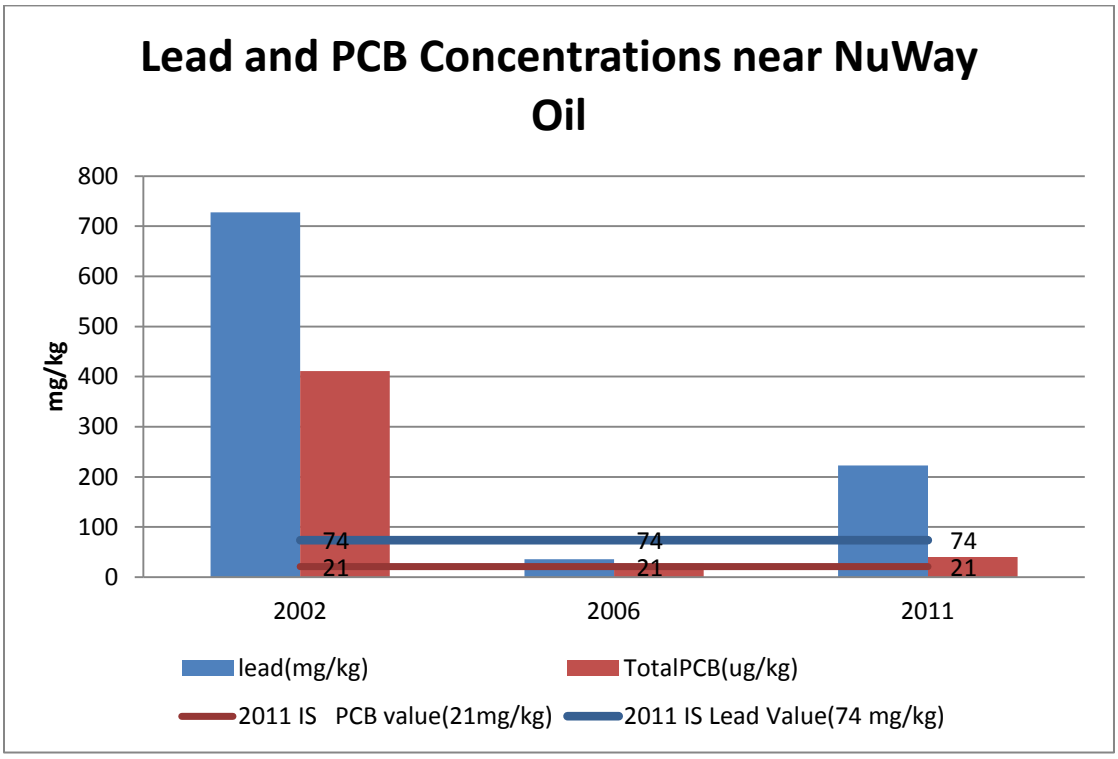

Figure 27 Nu Way Oil Co. area Concentrations: Lead and total PCBs

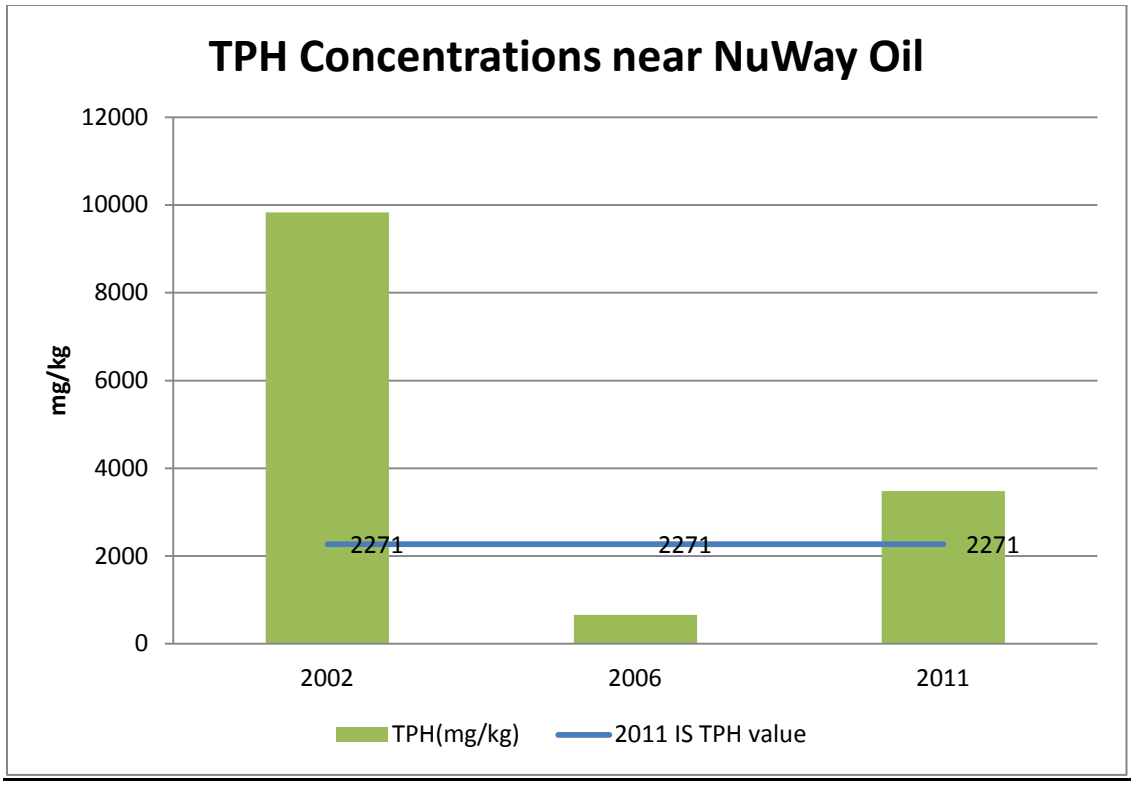

Figure 28 Nuway Oil area concentrations: TPH

5.1.2 Portland Willamette Inlet

Widespread metal contamination in a Whitaker Slough inlet was found where the Portland Willamette Co. (ECSI#2767) stormwater outlet and city of Portland Outfall #77A discharge. Sampling in 2007 found metals concentrations of up to 3,750 mg/kg copper, 266 mg/kg of chromium, 741 mg/kg of lead and 937 mg/kg of zinc. Petroleum and PCBs were also found in the sediment. Portland Willamette Co. has entered into a settlement agreement with DEQ for slough sediment cleanup and will control upland sources. It is possible that additional metal sources occur in the Outfall #77A drainage. Active sediment remediation has not occurred in the inlet.

5.1.3 Multnomah County Drainage District (MCDD)

In 2010, MCDD assessed ditches in need of dredging for flood control within the Columbia Slough watershed. The Whitaker Slough, north of Johnson Lake, between NE 82nd Ave and I-205 was sampled as part of this effort. Surface samples (10cm) for this section of Slough contained up to the following concentrations; 194 mg/kg lead, 68 mg/kg copper, 321 mg/kg of zinc and 30 ug/kg of PCBs. There are no outfalls or known sources in this stretch of Slough. MCDD is expected to dredge this section in the future for flood control.

5.1.4 City of Portland Sediment 2006 Study

The City of Portland (COP) collected 6 surface sediment samples located approximately every half mile in the Whitaker Slough sampling area in 2006 as part of their long-term monitoring of slough-wide conditions. Samples were analyzed for PCBs, semi-volatile organic compounds including PAHs, metals, pesticides, petroleum hydrocarbons, grain size, and organic carbon. Chlordane (technical) and DDx were detected at all six sites up to 13.5 ug/kg and 18.4 ug/kg, respectively. PCBs were only detected in the eastern two samples north of Johnson Lake at up to 71.5 ug/kg. Chromium and copper were detected above screening levels near the mouth of the Whitaker Slough. Lead was detected (101 mg/kg) above screening levels at one location.

5.2 Sediment Investigations Adjacent to the Whitaker Slough Study Area

5.2.1 Johnson Lake

Johnson Lake is directly south of Whitaker Slough and connected to the slough on its west end. Owens Brockway Glass Containers, owner of the majority of the property immediately adjacent to the lake has taken the lead on evaluating and cleaning up the lake (ECSI project #2086). Lake sediment has been sampled several times between 1994 and 2008. The primary contaminant of concern based on risk to fish consumers is PCBs. Metals, petroleum, pesticides and PAHs have also been detected. PCB concentrations exceeding 1 ppm have been detected in lake sediment. DEQ issued a ROD for the site in July 2009 selecting thin layer capping as the remedial action. Cap placement was in progress at the writing of this report. As part of the remedial investigation Owen's consultants collected sediment samples in the Whitaker Slough (Arcadas, 2003) up and downstream of the Johnson Lake. This data indicated contamination was present outside of the lake that may or may not be related to releases in the lake itself. This data has been incorporated into the data base for the Whitaker Slough.

5.2.2 Johnson Lake Slough

In order to compensate for placing fill in Johnson Lake, Owens has dredged sediment from the Johnson Lake Slough which connects the lake to the main stem of the Whitaker Slough. This segment was sampled in 2010 to assess management needed for the dredged material. One composite sediment sample found concentrations below levels of concern, except for lead at 20 ppm. DDT was also detected at 2.6 ppb. No PCBs were detected.

5.2.3 East Whitaker Pond/Metro Metals

East Whitaker Pond is separated from West Whitaker Pond by an earthen road causeway and culvert. Two outfalls from Metro Metals represent the only documented source of potential contamination in the East Whitaker Pond. In 2008, Metro Metals completed a large upgrade to the stormwater treatment system which included a solids separation tank and metals filtration. Metro Metals investigated sediments near their outfalls and initial draft data indicates metals and PCB concentrations above screening levels. Lead at 746 mg/kg , zinc at 1,460 mg/kg , and in surface sediments adjacent to a historic outfall. Aroclor 1254 at 544 ug/kg were detected. Future

work will determine extent of sediment contamination. This information was not included in the Whitaker Slough analysis.

Whitaker Slough Existing Sample locations

Figure 29 Other data locations in the Whitaker Slough sampling area

5.2.4 Marx-Whitaker Subbasin

The Marx-Whitaker Subbasin is the designation given to the easternmost 300 feet of the Whitaker Slough east of NE 122nd Ave between NE Whitaker Way and NE Marx Street. Elevated concentrations of pesticides (DDD, DDE, DDT, dieldrin, endosulfan II, and endosulfan sulfate) were noted in the screening level risk assessment conducted by the City in 1994/95. Additional sediment data was collected from this area in 1997 and a risk evaluation concluded the levels posed an unacceptable risk to birds eating fish exposed to the sediment. A stormwater and storm sewer sediment report completed in 1999 by the City found that pesticides and TSS were entering the sub-basin via a City of Portland outfall at 128th and Whitaker, and pointed to agricultural fields near NE Shaver St as the likely source. Fish tissue and sediment sampling conducted by the City in 2005 and 2006 indicated elevated pesticides in fish and sediment. Stormwater data collected in 2010 and 2011 indicated continued discharge of pesticides and TSS at levels of concern. The City and DEQ are working with the Department of Agriculture to ensure that agricultural processes are modified and source controls installed to prevent further discharge to this area. Once source controls are in place, sediment cleanup will be evaluated.

6.0 CONCLUSIONS

6.1 Baseline concentrations in Whitaker Slough

This study supports the use of the 2011 incremental sample results as the new "baseline" or "ambient" concentration for the Whitaker slough from the mouth to Interstate 1-205. The IS concentrations do not vary significantly from the baseline values derived by DEQ in 2002 as can be seen for pertinent compounds in Table 5, however 22 compounds have updated screening level values. The Whitaker Slough specific screening level table can be found in Appendix H.

With the exception of lead, the new baseline levels for metals in the Whitaker Slough are consistently lower than the previously established values, which will continue to be used for Middle and Upper Columbia Slough evaluation. This is either due to reduced sources contributing to contamination over time, higher metals concentrations elsewhere in the Slough that raised the baseline value, or effects of cleanup conducted in the Whitaker Slough (i.e., NuWay). Pesticide screening level concentrations are consistently lower than previous values except for DDD, DDE and dieldrin. This is due in part to lower detection limits achieved using analytical method U.S. EPA 1699. Pesticides were detected primarily between samples WS-PTL and WS-CLWD. This section of Whitaker Slough is wide and may represent a settling area for upstream sediments.

Baseline screening levels for polycyclic aromatic hydrocarbon (PAHs) are consistently lower, except for benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene in this section of the Slough than the Slough-wide levels. This may reflect fewer transportation corridors that drain to the Whitaker Slough. PCB total aroclors were found to be twice the value of previous 2002

baseline values. The original PCB baseline values were driven to a large extent by minimum reporting limits at the time. The 2011 data had fewer non-detect samples and are more likely to be representative of actual baseline concentrations.

6.2 Benthic Toxicity and Bioaccumulation in the Whitaker Slough

As discussed in Section 4.4, half of the bioassays conducted on sediment samples in this study appeared to have indicated some toxicity. It was not always possible to make correlations between sediment chemistry and toxicity, however four of six toxic bioassay results were found at locations with contaminant concentrations either moderately or significantly greater than the IS mean or background for the reach. There is not enough certainty in the results to make changes to the toxicity screening levels for the Whitaker Slough at this time. The results of the bioassays will be considered, however, in determining which portions of the Whitaker Slough are priorities for evaluation of active sediment remediation as discussed in Section 8.1 below.

There was insufficient data to support a calculation of Whitaker Slough specific BSAFs. Consequently, changes to the bioaccumulation screening levels could not be supported based on this study. Since PCBs are the primary bioaccumulative contaminant of concern in the Columbia Slough, the location of the highest PCB concentration will be considered in evaluating priority areas for active sediment remediation, as discussed in Section 8.1 below.

6.3 Priority Zones for Active Remediation

As described in Section 4.3, weighted average concentration of 4 indicator contaminants (PCBs, lead, copper, and benzo(a)pyrene) were calculated to aid in identifying priority areas for active remediation. The premise is that weighted average concentrations of the targeted samples will generate higher concentrations than actual average concentrations (represented by the IS average) of constituents for which actionable sources exist in this portion of the Slough. Priority areas are shown in Figure 29.

6.3.1 PCBs

Because the weighted average concentration of total PCBs for the Whitaker Slough was lower than the IS average, we surmised that significant discrete sources of PCBs are no longer present. However, because this contaminant poses the greatest bioaccumulative risk in the Slough overall and was detected in fish tissue samples at the outlet of the Whitaker Slough at levels exceeding protective concentrations for fish ingestion, the sample with the highest concentration of PCBs, at Nuway Oil east bank, was used to identify a priority area for active cleanup. This was the only location where a targeted sample considerably exceeded the IS average concentration for PCBs.

6.3.2 Lead and Copper

Priority areas for lead and copper were identified by sequentially reducing the highest concentrations to the IS average and recalculating the weighted average until the weighted average concentration fell below the IS average. In general, areas identified based on elevated copper were also identified based on elevated lead. These areas included the discharge area for the Portland Willamette site as well as the discharge from City of Portland Outfall 77A and a portion of the Whitaker Pond impacted by the outfall from the Halton facility. In addition, residual elevated lead was identified in the vicinity of the NuWay site.

6.3.3 Benzo(a)pyrene

The same process described above for lead and copper was used to identify areas where benzo(a)pyrene (and likely other PAHs) were elevated to the extent that the contribution of those areas and concentrations to the weighted average calculation caused the weighted average to exceed the IS average. One of the identified areas coincided with a location where bioassays had been performed that indicated no toxicity. Because the environmental concern associated with PAHs is toxicity, this areas was removed from those identified as priorities for active remediation.

6.3.4 Bioassay Results

All but one of the bioassays indicating toxicity were located in priority areas described above. The remaining location, near OF 73A, was identified as a priority area based on benthic toxicity concerns.

Whitaker Slough Priority Areas

Figure 30 Priority areas for Whitaker Slough circled in black

7.0 RECOMMENDATIONS/FUTURE STEPS

7.1 Sediment Cleanup Prioritization

As shown in Figure 29, three general areas are identified as priorities for follow-up by combining the criteria discussed in section 6. The location, approximate size, and basis for designation are summarized below:

Table 8 Whitaker Slough Sediment Cleanup Priority Areas

Area	Concerns	Approximate size
Whitaker Slough between City OFs 73A and 74 (and adjacent to Halton and Nuway)	Bioassay failure, lead (236 ppm, 363 ppm), PCBs at 61 ppb, BaP 299 ppb	2000 feet from OF 73A to Whitaker Pond and 500 feet into Whitaker Pond
City OFs 77, 77A, and PW-2	Bioassay failures, BaP (131, 236 ppb), lead (236, 302 ppm), copper (773 ppm)	1,000 feet of waterway including inlet
82nd Ave	BaP at 111 ppb	1,200 feet of waterway

Considering that bioassays performed on samples with higher PAH concentrations than detected in the sample near 82nd Ave passed, this area may be relatively lower priority for active remediation.

7.2 Remedial Options

Similar to the Lower Slough Segment, it is likely that additional characterization will be warranted prior to evaluating remedial action options for the identified priority areas. There is very limited information on the depth of contamination and many areas are defined as relatively large based on a lack of proximal data. As resources allow, DEQ will work with MCDD and the City to complete the needed characterization and remediation at the priority areas.

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Appendix A: Sample Location Maps

Figure A-1: IS Sample Locations

Appendix A: Sample Location Maps

Figure A-2: Detailed Whitaker Slough Map 1

Appendix A: Sample Location Maps

Figure A-3: Detailed Whitaker Slough Study Area Map 2

Appendix A: Sample Location Maps

Figure A-4: Detailed Whitaker Slough Study Area Map 3

Appendix A: Sample Location Maps

Figure A-5: Detailed Whitaker Slough Study Area Map 4

Appendix A: Sample Location Maps

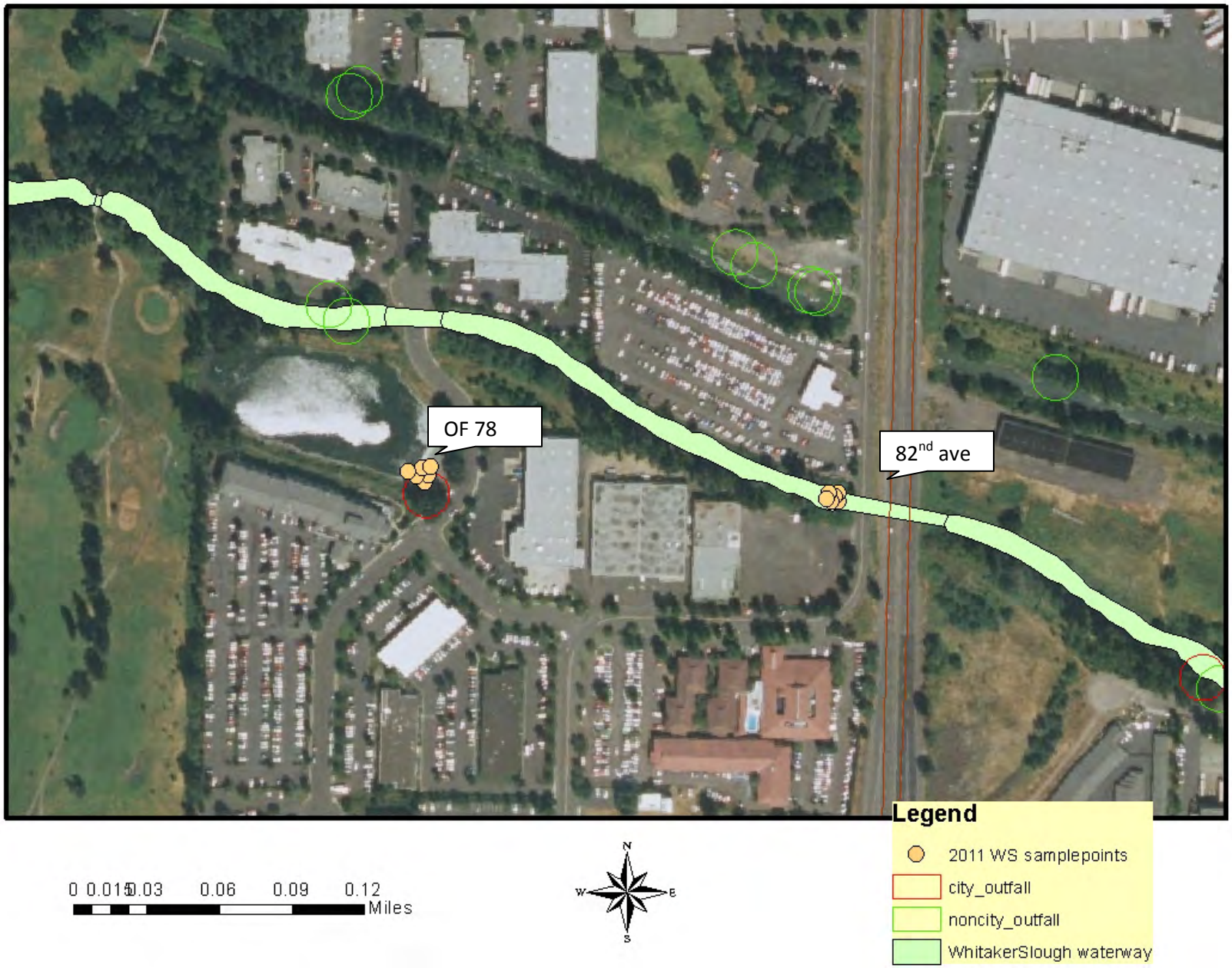

Figure A-6 Detailed Whitaker Slough Study Area Map 5

Appendix A: Sample Location Maps

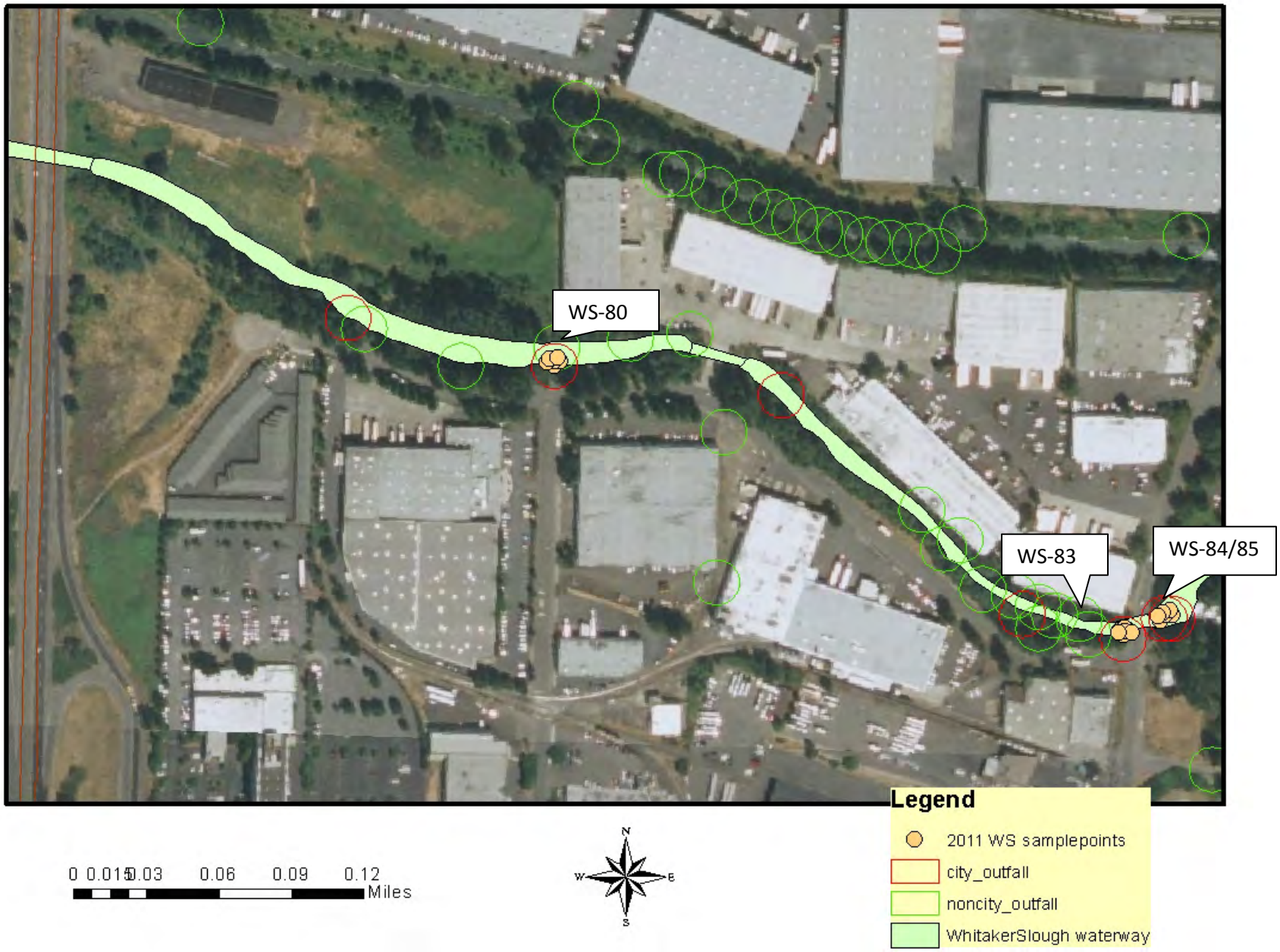

Figure A-7 Detailed Whitaker Slough Study Area Map 6

Appendix B: Location Field Notes

PaceLab ID #	Site Name	lattitude(dd)	Longitude(dd)	Date		How	
		Centroid	Centroid	Sampled	Depth(cm-av	Sampled	Comments
WS73A	Whitaker Slough at City of Portland Outfall 73A	45.576210	-122.619230	1/25/2011	7	drege	gravelly, organic odor, many macrophytes impeed depth of sample, woody debris, oil sheen
WS-NWds	Whitaker Slough downstream of Nuway Oil	45.574665	-122.399475	1/25/2011	8	dredge	macrophyes and clam
WS-HALT	Whitaker Slough Halton Outfall	45.575090	-122.616605	1/25/2011	10	dredge	organic odor and high sheen in sediment for one composite, riprap against shore
WS-NWEB	Whitaker Slough at NuWay East Bank	45.574865	-122.615760	1/25/2011	8	drege	Some macrophytes, and deep holes where sediment removed for nuway, etc.
WS-489	Whitaker Slough at 47th Ave	45.574685	-122.613320	1/25/2011	7	dredge	Marcrophytes and rocky bottom limited depth; many clams- only 5 sample points
WS74	Whitaker Ponds at City of Portland Outfall 74	45.573474	-122.612671	2/2/2011	10	clam gun	
WS-WMOR	Whitaker Slough at Waste Management of OR	45.574635	-122.609532	1/25/2011	10	dredge	Macrophytes
WS-PTL	Whitaker Slough at Pro Truck Lines	45.573420	-122.603025	1/27/2011	10	dredge	Many Clams- one dredge had 7 clams!
WS-77	Whitaker Slough at City of Portland Outfall 77	45.439610	-122.601445	1/27/2011	7	dredge/spoor	Macrophytes and very gravely- too much gravel close to the outlet for good sample- moved out
WS-77a	Whitaker Slough at City of Portland Outfall 77a & Portland Willar	45.572485	-122.599860	1/27/2011	10	dredge	Some floculance, very soft sediments, roofing material near outfall
WS-77a QA	Whitaker Slough at City of Portland Outfall 77a & Portland Willar	45.572485	-122.599860	1/27/2011	10	dredge	Some floculance, very soft sediments
WS-PW2	Portland/Willamette Inlet #2	45.572485	-122.599860	1/27/2011	10	dredge	Sulfur smell, very soft sediments,
WS-ORT	Whitaker Slough at Oregon Tractor	45.571675	-122.596025	1/24/2011	7	dredge	marcrophys limiting depth & cover bottom, woody debris down near outfall- cannot get close to outfall
WS-OFF	Whitaker Slough at Oregon Fresh Farms	45.571170	-122.592790	1/24/2011	7	spoon	biological activity- orange/iron sediments and biological sheen. Macrophytes on delta/fan
WS-CLWD	Whitaker Slough at Colwood Ave	45.570966	-122.591294	1/24/2011	10	dredge	
WS-GlfC	Whitaker Slough at Colwood Golf Course	45.570545	-122.582855	1/24/2011	10	dredge	
WS-78	Whitaker Slough at City of Portland Outfall 78	45.569050	-122.681265	2/7/2011	10	clam gun	very soft sediment- three on west side of outfall, three on east side. Rebar staked along bank. One sample with road gravel
WS-82ndAv	Whitaker Slough at 82nd Ave	45.569086	-122.581776	2/7/2011	10	clam gun	fines likely collect
WS-80	Whitaker Slough at City of Portland Outfall 80	45.567758	-122.573308	2/2/2011	10	clam gun	some oil sheen and organic smell in one composite. Asphalt roofing pebbles present
WS-83	Whitaker Slough at City of Portland 83	45.566207	-122.568377	2/2/2011	10	clam gun	some oil sheen, macroinverts in sample- two outfalls at this point?
WS-84/85	Whitaker Slough at City of Portland Outfall 84/85	45.566312	-122.568043	2/2/2011	10	clam gun	peat/roots near some samples, area adjacent to outfall rocky/riprap
WS-84/85- QA	Whitaker Slough at City of Portland Outfall 84/85	45.566312	-122.568043	2/2/2011	10	clam gun	peat/roots near some samples, area adjacent to outfall rocky/riprap

Appendix B: Sample Locations

	Whitaker Slough						
	Incremental Sampling Locations					2/7/2011	
	Triplicate Jar			Latitude	Longitude	Actual	Actual
	A	B	C				
IS-WS001	A		C	45.5657	-122.5599	45.56537	-122.3388
IS-WS002	A		C	45.5662	-122.5611	45.5662	-122.55923
IS-WS003		B	C	45.5664	-122.5624		
IS-WS004	A	B		45.5666	-122.5637	45.56626	-122.56312
IS-WS005	A			45.5668	-122.5651		
IS-WS006	A	B		45.5667	-122.5664	45.56680	-122.56680
IS-WS007	A	B		45.5666	-122.5678		
IS-WS008			C	45.5663	-122.5689		
IS-WS009		B		45.5668	-122.5700		
IS-WS010		B	C	45.5674	-122.5710		
IS-WS011	*A*	*B*	C	45.5679	-122.5722		
IS-WS012	*A*	B	*C*	45.5678	-122.5735		
IS-WS013		B	*C*	45.5681	-122.5748		
IS-WS014		*B*	C	45.5684	-122.5761		
IS-WS015	A		C	45.5689	-122.5773		
IS-WS016	*A*	*B*	C	45.5691	-122.5786		
IS-WS017	*A*	B	*C*	45.5694	-122.5798	45.56918	-122.58038
IS-WS018	A		C	45.5700	-122.5810	45.57000	-122.54174
IS-WS019	A	B		45.5701	-122.5824		
IS-WS020	A	B		45.5702	-122.5837		
IS-WS021	A		C	45.5707	-122.5848	54.5707	-122.5747
IS-WS022		B	C	45.5707	-122.5861		
IS-WS023		B	C	45.5705	-122.5875	45.57064	-122.58794
IS-WS024	A		C	45.5706	-122.5888		
IS-WS025	A		C	45.5713	-122.5899		
IS-WS026	A	B		45.5714	-122.5914		
IS-WS027	A	B		45.5714	-122.5926		
IS-WS028		B	C	45.5718	-122.5939		
IS-WS029	A	B		45.5719	-122.5952		
IS-WS030	A			45.5724	-122.5965		
IS-WS031	A		C	45.5725	-122.5978		
IS-WS032			C	45.5730	-122.5989		
IS-WS033		B	C	45.5732	-122.6003		
IS-WS034	A		C	45.5731	-122.6017		
IS-WS035	A			45.5736	-122.6030		
IS-WS036		B	C	45.5735	-122.6044		
IS-WS037		B	C	45.5738	-122.6057		
IS-WS038	A	B		45.5741	-122.6070		
IS-WS039	A		C	45.5745	-122.6082		
IS-WS040			C	45.5746	-122.6096		
IS-WS041		B	C	45.5748	-122.6109		

Appendix B: Sample Locations

	Triplicate Jar			Latitude	Longitude	Actual	Actual
	A	B	C				
IS-WS042		B		45.5748	-122.6123		
IS-WS043	A		C	45.5747	-122.6136		
IS-WS044		B	C	45.5748	-122.6149		
IS-WS045		B	C	45.5749	-122.6163		
IS-WS046	A		C	45.5754	-122.6175		
IS-WS047	A	B		45.5759	-122.6186		
IS-WS048		B	C	45.5765	-122.6197		
IS-WS049	A	B		45.5774	-122.6203		
IS-WS050	A	B		45.5782	-122.6199		

Red: Actual increment jar used due to operator error reading lines
Increment locations changed due to access issues- steep banks, property concerns, etc.

Whitaker Slough: Targeted Samples

		Proposed		Acutual*			
SITE_ID	**Location**	**LAT**	**LONG**	**Lat**	**Long**	**Centroid**	**Centroid**
WS-73A-01	Whitaker Slough at City of Portland Outfall 73A	45.57607	-122.61923	45.57629	-122.61926	**45.57621**	**-122.61923**
WS-73A-02	Whitaker Slough at City of Portland Outfall 73A	45.57608	-122.61916	45.57626	-122.61920		
WS-73A-03	Whitaker Slough at City of Portland Outfall 73A	45.57613	-122.61923	45.57613	-122.61927		
WS-73A-04	Whitaker Slough at City of Portland Outfall 73A	45.57613	-122.61916	45.57617	-122.61922		
WS-73A-05	Whitaker Slough at City of Portland Outfall 73A	45.57618	-122.61923	45.57618	-122.61926		
WS-73A-06	Whitaker Slough at City of Portland Outfall 73A	45.57611	-122.61913	45.57614	-122.61919		
WS-NWds-01	Whitaker Slough at Nuway downstream	45.57543	-122.61763	45.57566	-122.61810	**45.57551**	**-122.61779**
WS-NWds-02	Whitaker Slough at Nuway downstream	45.57553	-122.61772	45.57558	-122.61795		
WS-NWds-03	Whitaker Slough at Nuway downstream	45.57555	-122.61789	45.57554	-122.61787		
WS-NWds-04	Whitaker Slough at Nuway downstream	45.57563	-122.61795	45.57547	-122.61771		
WS-NWds-05	Whitaker Slough at Nuway downstream	45.57564	-122.61809	45.57542	-122.61751		
WS-NWds-06	Whitaker Slough at Nuway downstream	45.57542	-122.61750	45.57537	-122.61747		
WS-HALT-01	Whitaker Slough Halton Outfall	45.57501	-122.61656	45.57506	-122.61663	**45.57509**	**-122.61661**
WS-HALT-02	Whitaker Slough Halton Outfall	45.57505	-122.61660	45.57510	-122.61663		
WS-HALT-03	Whitaker Slough Halton Outfall	45.57504	-122.61654	45.57505	-122.6165		
WS-HALT-04	Whitaker Slough Halton Outfall	45.57500	-122.61649	45.57511	-122.61666		
WS-HALT-05	Whitaker Slough Halton Outfall	45.57507	-122.61657	45.57509	-122.61662		
WS-HALT-06	Whitaker Slough Halton Outfall	45.57504	-122.61649	45.57513	-122.61671		
WS-NWEB-01	Whitaker Slough at NuWay East Bank	45.57476	-122.61532	45.57491	-122.61623	**45.57484**	**-122.61576**
WS-NWEB-02	Whitaker Slough at NuWay East Bank	45.57482	-122.61567	45.57487	-122.61601		
WS-NWEB-03	Whitaker Slough at NuWay East Bank	45.57486	-122.61598	45.57489	-122.61587		
WS-NWEB-04	Whitaker Slough at NuWay East Bank	45.57491	-122.61624	45.57481	-122.61577		
WS-NWEB-05	Whitaker Slough at NuWay East Bank	45.57493	-122.61605	45.57480	-122.61562		
WS-NWEB-06	Whitaker Slough at NuWay East Bank	45.57489	-122.61579	45.57476	-122.61529		
WS-489-01	Whitaker Slough at 47th Ave	45.57465	-122.61419	45.57468	-122.61423	**45.57469**	**-122.61429**
WS-489-02	Whitaker Slough at 47th Ave	45.57469	-122.61423	45.57470	-122.61434		
WS-489-03	Whitaker Slough at 47th Ave	45.57469	-122.61414	45.57470	-122.61423		
WS-489-04	Whitaker Slough at 47th Ave	45.57474	-122.61420	45.57468	-122.61429		
WS-489-05	Whitaker Slough at 47th Ave	45.57472	-122.61428	45.57467	-122.61423		
WS-489-06	Whitaker Slough at 47th Ave	45.57472	-122.61413	not sampled	not sampled		

		Proposed		Acutual*			
SITE_ID	**Location**	**LAT**	**LONG**	**Lat**	**Long**	**Centroid**	**Centroid**
WS-74-01	West Whitaker Pond	45.57343	-122.61275			**45.57347**	**-122.61267**
WS-74-02	West Whitaker Pond	45.57347	-122.61268				
WS-74-03	West Whitaker Pond	45.57352	-122.61262				
WS-74-04	West Whitaker Pond	45.57350	-122.61274				
WS-74-05	West Whitaker Pond	45.57346	-122.61259				
WS-74-06	West Whitaker Pond	45.57343	-122.61265				
WS-WMOR-01	Whitaker Slough at Waste Management of OR	45.57443	-122.60806	45.57481	-122.61033	**45.57464**	**-122.60953**
WS-WMOR-02	Whitaker Slough at Waste Management of OR	45.57439	-122.60810	45.57479	-122.61037		
WS-WMOR-03	Whitaker Slough at Waste Management of OR	45.57467	-122.60902	45.57469	-122.610903		
WS-WMOR-04	Whitaker Slough at Waste Management of OR	45.57463	-122.60901	45.57462	-122.60907		
WS-WMOR-05	Whitaker Slough at Waste Management of OR	45.57482	-122.61031	45.57453	-122.60816		
WS-WMOR-06	Whitaker Slough at Waste Management of OR	45.57477	-122.61031	45.57446	-122.60816		
WS-PTL-01	Whitaker Slough at Pro Truck Lines	45.57326	-122.60264	45.57318	-122.60185	**45.57342**	**-122.60303**
WS-PTL-02	Whitaker Slough at Pro Truck Lines	45.57311	-122.60184	45.57325	-122.60255		
WS-PTL-03	Whitaker Slough at Pro Truck Lines	45.57344	-122.60361	45.57344	-122.6034		
WS-PTL-04	Whitaker Slough at Pro Truck Lines	45.57353	-122.60413	45.57357	-122.60413		
WS-PTL-05	Whitaker Slough at Pro Truck Lines	45.57353	-122.60425	45.57356	-122.6042		
WS-PTL-06	Whitaker Slough at Pro Truck Lines	45.57356	-122.60420	45.57366	-122.60413		
WS-77-01	Whitaker Slough at City of Portland Outfall 77	45.57304	-122.60141	45.57318	-122.60132	**45.57314**	**-122.60145**
WS-77-02	Whitaker Slough at City of Portland Outfall 77	45.57310	-122.60144	45.57322	-122.60157		
WS-77-03	Whitaker Slough at City of Portland Outfall 77	45.57309	-122.60136	45.57318	-122.60144		
WS-77-04	Whitaker Slough at City of Portland Outfall 77	45.57314	-122.60131	45.57306	-122.60152		
WS-77-05	Whitaker Slough at City of Portland Outfall 77	45.57315	-122.60140	45.57311	-122.60149		
WS-77-06	Whitaker Slough at City of Portland Outfall 77	45.57314	-122.60151	45.57318	-122.60146		
WS-77a/PW -01	Whitaker Slough at City of Portland Outfall 77a & Portland Willamette Outfall	45.57242	-122.59964	45.57244	-122.59972	**45.57249**	**-122.59986**
WS-77a/PW -02	Whitaker Slough at City of Portland Outfall 77a & Portland Willamette Outfall	45.57253	-122.59978	45.57250	-122.59977		
WS-77a/PW -03	Whitaker Slough at City of Portland Outfall 77a & Portland Willamette Outfall	45.57249	-122.59984	45.57241	-122.59985		
WS-77a/PW -04	Whitaker Slough at City of Portland Outfall 77a & Portland Willamette Outfall	45.57245	-122.59983	45.57246	-122.59985		
WS-77a/PW -05	Whitaker Slough at City of Portland Outfall 77a & Portland Willamette Outfall	45.57249	-122.59970	45.57256	-122.59985		
WS-77a/PW -06	Whitaker Slough at City of Portland Outfall 77a & Portland Willamette Outfall	45.57242	-122.59973				
WS-77a/PW -07	Whitaker Slough at City of Portland Outfall 77a & Portland Willamette Outfall	45.57252	-122.59999	45.57255	-122.6		
WS-77a/PW -08	Whitaker Slough at City of Portland Outfall 77a & Portland Willamette Outfall	45.57257	-122.59988				

		Proposed		Acutual*			
SITE_ID	**Location**	**LAT**	**LONG**	**Lat**	**Long**	**Centroid**	**Centroid**
WS-PW2-01	Portland/Willamette Inlet #2	45.57257	-122.60023	45.57264	-122.60003	**45.57258**	**-122.60015**
WS-PW2-02	Portland/Willamette Inlet #2	45.57253	-122.60016	45.57250	-122.60023		
WS-PW2-03	Portland/Willamette Inlet #2	45.57263	-122.60029	45.57255	-122.60011		
WS-PW2-04	Portland/Willamette Inlet #2	45.57266	-122.60020	45.57262	-122.60026		
WS-PW2-05	Portland/Willamette Inlet #2	45.57258	-122.60011	45.57266	-122.6002		
WS-PW2-06	Portland/Willamette Inlet #2	45.57260	-122.60019	45.57254	-122.6001		
WS-ORT-01	Whitaker Slough at Oregon Tractor	45.57162	-122.59594	45.57163	-122.59597	**45.57168**	**-122.59597**
WS-ORT-02	Whitaker Slough at Oregon Tractor	45.57165	-122.59587	45.57165	-122.59587		
WS-ORT-03	Whitaker Slough at Oregon Tractor	45.57167	-122.59599	45.57166	-122.59604		
WS-ORT-04	Whitaker Slough at Oregon Tractor	45.57165	-122.59607	45.57169	-122.59608		
WS-ORT-05	Whitaker Slough at Oregon Tractor	45.57171	-122.59590	45.57171	-122.59590		
WS-ORT-06	Whitaker Slough at Oregon Tractor	45.57171	-122.59605	45.57172	-122.59603		
WS-CLWD-01	Whitaker Slough at Colwood Ave	45.57074	-122.58970	45.57072	-122.58967	**45.57069**	**-122.58969**
WS-CLWD-02	Whitaker Slough at Colwood Ave	45.57079	-122.58981	45.57062	-122.58971		
WS-CLWD-03	Whitaker Slough at Colwood Ave	45.57076	-122.58962	45.57073	-122.58955		
WS-CLWD-04	Whitaker Slough at Colwood Ave	45.57081	-122.58971	45.57075	-122.58976		
WS-CLWD-05	Whitaker Slough at Colwood Ave	45.57070	-122.58975	45.57071	-122.58983		
WS-CLWD-06	Whitaker Slough at Colwood Ave	45.57075	-122.58978	45.57073	-122.58971		
WS-OFFarm-01	Whitaker Slough at Oregon Fresh Farms	45.57104	-122.59135			**45.57097**	**-122.59129**
WS-OFFarm-02	Whitaker Slough at Oregon Fresh Farms	45.57099	-122.59116				
WS-OFFarm-03	Whitaker Slough at Oregon Fresh Farms	45.57091	-122.59113				
WS-OFFarm-04	Whitaker Slough at Oregon Fresh Farms	45.57096	-122.59131				
WS-OFFarm-05	Whitaker Slough at Oregon Fresh Farms	45.57095	-122.59146				
WS-OFFarm-06	Whitaker Slough at Oregon Fresh Farms	45.57090	-122.59125				
WS-GlfC-01	Whitaker Slough at Colwood Golf Course	45.57052	-122.58756	45.57042	-122.58771	**45.57052**	**-122.58776**
WS-GlfC-02	Whitaker Slough at Colwood Golf Course	45.57046	-122.58760	45.57047	-122.5876		
WS-GlfC-03	Whitaker Slough at Colwood Golf Course	45.57054	-122.58764	45.57050	-122.58775		
WS-GlfC-04	Whitaker Slough at Colwood Golf Course	45.57057	-122.58770	45.57054	-122.58772		
WS-GlfC-05	Whitaker Slough at Colwood Golf Course	45.57049	-122.58769	45.57058	-122.5878		
WS-GlfC-06	Whitaker Slough at Colwood Golf Course	45.57041	-122.58767	45.57061	-122.58791		
WS-82nd-01	Whitaker Slough at 82nd Ave	45.56899	-122.57821	45.56904	-122.57833	**45.56905**	**-122.57844**
WS-82nd-02	Whitaker Slough at 82nd Ave	45.56903	-122.57821	45.56903	-122.57838		
WS-82nd-03	Whitaker Slough at 82nd Ave	45.56901	-122.57824	45.56905	-122.57842		
WS-82nd-04	Whitaker Slough at 82nd Ave	45.56899	-122.57827	45.56907	-122.57852		
WS-82nd-05	Whitaker Slough at 82nd Ave	45.56903	-122.57829	45.56907	-122.57847		
WS-82nd-06	Whitaker Slough at 82nd Ave	45.56900	-122.57831	45.56907	-122.57854		

		Proposed		Acutual*			
SITE_ID	**Location**	**LAT**	**LONG**	**Lat**	**Long**	**Centroid**	**Centroid**
WS-78-01	Whitaker Slough at City of Portland Outfall 78 Pond	45.56904	-122.58173			**45.56909**	**-122.58178**
WS-78-02	Whitaker Slough at City of Portland Outfall 78 Pond	45.56908	-122.58170				
WS-78-03	Whitaker Slough at City of Portland Outfall 78 Pond	45.56907	-122.58181				
WS-78-04	Whitaker Slough at City of Portland Outfall 78 Pond	45.56912	-122.58176				
WS-78-05	Whitaker Slough at City of Portland Outfall 78 Pond	45.56913	-122.58168				
WS-78-06	Whitaker Slough at City of Portland Outfall 78 Pond	45.56910	-122.58187				
WS-80-01	Whitaker Slough at City of Portland Outfall 80	45.56773	-122.57330			45.56776	-122.57331
WS-80-02	Whitaker Slough at City of Portland Outfall 80	45.56776	-122.57325				
WS-80-03	Whitaker Slough at City of Portland Outfall 80	45.56776	-122.57331				
WS-80-04	Whitaker Slough at City of Portland Outfall 80	45.56776	-122.57336				
WS-80-05	Whitaker Slough at City of Portland Outfall 80	45.56778	-122.57335				
WS-80-06	Whitaker Slough at City of Portland Outfall 80	45.56778	-122.57327				
WS-83-01	Whitaker Slough at City of Portland 83	45.56619	-122.56839			45.56621	-122.56838
WS-83-02	Whitaker Slough at City of Portland 83	45.56621	-122.56836				
WS-83-03	Whitaker Slough at City of Portland 83	45.56621	-122.56843				
WS-83-04	Whitaker Slough at City of Portland 83	45.56623	-122.56839				
WS-83-05	Whitaker Slough at City of Portland 83	45.56621	-122.56839				
WS-83-06	Whitaker Slough at City of Portland 83	45.56620	-122.56833				
WS-83-07	Whitaker Slough at City of Portland 83	45.56620	-122.56844				
WS-84/85-01	Whitaker Slough at City of Portland Outfall 84/85	45.56628	-122.56808			45.56631	-122.56804
WS-84/85-02	Whitaker Slough at City of Portland Outfall 84/85	45.56631	-122.56798				
WS-84/85-03	Whitaker Slough at City of Portland Outfall 84/85	45.56631	-122.56804				
WS-84/85-04	Whitaker Slough at City of Portland Outfall 84/85	45.56634	-122.56800				
WS-84/85-05	Whitaker Slough at City of Portland Outfall 84/85	45.56633	-122.56807				
WS-84/85-06	Whitaker Slough at City of Portland Outfall 84/85	45.56630	-122.56810				

* if no value appears in column, location was within proposed sampling location criteria

Appendix C: Summary Statistics
Whitaker Slough mouth to I-205 Sampling Area

			% of total	% of total		
	Whitaker Slough mouth to I-205 Sampling area		**exceeding**	**exceeding**	**Targeted**	
		% Detect	**2007 Risk base Values**	**2010 IS Mean**	**Mean(mg/kg)**	**Range(mg/kg)**
Metals	Total Antimony	45%	0%	35%	2.0	0.46-4.8
(ppm)	Total Arsenic	95%	0%	41%	4.5	1.5-11.5
	Total Cadmium	73%	0%	55%	0.5	0.074-1.1
	Total Chromium	100%	50%	59%	75.0	6.6-259
	Total Copper	100%	32%	55%	179.0	5.4-1570
	Total Lead	100%	45%	59%	117.2	3.8-363
	Total Manganese	100%	0%	32%	236.4	113-956
	Mercury	95%	0%	14%	0.1	0.015-0.13
	Total Nickel	100%	9%	55%	21.8	5.7-70.7
	Total Zinc	100%	0%	41%	164.2	34-267
			% Exceeding	**exceeding**	**Targeted**	**Targeted**
	Whitaker Slough mouth to I-205 Sampling area	**% Detect**	**Risk base**	**2010 IS Mean**	**Mean(ug/kg)**	**Range (ug/kg)**
Semi-Vols	4-Methylphenol (p-Cresol)	0%	N/A	N/A	<250	<250
(ppb)	Benzyl alcohol	5%	N/A	5%	32	32-<92
	bis(2-Ethylhexyl)phthalate	18%	0%	14%	652	548-742
	Butylbenzylphthalate	5%	N/A	0%	26	26-<95
	Dibenzofuran	0%	N/A	N/A	N/A	<109
	Diethylphthalate	0%	N/A	N/A	N/A	<107
	Dimethylphthalate	9%	N/A	9%	118	<87
	Di-n-butylphthalate	0%	N/A	N/A	N/A	<101
	Di-n-octylphthalate	14%	N/A	14%	37	26.7-47.8
	Pentachlorophenol	5%	5%	5%	294	294-<644
	Phenol	5%	0%	5%	44	44-<119
	2-Methylnaphthalene	55%	14%	41%	12	3.3-28.1
	Acenaphthene	45%	0%	32%	14	3.9-54
	Acenaphthylene	95%	0%	77%	15	1.3-151
	Anthracene	95%	5%	68%	32	2.7-340
	Benzo(a)anthracene	91%	45%	45%	123	5.4-1330
	Benzo(a)pyrene	95%	59%	55%	174	7.2-1800
	Benzo(b)fluoranthene	95%	41%	59%	169	9.5-1520
	Benzo(g,h,i)perylene	95%	5%	50%	143	8.8-1360
	Benzo(k)fluoranthene	95%	45%	41%	68	4.1-633
	Chrysene	95%	59%	59%	156	8.8-1470
	Dibenz(a,h)anthracene	95%	5%	45%	23	1.6-203
	Fluoranthene	95%	45%	64%	305	9-3550
	Fluorene	55%	5%	41%	24	3.3-111
	Indeno(1,2,3-cd)pyrene	95%	86%	55%	108	5.1-941
	Naphthalene	77%	0%	55%	13	4.7-39.3
	Phenanthrene	82%	55%	68%	179	14-1710
	Pyrene	95%	5%	59%	435	12.6-5600
TPH Dx	Diesel Range SG	100%	N/A	9%	213	8.7-1140
	Motor Oil Range SG	95%	N/A	23%	1229	247-4060

Appendix C: Summary Statistics
Whitaker Slough mouth to I-205 Sampling Area

			% Exceeding	exceeding	Targeted	Targeted
	Whitaker Slough mouth to I-205 Sampling area	**% Detect**	**Risk base**	**2010 IS Mean**	**Mean(ug/kg)**	**Range (ug/kg)**
			% Exceeding	exceeding	Targeted	Targeted
Whitaker Slough mouth to I-205 Sampling area		**% Detect**	**Risk base**	**2010 IS Mean**	**Mean**	**Range**
Pesticides	4,4'-DDD	9%	9%	9%	5.40	<2.2-7.33
ug/kg	4,4'-DDE	18%	18%	14%	7.30	<0.815-13
Method	4,4'-DDT	5%	5%	5%	10.40	<2.7-10.4
8082	Aldrin	9%	n/a	9%	7.65	<1-8.35
	Dieldrin	5%	5%	5%	8.56	<1.8-8.56
	Endosulfan I	0%	N/A	0%	1.07	<6.36
	Endosulfan II	0%	N/A	0%	n/A	<12.5
	Endosulfan sulfate	0%	N/A	0%	n/A	<12.5
	Endrin	0%	N/A	0%	n/A	<12.5
	Endrin aldehyde	0%	0%	0%	n/A	<12.5
	Endrin ketone	0%	N/A	0%	n/A	<12.5
	Heptachlor	9%	9%	9%	5.60	<1.3-6.16
	Heptachlor epoxide	5%	N/A	5%	1.72	<1.16-1.72
	Methoxychlor	0%	0%	0%	N/A	<63
	Toxaphene	0%	0%	0%	N/A	<249
	alpha-BHC	0%	0%	0%	N/A	<1.16-3.98
	alpha-Chlordane	18%	N/A	18%	5.50	<1.15-6.78
	beta-BHC	0%	N/A	0%	N/A	<6.36
	delta-BHC	0%	N/A	0%	N/A	<6.36
	gamma-BHC (Lindane)	9%	9%	9%	7.60	<1.16-12.4
	gamma-Chlordane	14%	N/A	9%	4.17	<1.03-6.77
			% Exceeding	exceeding	Targeted	Targeted
Whitaker Slough mouth to I-205 Sampling area		**% Detect**	**Risk base**	**2010 IS Mean**	**Mean(ug/kg)**	**Range (ug/kg)**
PCBs	Aroclor-1016	0%	N/A	N/A	N/A	<4.9
(ppb)	Aroclor-1242	0%	N/A	N/A	N/A	<2.5
	Aroclor 1221	0%	N/A	N/A	N/A	<3.4
	Aroclor 1232	0%	N/A	N/A	N/A	<4.4
	Aroclor 1248	23%	9%	23%	9.4	6.9-13.1
	Aroclor 1254	45%	5%	41%	5.3	2.3-13.3
	Aroclor 1260	55%	23%	5%	12.4	4.2-35.1
	Total Aroclor	55%	N/A	14%	20.7	4.2-61.5
			% Exceeding	exceeding	Targeted	Targeted
Whitaker Slough mouth to I-205 Sampling area		**% Detect**	**Risk base**	**2010 IS Mean**	**Mean(ug/kg)**	**Range (ug/kg)**
TBT(ppb)	Tributyltin	5%	5%	5%	14	14
General	Total Organic Carbon(ppm)	100%	N/A	N/A	37288	9730-71400
	Percent Moisture(%)	100%	N/A	N/A	59.8	27.9-86.8
	Gravel(>4750 micron)	64%	N/A	N/A	3.7	0.1-17.6
	Sand (4750-75 micron)	100%	N/A	N/A	49.1	13.5-92.7
	Silt(75-3.2 micron)	100%	N/A	N/A	40.8	0.3-73.8
	Clay(< 3.2 micron)	100%	N/A	N/A	6.4	1.3-13.9

Appendix D- Whitaker Slough mouth to I-205. Preliminary
Results above Screening Values Highlighted

			Risk-based Values*	Baseline Values**	WS-0F73A	WS-NWds	WS-HALT	WS-NWEB	WS-489	WS-74	WS-WMOR	WS-PTL	WS-77	WS-77a/PW-QA	WS-77a/PW	WS-PW-2	WS-ORT	WS-OFF	WS-CLWD	WS-GLCS	WS-OF78	WS-82nd Ave	WS-80	WS-83	WS-83 QA	WS-84/85	IS A	IS B	IS C	IS Mean
	Sampling 2011																													
Metals	Total Antimony	mg/Kg d	4	0.89	1.5 u	1.7 u	1.8 J	1.5 J	1 J	1.3 J	1.3 J	1.5 J	1.2 u	3.3 J	2.9 J	4.8 J	0.46 J	0.82 u	0.74 u	0.66 u	0.46 u	1.3 u	1.2 u	1.6 u	1.6 u	1 u	0.89	0.89	0.89	0.9
(mg/kg)	Total Arsenic	mg/Kg d	8	4	4 J	4 J	4.6 J	3.6 J	5 J	11.5 J	5.1 J	5.3 J	2.1 u	5.1 J	5.5 J	7.3 J	3.1 J	1.5 J	4.1 J	3.5 J	3.1 J	3 J	4.8 J	4.1 J	3.9 J	3.1 J	4.1	4.4	4.4	4.3
	Total Cadmium	mg/Kg d	1.9	0.3	0.094 u	0.11 u	0.086 J	0.25 J	0.47 J	0.66 J	0.45 J	0.84 J	0.076 u	0.58 J	1 J	0.34 J	0.027 u	0.052 u	0.46 J	0.35 J	0.074 J	0.52 J	1.1 J	0.44 J	0.19 J	0.065 u	0.48	0.29	0.21	0.3
	Total Chromium	mg/Kg d	42	48	70.8	107	122	77.3	79.2	146	69.9	89.6	25.1	173	151	259	54.3	6.6	48.3	27.8	24.3	23.5	33.9	23.4	22.4	15.6	46	51.3	47.3	48.2
	Total Copper	mg/Kg d	36	45	56.8	29.3	49	34.2	53.5	1570	45.9	79	73.5	668	656	302	23.4	5.4 J	48.6	34.8	32.8	45.2	43.1	33.5	28.1	25.2	40	42	52	44.7
	Total Lead	mg/Kg d	17	74	39.9	160	363	82.7	159	236	56.4	85.7	36.7	244	250	147	92	3.8	74.1	61.3	22.9	181	163	47	53.4	20.3	69	77	75	73.7
	Mercury	mg/Kg d	0.2	0.1	0.036 J	0.039 J	0.13 J	0.13 J	0.098 J	0.096 J	0.077 J	0.092 J	0.032 J	0.1 J	0.11 J	0.072 J	0.05 J	0.0025 u	0.1 J	0.071 J	0.034 J	0.026 J	0.068 J	0.038 J	0.037 J	0.015 J	0.087	0.1	0.078	0.1
	Manganese	mg/Kg d	1100	219	447	241	263	200	368	238	215	213	956	169	193	121	142	113	119	143	120	177	199	162	169	232	212	222	223	
	Total Nickel	mg/Kg d	38	17	23.4 J	13.4 J	15.6	15.4 J	16.8	70.7	17 J	22.1	19.8 J	31.3	40.6	23.2	11.6	5.7 J	13.2	13.2 J	16.4	21.7 J	22.3 J	21.8 J	20.5 J	22.9 J	17	17	18	17.3
	Total Zinc	mg/Kg d	123	181	219	88.8	143	133	211	168	180	260	185	221	267	174	70.8	34	132	163	99.3	185	237	183	173	84.8	165	186	192	181.0
	4-Methylphenol (p-Cresol)	ug/kg	ug/kg	52.1	101 u	123 u	175 u	215 u	189 u	73.8 u	275 u	248 u	87.2 u	186 u	187 u	317 u	130 u	69.9 u	229	196 u	150 u	105 u	92.3 u	97 u	95.8 u	86.6 u	51.8 U	52.3 U	52.3 U	52.1
Semi-Vols	Benzyl alcohol	ug/kg		30.9	29.5 u	35.7 u	50.9 u	62.4 u	55 u	21.5 u	80 u	72.3 u	25.4 u	54.2 u	54.3 u	92.1 u	37.9 u	20.3 u	66.6	57.1 u	43.7 u	30.6 u	26.9 u	28.2 u	27.9 u	32.7 J	38.5 J	30.4 J	23.7 J	30.9
(ug/Kg)	bis(2-Ethylhexyl)phthalate	ug/kg	750	601.7	742	439 u	628 u	769 u	678 u	265 u	987 u	891 u	313 u	668 u	737 J u	1130 u	467 u	250 u	820	704 u	548 J	662 J	656 u	348 u	343 u	310 u	866	564	375	601.7
	Butylbenzylphthalate	ug/kg		39.6	30.6 u	37 u	52.9 u	64.8 u	57.2 u	26.4 J	83.2 u	75.1 u	26.4 u	56.3 u	67.5 J u	95.7 u	39.3 u	21.1 u	69.2	59.3 u	45.4 u	49.8 J	27.9 u	31.3 J u	28.9 u	26.2 u	54.3 J	34.3 J	30.1 J	39.6
	Dibenzofuran	ug/kg	5100	20.7	40.2 u	48.6 u	69.4 u	85.1 u	75.1 u	29.3 u	109 u	98.6 u	34.6 u	73.9 u	74.1 u	126 u	51.6 u	27.7 u	90.8	77.9 u	59.6 u	41.7 u	36.6 u	38.5 u	38 u	34.3 u	20.6 U	20.8 U	20.7 U	20.7
	Diethylphthalate	ug/kg		20.3	39.5 u	47.8 u	68.3 u	83.7 u	73.8 u	28.8 u	107 u	96.9 u	34 u	72.6 u	72.8 u	123 u	50.7 u	27.2 u	89.2	76.6 u	58.6 u	41 u	36 u	37.8 u	37.3 u	33.8 u	20.2 U	20.4 U	20.4 U	20.3
	Dimethylphthalate	ug/kg		14.4	168 J	33.9 u	48.4 u	59.4 u	52.4 u	20.4 u	76.1 u	68.7 u	24.1 u	67.2 J	51.7 u	87.6 u	36 u	19.3 u	63.3	54.3 u	41.6 u	29.1 u	25.6 u	26.8 u	26.5 u	24 u	14.3 U	14.5 U	14.5 U	14.4
	Di-n-butylphthalate	ug/kg		24.5	37 u	44.8 u	64 u	78.4 u	69.1 u	27 u	101 u	90.8 u	31.9 u	68.1 u	68.2 u	116 u	47.5 u	25.5 u	83.6	71.8 u	54.9 u	38.4 u	33.7 u	35.4 u	35 u	31.6 u	18.9 U	35.5 J	19.1 U	24.5
	Di-n-octylphthalate	ug/kg		13.2	37.6 J	31 u	44.3 u	54.3 u	47.9 u	18.7 u	69.7 u	62.9 u	26.7 J	47.2 u	47.3 u	80.1 u	32.9 u	17.7 u	57.9	49.7 u	38 u	47.8 J	23.4 u	24.5 u	24.2 u	21.9 u	13.1 U	13.2 U	13.2 U	13.2
	Pentachlorophenol	ug/kg	100	105.7	206 u	249 u	356 u	436 u	385 u	150 u	560 u	505 u	177 u	379 u	380 u	644 u	265 u	142 u	465	399 u	306 u	294 J	188 u	197 u	195 u	176 u	105 U	106 U	106 U	105.7
	Phenol	ug/kg	48	22.6	43.9 u	53.1 u	75.8 u	92.9 u	82 u	32 u	119 u	108 u	37.8 u	80.7 u	80.9 u	137 u	56.4 u	30.3 u	99.1	85.1 u	65.1 u	45.5 u	43.6 J	42 u	41.5 u	37.5 u	22.5 U	22.7 U	22.6 U	22.6
	2-Methylnaphthalene	ug/kg	20	7.8	4.6 J	4.3 u	13.2 J	7.7 u	6.8 u	12.6	10 u	17.3 u	3.3 J	28.1 J	8.4 J	22.4 u	9 u	9.1	8.1	6.9 u	5.3 u	8.1 J	21.4	3.5 J	7.3 J	22.7	7.6	7.9	8	7.8
x,y	Acenaphthene	ug/kg	290	4.5	4.1 J	3.7 u	5.3 u	6.5 u	5.8 u	16.8	8.5 u	14.6 u	4 J	15 J	5.6 u	18.9 u	7.6 u	2.1 u	7.8 J	5.9 u	4.5 u	9.9 J	12.9	3.9 J	9.2 J	54	3.8 J	5.7 J	3.9 J	4.5
x,y	Acenaphthylene	ug/kg	160	3.0	1.9 J	4.5 J	8.4 J	3.2 J	17.5 J	4.6 J	3 J	4.9 J	1.3 J	19.1 J	9.9 J	8.7 J	1.6 J	0.31 u	4.2 J	2 J	8.2 J	5.1 J	7.8 J	11.3 J	30.6	151	2.5 J	2.7 J	3.8 J	3.0
x,y	Anthracene	ug/kg	57	6.1	4.6 J	2.7 J	11.6 J	3.4 J	28.4	18.4	7.3 J	11 J	6.6 J	44.8 J	20.8 J	16.7 J	1.8 u	0.51 u	6.5 J	2.8 J	3.7 J	23.7	26.8	14.4	49.4	340	5.8 J	6.2 J	6.2 J	6.1
x,z	Benzo(a)anthracene	ug/kg	32	26.4	13.4	12 J	34	5.4 J	192	86.8	7.3 J	19.6 J	21.7	170	141	49.2 J	0.52 u	0.14 u	29.5 J	5.4 J	7.8 J	96.2	28.6	75.5	140	1330	24.7	25.7	28.9	26.4
x,z	Benzo(a)pyrene	ug/kg	32	38.5	24.4	28.6	53.2	22.4 J	299	105	33.8 J	51.2 J	29	275	236	131	14.2 J	0.22 u	62.2	22.5 J	7.2 J	111	31.1	111	210	1800	33.9	37	44.5	38.5
x,z	Benzo(b)fluoranthene	ug/kg	104	43.2	38.1	33.2	72.8	25.8 J	261	142	47.4	70	34.9	290	221	172	16.8 J	0.91 u	94.2	38.9	9.5 J	133	42.3	107	180	1520	38	41.2	50.5	43.2
x,z	Benzo(g,h,i)perylene	ug/kg	300	47.4	25.9	24.3	57.7	23.4 J	217	78.8	22.6 J	54.7 J	23.2	256	193	154	16 J	0.41 u	47.3	25.1 J	8.8 J	86.9	33.4	98.3	198	1360	40.4	44.9	56.8	47.4
x,z	Benzo(k)fluoranthene	ug/kg	30	36.8	11.4 J	14.9 J	19.1 J	8 J	82.6	76.8	18.3 J	21 J	11.6	97.2	84.6	58.3 J	5.7 J	0.65 u	33.2	13.5 J	4.1 J	74.1	29.1	48.1	92.3	633	33.4	32.3	44.8	36.8
x,z	Chrysene	ug/kg	57	50.8	37.9	25.8	108	28.3	216	122	33.9 J	68.3	34.1	239	192	111	20.7 J	0.42 u	74.1	26.1	8.8 J	130	57.5	104	161	1470	47.2	48.4	56.8	50.8
x,z	Dibenz(a,h)anthracene	ug/kg	60	10.9	5.6 J	2.8 J	11.5 J	3.8 J	26.9	19.4	6.6 J	7.7 J	5.1 J	42.7 J	28.7	24.4 J	3.6 J	0.38 u	9.6 J	4.2 J	1.6 J	21.5	6.4 J	14.4	27	203	9.5	7.9	15.3	10.9
x,z	Fluoranthene	ug/kg	111	59.5	60.4	46.3	104	33.8	460	147	13.3 J	88.1	51.5	358	291	125	18.4 J	1.1 u	198	30.2	9 J	190	70.1	197	356	3550	56.8	58.6	63.1	59.5
x,y	Fluorene	ug/kg	77	8.6	5.8 J	4.3 u	6.1 u	7.5 u	11.4 J	15.4	9.8 u	17 u	3.3 J	14.7 J	6.5 u	54.9 J	8.8 u	2.4 u	10.8 J	6.8 u	5.2 u	11.5 J	23.1	7.6 J	19.4	111	7.6	8.7	9.5	8.6
x,z	Indeno(1,2,3-cd)pyrene	ug/kg	17	31.6	20.6	21.5	42.1	18.6 J	196	57.6	23.8 J	42.6 J	18.5	225	172	135	12.4 J	0.34 u	47.6	22.4 J	5.1 J	66.5	18.8	62.5	121	941	26.6	28.8	39.4	31.6
x,y	Naphthalene	ug/kg	176	8.4	5.9	4.7 J	15.1 J	7.5 u	12.6 J	15.2	9.8 u	22.9 J	5 J	39.3 J	14.2 J	21.8 u	8.8 u	5 J	9.3 J	8.7 J	5.1 u	8.8 J	14.1	7.1 J	10.3 J	26.4	8.3	8.3	8.5	8.4
x,y	Phenanthrene	ug/kg	42	29.0	40	14.5 J	30.3	19.1 J	194	90.3	17.2 u	48.3 J	28.3	181	109	47.2 J	15.4 u	4.3 u	173	14 J	9 u	94.1	76.4	83.9	263	1710	27.7	31.4	28	29.0
x,z	Pyrene	ug/kg	1900	71.6	65.4	62.2	129	44.8	568	172	16.1 J	116	57	455	375	160	23.1 J	0.41 u	159	34.5	12.6 J	227	81.3	283	498	5600	66.9	72.6	75.2	71.6
	LPAH[7]	ug/kg	802	60	62	34	77	47	270	161	56	119	49	314	166	168	44	15	212	40	36	153	161	128	382	2392	56	63	60	60
	HPAH[2]	ug/kg	2643	417	303	272	631	214	2519	1007	223	539	287	2408	1934	1120	131	5	755	223	75	1136	399	1101	1983	18407	377	397	475	417
	Total PAH[4]	ug/kg	3445	476	365	306	708	262	2788	1168	279	658	335	2722	2100	1288	175	20	966	263	110	1289	560	1229	2365	20799	433	460	535	476
Oil	Diesel Range SG	mg/Kg dry		421	283	45.9 J	403	551	314	99.6	119	176	138	152	260	73.4 J	337	8.7 J	128	134	50.8 J	118	1140	57.2	47.6	46.6	430	390	443	421.0
	Motor Oil Range SG	mg/Kg dry		1850	1450	264	1950	4060	1890	659	696	1090	1020	923	1370	385 J	3030	27.6 u	691	641	321	754	3760	323	247	283	1780	1880	1890	1850.0
TBT	Tributyltin	µg/Kg d	2.3	3.7	14	n/a	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.4 J	5.4	3.3 u	3.7
PCBs	Aroclor-1016 (PCB-1016)	µg/Kg dry		4.9	9.8 u	2.9 u	4.2 u	10.2 u	4.6 u	6.9 u	6.6 u	6 u	8.3 u	4.4 u	4.5 u	7.6 u	3.1 u	6.7 u	5.5 u	4.7 u	3.5 u	10 u	8.6 u	9.4 u	2.3 u	8.1 u	4.9 u	4.9 u	5 u	4.9
8082	Aroclor-1242 (PCB-1242)	µg/Kg dry		2.5	4.9 u	1.5 u	2.1 u	5.1 u	2.3 u	3.5 u	3.3 u	3 u	4.2 u	2.2 u	2.2 u	3.8 u	1.6 u	3.4 u	2.7 u	2.4 u	1.8 u	5 u	4.3 u	4.7 u	1.1 u	4 u	2.5 u	2.5 u	2.5 u	2.5
(ug/Kg)	Aroclor 1221	µg/Kg dry		3.4	6.8 u	2 u	2.9 u	7.1 u	3.2 u	4.8 u	4.6 u	4.2 u	5.8 u	3.1 u	3.1 u	5.3 u	2.2 u	4.7 u	3.8 u	3.3 u	2.5 u	7 u	6 u	6.6 u	1.6 u	5.6 u	3.4 u	3.4 u	3.5 u	3.4
	Aroclor 1232	µg/Kg dry		4.6	9.1 u	2.7 u	3.9 u	9.4 u	4.3 u	6.4 u	6.1 u	5.5 u	7.7 u	4.1 u	4.1 u	7 u	2.9 u	6.2 u	5.1 u	4.4 u	3.3 u	9.2 u	8 u	8.7 u	2.1 u	7.5 u	4.5 u	4.6 u	4.6 u	4.6
	Aroclor 1248	µg/Kg d	10	4.4	8.7 u	2.6 u	6.9	13.1	4.1 u	6.1 u	5.8 u	5.2 u	7.3 u	7.5	11.2	6.7 u	2.7 u	5.9 u	4.8 u	4.2 u	3.1 u	8.8 u	7.6 u	8.3 u	8	7.1 u	4.3 u	4.4 u	4.4 u	4.4
	Aroclor 1254	µg/Kg d	10	2.6	5.2 u	2.3	4.9	13.3	3.1	3.7 u	3.5 u	4.6	4.4 u	4.1	6.3	4.1 u	1.7 u	3.6 u	5	3.8	1.9 u	5.3 u	4.6 u	5 u	5.3	4.3 u	2.6 u	2.6 u	2.7 u	2.6
	Aroclor 1260	µg/Kg d	10	21.1	10.6 u	7	8.9	35.1	9.4	7.4 u	8.7	14.1	8.9 u	7.8	10	8.2 u	4.2	7.2 u	14.3	16	3.8 u	10.7 u	9.3 u	10.1 u	14.3	8.7 u	28	19.6	15.6 J	21.1
	Total Aroclors	ug/kg		21.1	n/a	9.3	20.7	61.5	12.5	n/a	8.7	18.7	n/a	19.4	27.5	n/a	4.2	n/a	19.3	19.8	n/a	n/a	n/a	n/a	27.6	n/a	28	19.6	15.6	21.1
Congener	Total Congener PCBs**	ug/kg			n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	95	311	81	162.3
Dioxin-like	PCB- 77	ng/kg	52	187	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	166	287	108	187
Congener	PCB 81	ng/kg	17	33	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	34 u	33 u	33 u	33.3333
	PCB 105	ng/kg	170	2562	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	583	6570	533	2562
	PCB 114	ng/kg	170	159	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	34	413	31	159.333
	PCB 118	ng/kg	120	5723	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	1460	14400	1310	5723.33
	PCB 123	ng/kg	210	130	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	47	312	30	129.667
	PCB 126	ng/kg	0.05	44	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	35	64	32	43.6667
	PCB 156 +PCB157 Co-Elution	ng/kg	210	1334	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	434	3190	378	1334
	PCB 167	ng/kg	210	474	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	224	986	213	474.333
	PCB 169	ng/kg	0.21	26	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	26 u	26 I	26	26
	PCB 189	ng/kg	1200	318	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	323 u	312 u	320 u	318.333

** Totals include all congeners. If congener values were below reporting limit, reporting limit was used as congener value.

Risk based Values*	
White Box	*Lower Columbia Slough Sediment Screening Levels Appendix I*
Purple Box	Table 3-1 *Portland Harbor Joint Source Control Strategy*
Blue Box	Table A-1b *Guidance for Assessing Bioaccumlative Chmeicals of Concern in Sediment*
Baseline Value **	IS average value of Whitaker Segment
Red Box	Over Risk based Values
Elevated	Values that exceed the baseline value or one order of magnitude above a risk-based screening level whichever is higher

Appendix D- Whitaker Slough mouth to I-205. Preliminary
Results above Screening Values Highlighted

			Risk-based Values*	Baseline Values**	WS-0F73A	WS-NWds	WS-HALT	WS-NWEB	WS-489	WS-74	WS-WMOR	WS-PTL	WS-77	WS-77a/PW-QA	WS-77a/PW	WS-PW-2	WS-ORT	WS-OFF	WS-CLWD	WS-GLCS	WS-OF78	WS-82nd Ave	WS-80	WS-83	WS-83 QA	WS-84/85	IS A	IS B	IS C	IS Mean
	Sampling 2011																													
Pesticides	4,4'-DDD	ug/kg	1	4.52	2.64 U	4.29 U	5.81 U	7.48 U	6.56 U	2.28 U	6.18 U	1.8 J	3.53 U	8.51 U	7.2 J	12.5 U	4.49 U	2.35 U	5.74 J	7.38 U	2.42 U	2.82 U	3.16 U	3.44 U	2.89 U	2.91 U	1.73 U	1.76 U	1.72 U	1.7
ug/kg	4,4'-DDE	ug/kg	1	6.58	2.64 U	4.29 U	5.81 U	7.48 U	6.56 U	2.28 U	6.18 U	8.1 J	5.01 J	11.7 J	5.58 J	12.5 U	4.49 U	2.35 U	0.815 U	7.38 U	2.42 U	2.82 U	3.16 U	3.44 U	2.89 U	2.91 U	3.43 J	8.17	8.85	6.8
Method	4,4'-DDT	ug/kg	1	0.95	3.16 U	5.14 U	6.95 U	8.96 U	7.86 U	2.73 U	7.4 U	10.6 U	4.23 U	10.2 U	8.32 U	15 U	5.38 U	2.82 U	10.4	8.83 U	2.89 U	3.38 U	3.79 U	4.11 U	3.46 U	3.48 U	2.07 U	2.11 U	2.06 U	2.1
8081	Aldrin	ug/kg	1	0.25	1.34 U	2.18 U	2.96 U	3.81 U	3.34 U	1.16 U	3.15 U	6.94 J	1.8 U	8.35 J	3.54 U	6.36 U	2.29 U	1.2 U	1.06 U	3.75 U	1.23 U	1.44 U	1.61 U	1.75 U	1.47 U	1.48 U	0.882 U	0.897 U	0.876 U	0.9
	alpha-BHC	ug/kg	1	0.02	1.34 U	2.18 U	2.96 U	3.81 U	3.34 U	1.16 U	3.15 U	4.53 U	1.8 U	4.33 U	3.54 U	6.36 U	2.29 U	1.2 U	1.38 U	3.75 U	1.23 U	1.44 U	1.61 U	1.75 U	1.47 U	1.48 U	3.98	0.897 U	0.876 U	1.9
	alpha-Chlordane	ug/kg		1.96	1.34 U	2.18 U	2.96 U	3.81 U	3.34 U	6.78	3.15 U	6.14 J	3.15 J	4.33 U	5.96 J	6.36 U	2.29 U	1.2 U	1.05 U	3.75 U	1.23 U	1.44 U	1.61 U	1.75 U	1.47 U	1.48 U	0.882 U	0.897 U	1.18 J	1.0
	beta-BHC	ug/kg	1	0.01	1.34 U	2.18 U	2.96 U	3.81 U	3.34 U	1.16 U	3.15 U	4.53 U	1.8 U	4.33 U	3.54 U	6.36 U	2.29 U	1.2 U	1.04 U	3.75 U	1.23 U	1.44 U	1.61 U	1.75 U	1.47 U	1.48 U	0.882 U	0.897 U	0.876 U	0.9
	delta-BHC	ug/kg	1	0.01	1.34 U	2.18 U	2.96 U	3.81 U	3.34 U	1.16 U	3.15 U	4.53 U	1.8 U	4.33 U	3.54 U	6.36 U	2.29 U	1.2 U	3.74 U	3.75 U	1.23 U	1.44 U	1.61 U	1.75 U	1.47 U	1.48 U	0.882 U	0.897 U	0.876 U	0.9
	Dieldrin	ug/kg	1	1.45	2.64 U	4.29 U	5.81 U	7.48 U	6.56 U	2.28 U	6.18 U	8.89 U	3.53 U	8.51 U	8.56 J	12.5 U	4.49 U	2.35 U	1.08 U	7.38 U	1.23 U	1.44 U	3.16 U	3.44 U	2.89 U	2.91 U	1.73 U	1.76 U	1.72 U	1.7
	Endosulfan I	ug/kg		0.09	1.34 U	2.18 U	2.96 U	3.81 U	3.34 U	1.16 U	3.15 U	4.53 U	1.8 U	4.33 U	1.07 j	6.36 U	2.29 U	1.2 U	0.771 U	3.75 U	1.23 U	1.44 U	1.61 U	1.75 U	1.47 U	1.48 U	0.882 U	0.897 U	0.876 U	0.9
	Endosulfan II	ug/kg		0.25	2.64 U	4.29 U	5.81 U	7.48 U	6.56 U	2.28 U	6.18 U	8.89 U	3.53 U	8.51 U	6.95 U	12.5 U	4.49 U	2.35 U	1.03 U	7.38 U	2.42 U	2.82 U	3.16 U	3.44 U	2.89 U	2.91 U	1.73 U	1.76 U	1.72 U	1.7
	Endosulfan sulfate	ug/kg		0.33	2.64 U	4.29 U	5.81 U	7.48 U	6.56 U	2.28 U	6.18 U	8.89 U	3.53 U	8.51 U	6.95 U	12.5 U	4.49 U	2.35 U	1.23 U	7.38 U	2.42 U	2.82 U	3.16 U	3.44 U	2.89 U	2.91 U	1.73 U	1.76 U	1.72 U	1.7
	Endrin	ug/kg		0.23	2.64 U	4.29 U	5.81 U	7.48 U	6.56 U	2.28 U	6.18 U	8.89 U	3.53 U	8.51 U	6.95 U	12.5 U	4.49 U	2.35 U	0.997 U	7.38 U	2.42 U	2.82 U	3.16 U	3.44 U	2.89 U	2.91 U	1.73 U	1.76 U	1.72 U	1.7
	Endrin aldehyde	ug/kg	3	0.30	2.64 U	4.29 U	5.81 U	7.48 U	6.56 U	2.28 U	6.18 U	8.89 U	3.53 U	8.51 U	6.95 U	12.5 U	4.49 U	2.35 U	1.11 U	7.38 U	2.42 U	2.82 U	3.16 U	3.44 U	2.89 U	2.91 U	1.73 U	1.76 U	1.72 U	1.7
	Endrin ketone	ug/kg		0.36	2.64 U	4.29 U	5.81 U	7.48 U	6.56 U	2.28 U	6.18 U	8.89 U	3.53 U	8.51 U	6.95 U	12.5 U	4.49 U	2.35 U	1.19 U	7.38 U	2.42 U	2.82 U	3.16 U	3.44 U	2.89 U	2.91 U	1.73 U	1.76 U	1.72 U	1.7
	gamma-BHC (Lindane)	ug/kg	0.9	0.02	1.34 U	2.18 U	2.96 U	3.81 U	3.34 U	1.16 U	3.15 U	12.4	1.8 U	4.33 U	5.1 J	6.36 U	2.29 U	1.2 U	5.49	3.75 U	1.23 U	1.44 U	1.61 U	1.75 U	1.47 U	1.48 U	0.928 J	0.897 U	0.876 U	0.9
	gamma-Chlordane	ug/kg		2.24	1.69 J	2.18 U	2.96 U	3.81 U	3.34 U	4.05	3.15 U	4.53 U	1.8 U	4.33 U	6.77 J	6.36 U	2.29 U	1.2 U	1.03 U	3.75 U	1.23 U	1.44 U	1.61 U	1.75 U	1.47 U	1.48 U	0.882 U	0.897 U	0.876 U	0.9
	Heptachlor	ug/kg	1	0.02	1.34 U	2.18 U	2.96 U	3.81 U	3.34 U	1.16 U	3.15 U	6.16	1.8 U	4.33 U	3.3 J	6.36 U	2.29 U	1.2 U	1.06 U	3.75 U	1.23 U	1.44 U	1.61 U	1.75 U	1.47 U	1.48 U	0.882 U	0.897 U	0.876 U	
	Heptachlor epoxide	ug/kg		0.16	1.34 U	2.18 U	2.96 U	3.81 U	3.34 U	1.16 U	3.15 U	4.53 U	1.8 U	4.33 U	3.54 U	6.36 U	2.29 U	1.2 U	1.72 J	3.75 U	1.23 U	1.44 U	1.61 U	1.75 U	1.47 U	1.48 U	0.882 U	0.897 U	0.876 U	
	Methoxychlor	ug/kg		3.51	13.4 U	21.8 U	29.6 U	38.1 U	33.4 U	11.6 U	31.5 U	45.3 U	18 U	43.3 U	35.4 U	63.6 U	22.9 U	12 U	0.962 U	37.5 U	12.3 U	14.4 U	16.1 U	17.5 U	14.7 U	14.8 U	8.82 U	8.97 U	8.76 U	8.9
	Toxaphene	ug/kg			52.6 U	85.6 U	116 U	149 U	131 U	45.4 U	123 U	177 U	70.4 U	170 U	138 U	249 U	89.6 U	46.9 U	77.8 U	147 U	48.2	56.3	63.1 U	68.5 U	57.6 U	58 U	34.5 U	35.1 U	34.3 U	
Pesticides	2,4'-DDD	ug/kg		1.04	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	1	1.21	0.909	1.04
ug/kg	2,4'-DDE	ug/kg		0.28	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.237	0.328	0.282	0.28
Method	2,4'-DDT	ug/kg		0.27	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.387 u	0.192	0.225	0.27
1699	4,4'-DDD	ug/kg	1	4.52	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	4.05	5.78	3.72	4.52
pg/g	4,4'-DDE	ug/kg	1	6.58	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	5.66	7.48	6.59	6.58
	4,4'-DDT	ug/kg	1	0.95	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.862	0.957	1.03	0.95
	4,4'-Methoxychlor	ug/kg		3.51	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	2.01 u	0.087 u	8.42 u	3.51
	Aldrin	ug/kg		0.25	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.226	0.299	0.219	0.25
	alpha-BHC	ug/kg	1	0.02	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.0152 J	0.0167 J	0.0204 J	0.02
	beta-BHC	ug/kg	1	0.01	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.008 u	0.007 u	0.006 u	0.01
	Lindane (gamma-BHC)	ug/kg	0.9	0.02	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.0174 J	0.0159 J	0.013 J	0.02
	delta-BHC	ug/kg	1	0.01	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.006 u	0.005 u	0.005 u	0.01
	cis-Chlordane (alpha)	ug/kg		1.96	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	1.85	2.13	1.89	1.96
	trans-Chlordane (gamma)	ug/kg		2.24	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	1.75	2.66	2.3	2.24
	Oxychlordane	ug/kg		0.20	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.056 u	0.439 u	0.096 u	0.20
	cis-Heptachlor Epoxide	ug/kg		0.13	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.087	0.21	0.094	0.13
	cis-Nonachlor	ug/kg		0.54	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.403	0.601	0.622	0.54
	Dieldrin	ug/kg	1	1.45	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	1.12	1.66	1.58	1.45
	Endosulfan I (alpha)	ug/kg		0.09	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.099 u	0.07 u	0.087 u	0.09
	Endosulfan II (beta)	ug/kg		0.25	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.282 u	0.269 u	0.201 u	0.25
	Endosulfan Sulfate	ug/kg		0.33	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.46 u	0.215 u	0.305 u	0.33
	Endrin	ug/kg		0.23	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.191 u	0.194 u	0.292 u	0.23
	Endrin Aldehyde	ug/kg	3	0.30	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.406 u	0.256 u	0.231 u	0.30
	Endrin Ketone	ug/kg		0.36	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.384 u	0.363 u	0.328 u	0.36
	Heptachlor	ug/kg	1	0.02	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.026 u	0.028 u	0.011 J	0.02
	Hexachlorobenzene	ug/kg		0.24	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.202	0.265	0.238 J	0.24
	Hexachlorobutadiene	ug/kg		0.07	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.122 J	0.0402 J	0.035 J	0.07
	Mirex	ug/kg		0.11	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.161 u	0.099	0.082 u	0.11
	trans-Heptachlor Epoxide	ug/kg		0.16	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.14 u	0.12 u	0.229 u	0.16
	trans-Nonachlor	ug/kg		1.36	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	1.28	1.51	1.29	1.36
PBDE	Total **	ug/kg			n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	28.0	100.0	30.0	52.7
Bioassay	Bioassay	Toxic/not toxic			Toxic		Toxic						Toxic	Toxic	Toxic	Toxic		Not Toxic			Not toxic			Not Toxic		Not toxic				
General	Total Organic Carbon	mg/Kg d	30933		56900	23200	31700	34300	54200	8900	40800	52600	35000	48000	54900	58300	11400	2840	6520	46200	36500	70800	71400	17800	9730	17500	26500	33200	33100	30933.3
	Percent Solids	%																												1.7
	Percent Moisture	%	4		38.2	61.6	72.1	78.4	74.8	27.9	73.2	81.3	54.4	80.7	76.1	86.8	63.2	29.1	81.4	77.7	30.9	40.9	49.1	52.3	42.6	42.8	4	5.2	3.3	4.2
	Gravel(>4750 micron)	%			4.5	0.1 U	0.1	0.1 U	6.1	5	0.1 U	0.1 U	3.5	1	0.1 U	0.1 U	0.1	0.1 U	0.1 U	0.1	4.9	13.7	17.6	8.2	2.4	14.4	n/a	n/a	n/a	
	Sand (4750-75 micron)	%			88.3	62.4	30.5	25.9	39.1	87.9	13.5	16.1	92.7	25.7	25.1	16.8	37.1	63.8	20.3	19.7	83.8	83.7	78	49.2	52.3	68.2	n/a	n/a	n/a	
	Silt(75-3.2 micron)	%			4.9	32	62.1	63.3	42.9	4.2	72.6	71.7	0.3	68.3	69.4	73.8	57.9	34.1	71.3	72.2	9.6	1.3	1.2	35.7	36.9	11.6	n/a	n/a	n/a	
	Clay(< 3.2 micron)	%			2.4	5.6	7.2	10.7	11.9	3	13.9	12.3	3.5	5.1	5.5	9.4	5	2	8.5	8.1	1.7	1.3	3.3	7	8.3	5.8	n/a	n/a	n/a	
	Field Sample Depth	m			0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

U	Under method detection limit
J	Estimate below Limit of Quantitation(LOQ)
JH	Estimate concentration; potential high bias due to lab QC failure
JL	Estimate concentration; potentail low bias due to lab QC failure
Risk based Values*	
White Box	*Lower Columbia Slough Sediment Screening Levels Appendix I*
Purple Box	Table 3-1 *Portland Harbor Joint Source Control Strategy*
Blue Box	Table A-1b *Guidance for Assessing Bioaccumlative Chmeicals of Concern in Sediment*
Baseline Value **	IS average value of Whitaker Segment
Red Box	Over Risk based Values — Elevated: Values that exceed the baseline value or one order of magnitude above a risk-based screening level whichever is higher

Appendix E: Whitaker Slough Sediment between mouth and I-205
Duplicate QA/QC Review

	Whitaker Slough		Precision acceptable when RPD <50% for Organics or RPD<35% for inorganics*										
			OF 77a/PW QA		OF 77a /PW		Precision relative percent difference		OF 83		OF 83 QA		Precision relative percent difference
	Sampling 2011												
Metals	Total Antimony	mg/Kg dry	3.3	J	2.9	J	12.9%		1.6	u	1.6	u	0.0%
	Total Arsenic	mg/Kg dry	5.1	J	5.5	J	-7.5%		4.1	J	3.9	J	5.0%
	Total Cadmium	mg/Kg dry	0.58	J	1	J	-53.2%		0.44	J	0.19	J	79.4%
	Total Chromium	mg/Kg dry	173		151		13.6%		23.4		22.4		4.4%
	Total Copper	mg/Kg dry	668		656		1.8%		33.5		28.1		17.5%
	Total Lead	mg/Kg dry	244		250		-2.4%		47.0		53.4		-12.7%
	Mercury	mg/Kg dry	0.1	J	0.11	J	-9.5%		0.038	J	0.037	J	2.7%
	Manganese	mg/Kg dry	169		193		-13.3%		162		169		-4.2%
	Total Nickel	mg/Kg dry	31.3		40.6		-25.9%		21.8	J	20.5	J	6.1%
	Total Zinc	mg/Kg dry	221		267		-18.9%		183		173		5.6%
Semi-Vols	4-Methylphenol (p-Cresol)	µg/Kg dry	186	U	187	U	-0.5%		97	U	95.8	U	1.2%
PAHs	Benzyl alcohol	µg/Kg dry	54.2	U	54.3	U	-0.2%		28.2	U	27.9	U	1.1%
	bis(2-Ethylhexyl)phthalate	µg/Kg dry	668	U	737	J	-9.8%		348	U	343	U	1.4%
	Butylbenzylphthalate	µg/Kg dry	56.3	U	67.5	U	-18.1%		31.3	J	28.9	U	8.0%
	Dibenzofuran	µg/Kg dry	73.9	U	74.1	U	-0.3%		38.5	U	38	U	1.3%
	Diethylphthalate	µg/Kg dry	72.6	U	72.8	U	-0.3%		37.8	U	37.3	U	1.3%
	Dimethylphthalate	µg/Kg dry	67.2	J	51.7	U	26.1%		26.8	U	26.5	U	1.1%
	Di-n-butylphthalate	µg/Kg dry	68.1	U	68.2	U	-0.1%		35.4	U	35	U	1.1%
	Di-n-octylphthalate	µg/Kg dry	47.2	U	47.3	U	-0.2%		24.5	U	24.2	U	1.2%
	Pentachlorophenol	µg/Kg dry	379	U	380	U	-0.3%		197	U	195	U	1.0%
	Phenol	µg/Kg dry	80.7	U	80.9	U	-0.2%		42	U	41.5	U	1.2%
	2-Methylnaphthalene	µg/Kg dry	28.1	j	8.4	J	107.9%		3.5	J	7.3	J	-70.4%
	Acenaphthene	µg/Kg dry	15	J	5.6	U	91.3%		3.9	J	9.2	J	-80.9%
	Acenaphthylene	µg/Kg dry	19.1	J	9.9	J	63.4%		11.3	J	30.6		-92.1%
	Anthracene	µg/Kg dry	44.8	J	20.8	J	73.2%		14.4		49.4		-109.7%
	Benzo(a)anthracene	µg/Kg dry	170		141		18.6%		75.5		140		-59.9%
	Benzo(a)pyrene	µg/Kg dry	275		236		15.3%		111		210		-61.7%
	Benzo(b)fluoranthene	µg/Kg dry	290		221		27.0%		107		180		-50.9%
	Benzo(g,h,i)perylene	µg/Kg dry	256		193		28.1%		98.3		198		-67.3%
	Benzo(k)fluoranthene	µg/Kg dry	97.2		84.6		13.9%		48.1		92.3		-63.0%
	Chrysene	µg/Kg dry	239		192		21.8%		104		161		-43.0%
	Dibenz(a,h)anthracene	µg/Kg dry	42.7	J	28.7		39.2%		14.4		27		-60.9%
	Fluoranthene	µg/Kg dry	358		291		20.6%		197		356		-57.5%
	Fluorene	µg/Kg dry	14.7	J	6.5	U	77.4%		7.6	J	19.4		-87.4%
	Indeno(1,2,3-cd)pyrene	µg/Kg dry	225		172		26.7%		62.5		121		-63.8%
	Naphthalene	µg/Kg dry	39.3	J	14.2	J	93.8%		7.1	J	10.3	J	-36.8%
	Phenanthrene	µg/Kg dry	181		109		49.7%		83.9		263		-103.3%
	Pyrene	µg/Kg dry	455		375		19.3%		283		498		-55.1%
Oil	Diesel Range SG	mg/Kg dry	152		260		-52.4%		57.2		47.6		18.3%
NWTPH-Dx	Motor Oil Range SG	mg/Kg dry	923		1370		-39.0%		323		247		26.7%

Appendix E: Whitaker Slough Sediment between mouth and I-205
Duplicate QA/QC Review

	Whitaker Slough		Precision acceptable when RPD <50% for Organics or RPD<35% for inorganics*										
			OF 77a/PW QA		OF 77a /PW		Precision relative percent difference		OF 83		OF 83 QA		Precision relative percent difference
	Sampling 2011												
Pesticides	4,4'-DDD	ug/kg	8.51	U	**7.33**	J	14.9%		3.44	U	2.89	U	17.4%
ug/kg	4,4'-DDE	ug/kg	**11.7**	J	**9.87**	J	17.0%		3.44	U	2.89	U	17.4%
Method	4,4'-DDT	ug/kg	10.2	U	8.32	U	20.3%		4.11	U	3.46	U	17.2%
8081	Aldrin	ug/kg	**8.35**	J	3.54	U	80.9%		1.75	U	1.47	U	17.4%
	alpha-BHC	ug/kg	4.33	U	3.54	U	20.1%		1.75	U	1.47	U	17.4%
	alpha-Chlordane	ug/kg	4.33	U	**5.96**	J	-31.7%		1.75	U	1.47	U	17.4%
	beta-BHC	ug/kg	4.33	U	3.54	U	20.1%		1.75	U	1.47	U	17.4%
	delta-BHC	ug/kg	4.33	U	3.54	U	20.1%		1.75	U	1.47	U	17.4%
	Dieldrin	ug/kg	8.51	U	**8.56**	J	-0.6%		3.44	U	2.89	U	17.4%
	Endosulfan I	ug/kg	4.33	U	3.54	U	20.1%		1.75	U	1.47	U	17.4%
	Endosulfan II	ug/kg	8.51	U	6.95	U	20.2%		3.44	U	2.89	U	17.4%
	Endosulfan sulfate	ug/kg	8.51	U	6.95	U	20.2%		3.44	U	2.89	U	17.4%
	Endrin	ug/kg	8.51	U	6.95	U	20.2%		3.44	U	2.89	U	17.4%
	Endrin aldehyde	ug/kg	8.51	U	6.95	U	20.2%		3.44	U	2.89	U	17.4%
	Endrin ketone	ug/kg	8.51	U	6.95	U	20.2%		3.44	U	2.89	U	17.4%
	gamma-BHC (Lindane)	ug/kg	4.33	U	3.54	U	20.1%		1.75	U	1.47	U	17.4%
	gamma-Chlordane	ug/kg	4.33	U	**6.77**	J	-44.0%		1.75	U	1.47	U	17.4%
	Heptachlor	ug/kg	4.33	U	**5.17**	J	-17.7%		1.75	U	1.47	U	17.4%
	Heptachlor epoxide	ug/kg	4.33	U	3.54	U	20.1%		1.75	U	1.47	U	17.4%
	Methoxychlor	ug/kg	43.3	U	35.4	U	20.1%		17.5	U	14.7	U	17.4%
	Toxaphene	ug/kg	170	U	138	U	20.8%		68.5	U	57.6	U	17.3%
PCBs	Aroclor-1016 (PCB-1016)	µg/Kg dry	4.4	u	4.5	u	-2.2%		9.4	u	2.3	u	121.4%
	Aroclor-1242 (PCB-1242)	µg/Kg dry	2.2	u	2.2	u	0.0%		4.7	u	1.1	u	124.1%
	Aroclor 1221	µg/Kg dry	3.1	u	3.1	u	0.0%		6.6	u	1.6	u	122.0%
	Aroclor 1232	µg/Kg dry	4.1	u	4.1	u	0.0%		8.7	u	2.1	u	122.2%
	Aroclor 1248	µg/Kg dry	**7.5**		**11.2**		-39.6%		8.3	u	**8**		3.7%
	Aroclor 1254	µg/Kg dry	**4.1**		**6.3**		-42.3%		5	u	**5.3**		-5.8%
	Aroclor 1260	µg/Kg dry	**7.8**		**10**		-24.7%		10.1	u	**14.3**		-34.4%
General	Total Organic Carbon	mg/Kg dry	**48000**		**54900**		-13.4%		**17800**		**9730**		58.6%
	Percent Solids	%					#DIV/0!						#DIV/0!
	Clay	%	**1**		**0.1**		163.6%		**8.2**		**2.4**		109.4%
	Silt	%	**25.7**		**25.1**		2.4%		**49.2**		**52.3**		-6.1%
	Sand	%	**68.3**		**69.4**		-1.6%		**35.7**		**36.9**		-3.3%
	Gravel	%	**5.1**		**5.5**		-7.5%		**7**		**8.3**		-17.0%
	Field Sample Depth	m	**0.1**		**0.1**		0.0%		**0.1**		**0.1**		0.0%
U	Under method detection limit												
J	Estimate below Limit of Quantitation(LOQ)												
	Precision >35% or 50%												
* Inorganics	Metals												
* Organics	PAHs, Pesticides, PCBs, PBDEs, TPHx, Semi-Vol												

Appendix E Columbia Slough Triplicate QA/QC Review

Decision Area: Whitaker Slough Sediment between mouth and I-205

	Whitaker Slough									
	Sampling 2011		IS A Sample	IS B	IS C	Simple Mean		Standard Deviation	Relative Standard Deviation	95% UCL Factor
Metals	Total Antimony	mg/Kg dr	0.89	0.89	0.89	0.9		0.0	0.0	0.9
	Total Arsenic	mg/Kg dr	4.1	4.4	4.4	4.3		0.2	4.0	4.6
	Total Cadmium	mg/Kg dr	0.48	0.29	0.21	0.3		0.1	42.5	0.6
	Total Chromium	mg/Kg dr	46	51.3	47.3	48.2		2.8	5.7	52.9
	Total Copper	mg/Kg dr	40	42	52	44.7		6.4	14.4	55.5
	Total Lead	mg/Kg dr	69	77	75	73.7		4.2	5.7	80.7
	Mercury	mg/Kg dr	0.087	0.1	0.078	0.1		0.0	12.5	0.1
	Manganese	mg/Kg dr	212	222	223	219.0		6.1	2.8	229.3
	Total Nickel	mg/Kg dr	17	17	18	17.3		0.6	3.3	18.3
	Total Zinc	mg/Kg dr	165	186	192	181.0		14.2	7.8	204.9
Semi-Vol	4-Methylphenol (p-Cresol)	µg/Kg dry	51.8	52.3	52.3	52.1		0.3	0.6	52.6
	Benzyl alcohol	µg/Kg dry	38.5	30.4	23.7	30.9		7.4	24.0	43.4
	bis(2-Ethylhexyl)phthalate	µg/Kg dry	866	564	375	601.7		247.7	41.2	1019.2
	Butylbenzylphthalate	µg/Kg dry	54.3	34.3	30.1	39.6		12.9	32.7	61.4
	Dibenzofuran	µg/Kg dry	20.6	20.8	20.7	20.7		0.1	0.5	20.9
	Diethylphthalate	µg/Kg dry	20.2	20.4	20.4	20.3		0.1	0.6	20.5
	Dimethylphthalate	µg/Kg dry	14.3	14.5	14.5	14.4		0.1	0.8	14.6
	Di-n-butylphthalate	µg/Kg dry	18.9	35.5	19.1	24.5		9.5	38.9	40.6
	Di-n-octylphthalate	µg/Kg dry	13.1	13.2	13.2	13.2		0.1	0.4	13.3
	Pentachlorophenol	µg/Kg dry	105	106	106	105.7		0.6	0.5	106.6
	Phenol	µg/Kg dry	22.5	22.7	22.6	22.6		0.1	0.4	22.8
	2-Methylnaphthalene	µg/Kg dry	7.6	7.9	8	7.8		0.2	2.7	8.2
	Acenaphthene	µg/Kg dry	3.8	5.7	3.9	4.5		1.1	23.9	6.3
	Acenaphthylene	µg/Kg dry	2.5	2.7	3.8	3.0		0.7	23.3	4.2
	Anthracene	µg/Kg dry	5.8	6.2	6.2	6.1		0.2	3.8	6.5
	Benzo(a)anthracene	µg/Kg dry	24.7	25.7	28.9	26.4		2.2	8.3	30.1
	Benzo(a)pyrene	µg/Kg dry	33.9	37	44.5	38.5		5.5	14.2	47.7
	Benzo(b)fluoranthene	µg/Kg dry	38	41.2	50.5	43.2		6.5	15.0	54.2
	Benzo(g,h,i)perylene	µg/Kg dry	40.4	44.9	56.8	47.4		8.5	17.9	61.7
	Benzo(k)fluoranthene	µg/Kg dry	33.4	32.3	44.8	36.8		6.9	18.8	48.5
	Chrysene	µg/Kg dry	47.2	48.4	56.8	50.8		5.2	10.3	59.6
	Dibenz(a,h)anthracene	µg/Kg dry	9.5	7.9	15.3	10.9		3.9	35.7	17.5
	Fluoranthene	µg/Kg dry	56.8	58.6	63.1	59.5		3.2	5.5	65.0
	Fluorene	µg/Kg dry	7.6	8.7	9.5	8.6		1.0	11.1	10.2
	Indeno(1,2,3-cd)pyrene	µg/Kg dry	26.6	28.8	39.4	31.6		6.8	21.7	43.1
	Naphthalene	µg/Kg dry	8.3	8.3	8.5	8.4		0.1	1.4	8.6
	Phenanthrene	µg/Kg dry	27.7	31.4	28	29.0		2.1	7.1	32.5
	Pyrene	µg/Kg dry	66.9	72.6	75.2	71.6		4.2	5.9	78.7
Oil	Diesel Range SG	mg/Kg dr	430	390	443	421.0		27.6	6.6	467.6
NWTPH-D	Motor Oil Range SG	mg/Kg dr	1780	1880	1890	1850.0		60.8	3.3	1952.5

Appendix E Columbia Slough Triplicate QA/QC Review

Decision Area: Whitaker Slough Sediment between mouth and I-205

	Whitaker Slough									
	Sampling 2011		IS A Sample	IS B	IS C	Simple Mean		Standard Deviation	Relative Standard Deviation	95% UCL Factor
Pesticide	4,4'-DDD	ug/kg	1.73	1.76	1.72	**1.7**		0.0	1.2	1.8
Method	4,4'-DDE	ug/kg	**3.43**	**8.17**	**8.85**	**6.8**		3.0	43.3	11.8
8081	4,4'-DDT	ug/kg	2.07	2.11	2.06	**2.1**		0.0	1.3	2.1
	Aldrin	ug/kg	0.882	0.897	0.876	**0.9**		0.0	1.2	0.9
	alpha-BHC	ug/kg	**3.98**	0.897	0.876	**1.9**		1.8	93.1	4.9
	alpha-Chlordane	ug/kg	0.882	0.897	**1.18**	**1.0**		0.2	17.0	1.3
	beta-BHC	ug/kg	0.882	0.897	0.876	**0.9**		0.0	1.2	0.9
	delta-BHC	ug/kg	0.882	0.897	0.876	**0.9**		0.0	1.2	0.9
	Dieldrin	ug/kg	1.73	1.76	1.72	**1.7**		0.0	1.2	1.8
	Endosulfan I	ug/kg	0.882	0.897	0.876	**0.9**		0.0	1.2	0.9
	Endosulfan II	ug/kg	1.73	1.76	1.72	**1.7**		0.0	1.2	1.8
	Endosulfan sulfate	ug/kg	1.73	1.76	1.72	**1.7**		0.0	1.2	1.8
	Endrin	ug/kg	1.73	1.76	1.72	**1.7**		0.0	1.2	1.8
	Endrin aldehyde	ug/kg	1.73	1.76	1.72	**1.7**		0.0	1.2	1.8
	Endrin ketone	ug/kg	1.73	1.76	1.72	**1.7**		0.0	1.2	1.8
	gamma-BHC (Lindane)	ug/kg	**0.928**	0.897	0.876	**0.9**		0.0	2.9	0.9
	gamma-Chlordane	ug/kg	0.882	0.897	0.876	**0.9**		0.0	1.2	0.9
	Heptachlor	ug/kg	0.882	0.897	0.876	**0.9**		0.0	1.2	0.9
	Heptachlor epoxide	ug/kg	0.882	0.897	0.876	**0.9**		0.0	1.2	0.9
	Methoxychlor	ug/kg	8.82	8.97	8.76	**8.9**		0.1	1.2	9.0
	Toxaphene	ug/kg	34.5	35.1	34.3	**34.6**		0.4	1.2	35.3
Pesticide	2,4'-DDD	ug/kg	**1**	**1.21**	**0.909**	**1.04**		0.15	14.8	1.3
Method	2,4'-DDE	ug/kg	**0.237**	**0.328**	**0.282**	**0.28**		0.05	16.1	0.4
1669	2,4'-DDT	ug/kg	0.387	**0.192**	**0.225**	**0.27**		0.10	38.9	0.4
	4,4'-DDD	ug/kg	**4.05**	**5.78**	**3.72**	**4.52**		1.11	24.5	6.4
	4,4'-DDE	ug/kg	**5.66**	**7.48**	**6.59**	**6.58**		0.91	13.8	8.1
	4,4'-DDT	ug/kg	**0.862**	**0.957**	**1.03**	**0.95**		0.08	8.9	1.1
	4,4'-Methoxychlor	ug/kg	2.01	0.087	8.42	3.51		4.36	124.5	10.9
	Aldrin	ug/kg	**0.226**	**0.299**	**0.219**	**0.25**		0.04	17.9	0.3
	alpha-BHC	ug/kg	**0.0152**	**0.0167**	**0.0204**	**0.02**		0.00	15.4	0.0
	beta-BHC	ug/kg	0.008	0.007	0.006	0.01		0.00	14.3	0.0
	Lindane (gamma-BHC)	ug/kg	**0.0174**	**0.0159**	**0.013**	**0.02**		0.00	14.5	0.0
	delta-BHC	ug/kg	0.006	0.005	0.005	0.01		0.00	10.8	0.0
	cis-Chlordane (alpha)	ug/kg	**1.85**	**2.13**	**1.89**	**1.96**		0.15	7.7	2.2
	trans-Chlordane (gamma)	ug/kg	**1.75**	**2.66**	**2.3**	**2.24**		0.46	20.5	3.0
	Oxychlordane	ug/kg	0.056	0.439	0.096	0.20		0.21	106.9	0.6
	cis-Heptachlor Epoxide	ug/kg	**0.087**	**0.21**	**0.094**	**0.13**		0.07	53.0	0.2
	cis-Nonachlor	ug/kg	**0.403**	**0.601**	**0.622**	**0.54**		0.12	22.3	0.7
	Dieldrin	ug/kg	**1.12**	**1.66**	**1.58**	**1.45**		0.29	20.1	1.9
	Endosulfan I (alpha)	ug/kg	0.099	0.07	0.087	0.09		0.01	17.1	0.1
	Endosulfan II (beta)	ug/kg	0.282	0.269	0.201	0.38		0.04	11.6	0.4
	Endosulfan Sulfate	ug/kg	0.46	0.215	0.305	0.33		0.12	37.9	0.5
	Endrin	ug/kg	0.191	0.194	0.292	0.23		0.06	25.5	0.3
	Endrin Aldehyde	ug/kg	0.406	0.256	0.231	0.30		0.09	31.8	0.5
	Endrin Ketone	ug/kg	0.384	0.363	0.328	0.36		0.03	7.9	0.4
	Heptachlor	ug/kg	0.026	0.028	**0.011**	**0.02**		0.01	42.9	0.0
	Hexachlorobenzene	ug/kg	**0.202**	**0.265**	**0.238**	**0.24**		0.03	13.4	0.3
	Hexachlorobutadiene	ug/kg	**0.122**	**0.0402**	**0.035**	**0.07**		0.05	74.2	0.1
	Mirex	ug/kg	0.161	**0.099**	0.082	**0.11**		0.04	36.5	0.2
	trans-Heptachlor Epoxide	ug/kg	0.14	0.12	0.229	0.16		0.06	35.6	0.3
	trans-Nonachlor	ug/kg	**1.28**	**1.51**	**1.29**	**1.36**		0.13	9.6	1.6
TBT	Tributyltin	µg/Kg dry	**2.4**	**5.4**	3.3	**3.7**		1.5	41.6	6.3

Appendix E Columbia Slough Triplicate QA/QC Review

Decision Area: Whitaker Slough Sediment between mouth and I-205

	Whitaker Slough									
	Sampling 2011		IS A Sample	IS B	IS C	Simple Mean		Standard Deviation	Relative Standard Deviation	95% UCL Factor
PCBs	Aroclor-1016 (PCB-1016)	µg/Kg dry	4.9	4.9	4.9	4.9		0.0	0.0	4.9
	Aroclor-1242 (PCB-1242)	µg/Kg dry	4.6	4.6	4.6	4.6		0.0	0.0	4.6
	Aroclor 1221	µg/Kg dry	2.5	2.5	2.5	2.5		0.0	0.0	2.5
	Aroclor 1232	µg/Kg dry	3.4	3.4	3.4	3.4		0.0	0.0	3.4
	Aroclor 1248	µg/Kg dry	4.3	4.3	4.3	4.3		0.0	0.0	4.3
	Aroclor 1254	µg/Kg dry	2.6	2.6	2.6	2.6		0.0	0.0	2.6
	Aroclor 1260	µg/Kg dry	**28**	**19.6**	**15.6**	**21.1**		6.3	30.0	31.7
Dioxin-lik	PCB- 77	ng/Kg	**166**	**287**	**108**	**187.0**		91.3	48.8	341.0
Congener	PCB 81	ng/Kg	34	33	33	33.3		0.6	1.7	34.3
	PCB 105	ng/Kg	**583**	**6570**	**533**	**2562.0**		3471.1	135.5	8413.8
	PCB 114	ng/Kg	**34**	**413**	**31**	**159.3**		219.7	137.9	529.7
	PCB 118	ng/Kg	**1460**	**14400**	**1310**	**5723.3**		7514.6	131.3	18391.9
	PCB 123	ng/Kg	**47**	**312**	**30**	**129.7**		158.1	122.0	396.3
	PCB 126	ng/Kg	**35**	**64**	**32**	**43.7**		17.7	40.5	73.5
	PCB 156 + 157	ng/Kg	**434**	**3190**	**378**	**1334.0**		1607.6	120.5	4044.2
	PCB 167	ng/Kg	**224**	**986**	**213**	**474.3**		443.2	93.4	1221.4
	PCB 169	ng/Kg	26	26	26	26.0		0.0	0.0	26.0
	PCB 189	ng/Kg	323	312	320	**318.3**		5.7	1.8	327.9
	Total PCBs	ng/Kg	**95200**	**311000**	**81300**	**162500**		128792.4	79.3	379626.4
PBDE	BDE-(28/33)	ng/Kg	**112.0**	**59.6**	**46.1**	**108.9**		37.1	34.0	171.3
	BDE-47	ng/Kg	**2880**	**2560**	**2100**	**3770.0**		226.3	6.0	4151.5
	BDE-99	ng/Kg	**3730**	**3480**	**3150**	**5180.0**		176.8	3.4	5478.0
	BDE-100	ng/Kg	**783**	**837**	**701**	**1160.5**		38.2	3.3	1224.9
	BDE-153	ng/Kg	**651**	**276**	**361**	**644.0**		265.2	41.2	1091.0
	BDE-154	ng/Kg	**435**	**276**	**357**	**534.0**		112.4	21.1	723.5
	BDE-183	ng/Kg	**819**	**455**	**236**	**755.0**		257.4	34.1	1188.9
	BDE-209	ng/Kg	**7940**	**78000**	**14600**	**50270.0**		49539.9	98.5	133787.5
	Total BDE	ng/Kg	**28753.65**	**100702.9**	**30343.2**	**79899.9**		50875.8	63.7	165669.5
General	Total Organic Carbon	mg/Kg dr	**26500**	**33200**	**33100**	30933.3		4737.6	15.3	38920.3
	Percent Solids	%	**n/a**	**n/a**	**n/a**					
	Clay	%	**n/a**	**n/a**	**n/a**					
	Silt	%	**n/a**	**n/a**	**n/a**					
	Sand	%	**n/a**	**n/a**	**n/a**					
	Gravel	%	**n/a**	**n/a**	**n/a**					
	Bold values are detected values									
	Green	RSD>30% for detected values								
	RST=100* StDv/mean									
	95% UCL=									
	mean+(2.92*StDv)/SQRT(3)									

Appendix F -- 2011 Whitaker Slough Sediment between River Mile 0-3.2
Congener Data Table

		IS Triplicate A		IS (Triplicate B)		IS (Triplicate C)		IS
Parameter	**Unit**	2/14/2011		2/14/2011		2/14/2011		Mean
Total	**ug/kg**	**95**		**311**		**81**		**162**
Total	**ng/Kg**	**95500**		**313190**		**81840**		**163510**
PCB-001	ng/Kg	**30.6**		**125**		**82**		**79**
PCB-002	ng/Kg	**47.3**		**79.1**		**46.3**		**58**
PCB-003	ng/Kg	52.1	U	**125**		**98.7**		**92**
PCB-004	ng/Kg	**94.7**		**175**		**105**		**125**
PCB-005	ng/Kg	25.8	U	24.9	U	25.6	U	25
PCB-006	ng/Kg	**79.6**		**139**		**104**		**108**
PCB-007	ng/Kg	22.3	U	**44.5**		**33.8**		**34**
PCB-008	ng/Kg	**377**		**560**		**415**		**451**
PCB-009	ng/Kg	**30.8**		**50.2**		**49.5**		**44**
PCB-010	ng/Kg	28.8	U	27.8	U	28.5	U	28
PCB-011	ng/Kg	**657**		**984**		**968**		**870**
PCB-012	ng/Kg	**54.2**		**108**		**96**		**86**
PCB-013	ng/Kg	0		0		0		0
PCB-014	ng/Kg	12.9	U	12.4	U	12.8	U	13
PCB-015	ng/Kg	**325**		**437**		**252**		**338**
PCB-016	ng/Kg	**229**		**314**		**131**		**225**
PCB-017	ng/Kg	**335**		**411**		**180**		**309**
PCB-018	ng/Kg	**602**		**821**		**375**		**599**
PCB-019	ng/Kg	**60.5**		**90.9**		**42.6**		**65**
PCB-020	ng/Kg	**1460**		**1680**		**767**		**1302**
PCB-021	ng/Kg	**566**		**789**		**359**		**571**
PCB-022	ng/Kg	**417**		**542**		**260**		**406**
PCB-023	ng/Kg	19.8	U	19.2	U	19.7	U	20
PCB-024	ng/Kg	27.3	U	26.3	U	27	U	27
PCB-025	ng/Kg	**92.8**		**112**		**48.7**		**85**
PCB-026	ng/Kg	**197**		**241**		**116**		**185**
PCB-027	ng/Kg	**61.7**		**89.1**		**33.5**		**61**
PCB-028	ng/Kg	0		0		0		0
PCB-029	ng/Kg	0		0		0		0
PCB-030	ng/Kg	0		0		0		0
PCB-031	ng/Kg	**982**		**1300**		**586**		**956**
PCB-032	ng/Kg	**206**		**289**		**137**		**211**
PCB-033	ng/Kg	0		0		0		0
PCB-034	ng/Kg	20.8	U	20.1	U	20.6	U	21
PCB-035	ng/Kg	34.2	U	37		33.9	U	35
PCB-036	ng/Kg	16.9	U	16.3	U	16.7	U	17
PCB-037	ng/Kg	**482**		**579**		**277**		**446**
PCB-038	ng/Kg	20.8	U	20.1	U	20.6	U	21
PCB-039	ng/Kg	23.3	U	22.5	U	23.1	U	23
PCB-040	ng/Kg	**2750**		**5530**		**1900**		**3393**
PCB-041	ng/Kg	0		0		0		0
PCB-042	ng/Kg	**357**		**674**		**224**		**418**
PCB-043	ng/Kg	**51.8**		31.1	U	**31.9**	**U**	**38**
PCB-044	ng/Kg	**1220**		**3610**		**841**		**1890**
PCB-045	ng/Kg	**258**		**381**		**167**		**269**
PCB-046	ng/Kg	**85.4**		**150**		**64.8**		**100**
PCB-047	ng/Kg	0		0		0		0
PCB-048	ng/Kg	**243**		**420**		**152**		**272**
PCB-049	ng/Kg	**759**		**1810**		**490**		**1020**
PCB-050	ng/Kg	**186**		**322**		**132**		**213**
PCB-051	ng/Kg	0		0		0		0

Appendix F -- 2011 Whitaker Slough Sediment between River Mile 0-3.2
Congener Data Table

		IS Triplicate A		IS (Triplicate B)		IS (Triplicate C)		IS
Parameter	Unit	2/14/2011		2/14/2011		2/14/2011		Mean
PCB-052	ng/Kg	1540		6420		1200		3053
PCB-053	ng/Kg	0		0		0		0
PCB-054	ng/Kg	16.4	U	15.8	U	16.2	U	16
PCB-055	ng/Kg	24.8	U	23.9	U	24.6	U	24
PCB-056	ng/Kg	545		1430		359		778
PCB-057	ng/Kg	26.3	U	60.3		26	U	38
PCB-058	ng/Kg	38.2	U	64.3		37.8	U	47
PCB-059	ng/Kg	131		183		76.3		130
PCB-060	ng/Kg	155		496		122		258
PCB-061	ng/Kg	1990		8630		1340		3987
PCB-062	ng/Kg	0		0		0		0
PCB-063	ng/Kg	48.7		120		29.7		66
PCB-064	ng/Kg	348		946		286	U	527
PCB-065	ng/Kg	0		0		0		0
PCB-066	ng/Kg	1180		2890		726		1599
PCB-067	ng/Kg	47.6		72.1		25		48
PCB-068	ng/Kg	13.9	U	14.2		13.8	U	14
PCB-069	ng/Kg	0		0		0		0
PCB-070	ng/Kg	0		0		0		0
PCB-071	ng/Kg	0		0		0		0
PCB-072	ng/Kg	322	U	311	U	319	U	317
PCB-073	ng/Kg	0	U	0	U	0	U	0
PCB-074	ng/Kg	0		0		0		0
PCB-075	ng/Kg	0		0		0		0
PCB-076	ng/Kg	0		0		0		0
PCB-077	ng/Kg	166		287		108		187
PCB-078	ng/Kg	33.2	U	32.1	U	32.9	U	33
PCB-079	ng/Kg	42.2	U	146		41.8	U	77
PCB-080	ng/Kg	43.2	U	41.7	U	42.8	U	43
PCB-081	ng/Kg	34.2	U	33	U	33.9	U	34
PCB-082	ng/Kg	206		2150		200		852
PCB-083	ng/Kg	151		1440		187		593
PCB-084	ng/Kg	494		5120		504		2039
PCB-085	ng/Kg	252		2470		291		1004
PCB-086	ng/Kg	1270		13100		1200		5190
PCB-087	ng/Kg	0		0		0		0
PCB-088	ng/Kg	304		1900		258		821
PCB-089	ng/Kg	27.3		179		26.7		78
PCB-090	ng/Kg	2610		17600		2450		7553
PCB-091	ng/Kg	0		0		0		0
PCB-092	ng/Kg	530		3210		509		1416
PCB-093	ng/Kg	65.7		434		65.4		188
PCB-094	ng/Kg	10.9	U	58.5		12.7		27
PCB-095	ng/Kg	2360		14000		2240		6200
PCB-096	ng/Kg	31.8	U	92.3		31.5	U	52
PCB-097	ng/Kg	0		0		0		0
PCB-098	ng/Kg	0		0		0		0
PCB-099	ng/Kg	893		7450		844		3062
PCB-100	ng/Kg	0		0		0		0
PCB-101	ng/Kg	0		0		0		0
PCB-102	ng/Kg	0		0		0		0
PCB-103	ng/Kg	27.5		80.1		24.8		44
PCB-104	ng/Kg	15.4	U	14.8	U	15.2	U	15

Appendix F -- 2011 Whitaker Slough Sediment between River Mile 0-3.2
Congener Data Table

		IS Triplicate A		IS (Triplicate B)		IS (Triplicate C)		IS
Parameter	Unit	2/14/2011		2/14/2011		2/14/2011		Mean
PCB-105	ng/Kg	583		6570		533		2562
PCB-106	ng/Kg	34.7	U	33.5	U	34.4	U	34
PCB-107	ng/Kg	74.8		689		68.6		277
PCB-108	ng/Kg	0		0		0		0
PCB-109	ng/Kg	144		992		141		426
PCB-110	ng/Kg	2310		20500		2200		8337
PCB-111	ng/Kg	25.8	U	24.9	U	25.6	U	25
PCB-112	ng/Kg	238	U	230	U	236	U	235
PCB-113	ng/Kg	0		0		0		0
PCB-114	ng/Kg	34.1		413		30.9		159
PCB-115	ng/Kg	0		0		0		0
PCB-116	ng/Kg	0		0		0		0
PCB-117	ng/Kg	0		0		0		0
PCB-118	ng/Kg	1460		14400		1310		5723
PCB-119	ng/Kg	0		0		0		0
PCB-120	ng/Kg	34.2	U	34		34	U	34
PCB-121	ng/Kg	21.8	U	21.1	U	22	U	22
PCB-122	ng/Kg	24.8	U	206		25	U	85
PCB-123	ng/Kg	47		312		29.7		130
PCB-124	ng/Kg	0		0		0		0
PCB-125	ng/Kg	0		0		0		0
PCB-126	ng/Kg	34.9		64.2		31.9		44
PCB-127	ng/Kg	18.9	U	48.2		18.7	U	29
PCB-128	ng/Kg	519		3860		469		1616
PCB-129	ng/Kg	6070		24100		5260		11810
PCB-130	ng/Kg	389		1710		357		819
PCB-131	ng/Kg	50.8		371		46		156
PCB-132	ng/Kg	1850		7930		1680		3820
PCB-133	ng/Kg	123		327		107		186
PCB-134	ng/Kg	347		1280		352		660
PCB-135	ng/Kg	3210		7920		3020		4717
PCB-136	ng/Kg	1060		3280		1010		1783
PCB-137	ng/Kg	206		1350		130		562
PCB-138	ng/Kg	0		0		0		0
PCB-139	ng/Kg	69.5	U	431		68.8	U	190
PCB-140	ng/Kg	69.5	U	0		68.8	U	46
PCB-141	ng/Kg	1100		4080		1040		2073
PCB-142	ng/Kg	22.8	U	22	U	22.6	U	22
PCB-143	ng/Kg	0		0		0		0
PCB-144	ng/Kg	401		1150		347		633
PCB-145	ng/Kg	30.8	U	29.7	U	30.5	U	30
PCB-146	ng/Kg	1310		3450		1180		1980
PCB-147	ng/Kg	6030		17200		5510		9580
PCB-148	ng/Kg	26.8	U	25.9	U	26.5	U	26
PCB-149	ng/Kg	0		0		0		0
PCB-150	ng/Kg	29.3	U	28.2	U	29	U	29
PCB-151	ng/Kg	0		0		0		0
PCB-152	ng/Kg	11.4	U	21.2		11.3	U	15
PCB-153	ng/Kg	6270		16700		5470		9480
PCB-154	ng/Kg	58.4		175		60.2		98
PCB-155	ng/Kg	13.4	U	12.9	U	13.3	U	13
PCB-156	ng/Kg	434		3190		378		1334
PCB-157	ng/Kg	0		0		0		0

Appendix F -- 2011 Whitaker Slough Sediment between River Mile 0-3.2
Congener Data Table

		IS Triplicate A		IS (Triplicate B)		IS (Triplicate C)		IS
Parameter	Unit	2/14/2011		2/14/2011		2/14/2011		Mean
PCB-158	ng/Kg	470		2290		409		1056
PCB-159	ng/Kg	37.2	U	35.9	U	36.9	U	37
PCB-160	ng/Kg	19.8	U	19.2	U	19.7	U	20
PCB-161	ng/Kg	42.7	U	41.2	U	42.3	U	42
PCB-162	ng/Kg	25.3		91.1		45.7		54
PCB-163	ng/Kg	0		0		0		0
PCB-164	ng/Kg	328		1320		334		661
PCB-165	ng/Kg	26.8	U	25.9	U	26.5	U	26
PCB-166	ng/Kg	0		0		0		0
PCB-167	ng/Kg	224		986		213		474
PCB-168	ng/Kg	0		0		0		0
PCB-169	ng/Kg	26.8	U	25.9	U	26.5	U	26
PCB-170	ng/Kg	2210		3880		1930		2673
PCB-171	ng/Kg	655		1370		652		892
PCB-172	ng/Kg	441		707		398		515
PCB-173	ng/Kg	0		0		0		0
PCB-174	ng/Kg	2670		4410		2410		3163
PCB-175	ng/Kg	116		221		111		149
PCB-176	ng/Kg	402		669		357		476
PCB-177	ng/Kg	1600		2590		1430		1873
PCB-178	ng/Kg	679		1080		595		785
PCB-179	ng/Kg	1360		2260		1230		1617
PCB-180	ng/Kg	5190		8470		4530		6063
PCB-181	ng/Kg	13.9	U	48.4		13.8	U	25
PCB-182	ng/Kg	88.3	U	85.2	U	87.5	U	87
PCB-183	ng/Kg	1870		3170		1570		2203
PCB-184	ng/Kg	38.7	U	37.3	U	38.3	U	38
PCB-185	ng/Kg	0		0		0		0
PCB-186	ng/Kg	47.1	U	45.5	U	46.7	U	46
PCB-187	ng/Kg	3690		6280		3130		4367
PCB-188	ng/Kg	21.8	U	21.1	U	21.6	U	22
PCB-189	ng/Kg	323	U	312	U	320	U	318
PCB-190	ng/Kg	444		752		389		528
PCB-191	ng/Kg	89.4		164		82.9		112
PCB-192	ng/Kg	30.3	U	29.2	U	30	U	30
PCB-193	ng/Kg	0		0		0		0
PCB-194	ng/Kg	1340		2060		1120		1507
PCB-195	ng/Kg	540		749		463		584
PCB-196	ng/Kg	929		1330		717		992
PCB-197	ng/Kg	259		473		220		317
PCB-198	ng/Kg	1930		3640		1550		2373
PCB-199	ng/Kg	0		0		0		0
PCB-200	ng/Kg	0		0		0		0
PCB-201	ng/Kg	227		437		201		288
PCB-202	ng/Kg	318		753		268		446
PCB-203	ng/Kg	1000		1990		849		1280
PCB-204	ng/Kg	30.3	U	29.2	U	30	U	30
PCB-205	ng/Kg	77.3		109		65.8		84
PCB-206	ng/Kg	740		1420		540		900
PCB-207	ng/Kg	94.5		204		69.3		123
PCB-208	ng/Kg	208		407		134		250
PCB-209	ng/Kg	242		215		145		201
Dioxin like congener								

Appendix G : PBDE 2011 Whitaker Slough Sediment between River Mile 0 and 3.2.

PBDE	Unit	IS		A		B		C	
Date		Mean		2/14/2011		2/14/2011		2/14/2011	
Total	ug/kg	53		28		100		30	
Total	ng/Kg	53267		28754		100703		30343	
BDE-1	ng/Kg	275		265	U	210	U	349	U
BDE-2	ng/Kg	158		154	U	121	U	200	U
BDE-3	ng/Kg	117		97.8	U	101	U	151	U
BDE-10	ng/Kg	34		19.8	U	40.6	U	40.9	U
BDE-7	ng/Kg	101		95.9		150		55.6	
BDE-(8/11)	ng/Kg	60		18.1		81.1	U	81.7	U
BDE-11	ng/Kg	34		19.8	U	40.6	U	40.9	U
BDE-12	ng/Kg	34		19.8	U	40.6	U	40.9	U
BDE-15	ng/Kg	23		22.6	B	40.6	U	6.22	B
BDE-30	ng/Kg	34		19.8	U	40.6	U	40.9	U
BDE-32	ng/Kg	49		52.5		66.4		27.1	
BDE-17	ng/Kg	50		60.9		48.3		40.5	
BDE-25	ng/Kg	196		238		235		116	
BDE-(28/33)	ng/Kg	73		112		59.6		46.1	B
BDE-35	ng/Kg	30		9.25		40.6	U	40.9	U
BDE-37	ng/Kg	34		19.8	U	40.6	U	40.9	U
BDE-75	ng/Kg	33		41		16.3		40.9	U
BDE-51	ng/Kg	108		178		98.7		47.3	
BDE-49	ng/Kg	648		865		632		446	
BDE-71	ng/Kg	32		15.9		40.3		40.9	U
BDE-47	ng/Kg	2513		2880		2560		2100	
BDE-79	ng/Kg	47		60.4	U	40.6	U	40.9	U
BDE-66	ng/Kg	145		281		89		65.3	
BDE-77	ng/Kg	34		19.8	U	40.6	U	40.9	U
BDE-100	ng/Kg	774		783		837		701	
BDE-(119/120)	ng/Kg	73		47.8	U	89.9	U	81.7	U
BDE-99	ng/Kg	3453		3730		3480		3150	
BDE-116	ng/Kg	63		50.3	U	89.8	U	48.3	U
BDE-118	ng/Kg	109		202		75	U	49.6	U
BDE-85	ng/Kg	161		222		164		96.9	
BDE-126	ng/Kg	34		19.8	U	40.6	U	40.9	U
BDE-105	ng/Kg	62		57.5	U	78.5	U	50	U
BDE-155	ng/Kg	114		74.1	U	225	U	42.8	U
BDE-154	ng/Kg	356		435		276		357	
BDE-153	ng/Kg	429		651		276		361	
BDE-140	ng/Kg	243		173	U	481	U	76.2	U
BDE-138	ng/Kg	292		208		566	U	102	U
BDE-166	ng/Kg	331		202	U	661	U	130	U
BDE-128	ng/Kg	933		760	U	1730	U	309	U
BDE-183	ng/Kg	503		819		455		236	
BDE-181	ng/Kg	194		120	U	306	U	156	U
BDE-190	ng/Kg	287		173	U	438	U	251	U
BDE-203	ng/Kg	1398		1570		2100	U	523	U
BDE-208	ng/Kg	1190		1200		1260		1110	
BDE-207	ng/Kg	1490		1490		1630		1350	
BDE-206	ng/Kg	2403		2260		2570		2380	
BDE-209	ng/Kg	33513		7940	B	78000		14600	

Whitaker Slough Sediment Screening Levels - (11/1/11)				
Compound	**Source Control Screening Level (mg/kg-dry weight)**		**Sediment Screening Level (mg/kg)**	
	Concentration	Basis	Concentration	Basis
Metals				
Aluminum	NA		NA	
Antimony	4	background	4	background
Arsenic	7	background	7	background
Barium	NA		NA	
Cadmium	1	background	1.0	background
Chromium	42	background	48	baseline
Copper	36	background	45	baseline
Cobalt	NA		NA	
Lead	17	background	74	baseline
Manganese	1100	toxicity	1100	toxicity
Mercury (inorganic)	0.07	background	0.2	toxicity
Selenium	2	background	*	
Silver	4.5	toxicity	4.5	toxicity
Nickel	38	background	38	background
Thallium	0.7	bioaccum	0.7	bioaccum
Zinc	123	toxicity	181	baseline
Polychlorinated Biphenyls				
Aroclor 1248	0.01	MRL	0.010	MRL
Aroclor 1254	0.01	MRL	0.010	MRL
Aroclor 1260	0.01	MRL	0.021	baseline
Pesticides				
alpha-BHC	0.001	MRL	0.001	MRL
beta-BHC	0.001	MRL	0.001	MRL
gamma-BHC	0.0009	toxicity	0.009	toxicity
delta-BHC	NA			
DDD	0.001	MRL	0.0045	baseline
DDE	0.001	MRL	0.007	baseline
DDT	0.001	MRL	0.0010	baseline
Endosulfan	0.35	bioaccum	0.35	bioaccum
Endrin Aldehyde	0.003	toxicity	0.003	toxicity
Aldrin	0.001	MRL	0.001	MRL
Chlordane	0.001	MRL	0.005	baseline
Dieldrin	0.001	MRL	0.001	baseline
Heptachlor	0.001	MRL	0.001	MRL
Semivolatile Organics				
2-Methylnaphthalene	0.02	toxicity	0.02	toxicity
Acenaphthene	0.29	toxicity	0.29	toxicity
Acenaphthylene	0.16	toxicity	0.16	toxicity
Anthracene	0.057	toxicity	0.057	toxicity
Benzo(a)anthracene	0.032	toxicity	0.032	toxicity
Benzo(a)pyrene	0.032	toxicity	0.04	baseline
Benzo(b)fluoranthene	NA		0.043	baseline
Benzo(g,h,i)perylene	0.3	toxicity	0.3	toxicity
Benzo(k)fluoranthene	0.03	toxicity	0.037	baseline
Bis(2-ethylhexyl)phthal	0.75	toxicity	0.750	toxicity
Chrysene	0.057	toxicity	0.057	toxicity
Dibenzo(a,h)anthracen	0.06	toxicity	0.06	toxicity
Dibenzofuran	5.1	toxicity	5.1	toxicity
Fluoranthene	0.111	toxicity	0.111	toxicity
Fluorene	0.077	toxicity	0.077	toxicity
Indeno(1,2,3-cd)pyren	0.017	toxicity	0.032	baseline
Naphthalene	0.176	toxicity	0.176	toxicity
Phenanthrene	0.042	toxicity	0.04	toxicity
Phenol	0.048	toxicity	0.048	toxicity
4-methylphenol	NA		NA	
Pyrene	1.9	CTL	1.9	CTL
Pentachlorophenol	0.1	bioaccum	0.1	bioaccum

*** - Selenium should be screened using site-specific concentrations as per DEQ 2006 (bioaccumulation guidance)**

N/A - Not Available

Red text- updated values

Appendix I: Modeling of Benthic Toxicity and Chemistry

Evaluation of Potential Causes of Toxicity

As part of this investigation an attempt was made to determine if it might be possible to relate the observed toxicity results to the measured analytical chemistry. It is recognized that relating bulk sediment toxicity to sediment chemistry can be very challenging and complex, due to a number of factors. The most common approach to predict sediment toxicity is to compare individual analyte results to chemical specific sediment quality guidelines (Ecology 2003). However, the use of numeric sediment quality guidelines is subject to a high degree of uncertainty, and the relationship between total chemical concentrations and benthic toxicity is poorly understood (USACOE 2009). The principle complexities that complicate such an assessment are the variable physical and chemical mixtures that occur in the sediment environment, including differences in important factors such as sediment matrix (e.g., grain size) and organic carbon as well as other factors that may relate to the availability of any substance for uptake- and subsequent toxic potential to benthic organisms. In this investigation, ten bioassay samples were collected. Given the complexities of the sediment environment, it is not expected that a data set this small would allow clear resolution to these challenging questions. Nevertheless, exploratory modeling was attempted with the general goal whether any general patterns could be observed and whether the methods used could be applicable to this type of problem.

The methods attempted were general pattern recognition techniques including hierarchical cluster analysis (HCA) and principle components analysis (PCA). Subsequently, multivariate regression methods were attempted-principle components regression (PCR), and partial least squares regression (PLS). Details on these methods are presented elsewhere and are not discussed here (Geladi and Kowalski, 1986; Garthwaite 1994; Frank and Friedman 1993; Hoskuldsson 1988; Abdi 2007; Mevik and Wehrens 2007). After initial exploratory analysis, we determined that the ten available samples contained substantial heterogeneity. As such, they do not represent a data set for which regression-based prediction methods are likely to be successful. Nevertheless, regressions were attempted and some general observations are made. A more complete assessment of the utility of these methods in this application will require use of a much larger data set encompassing a range of environmental variability.

Univariate Exploratory Analysis

Initial graphical evaluation was performed to understand if there might be a correlation between any of the measured toxicity endpoints in relation to each other or any of the individual chemical constituents in sediment. Several of the growth and mortality endpoints are correlated. In particular, as mortality increases in each test species, the growth (i.e., biomass) in the same species decreases- an intuitive result. However, between the two test species the growth endpoints are not correlated, nor are the growth endpoints correlated to the mortality endpoints.

Mortality is correlated between species, but the relation is tenuous and somewhat speculative, and is heavily influenced by a single data point. Figure 1 presents a scatterplot showing the relation between *Chironomus* and *Hyalella* mortality endpoints (p =0.03).

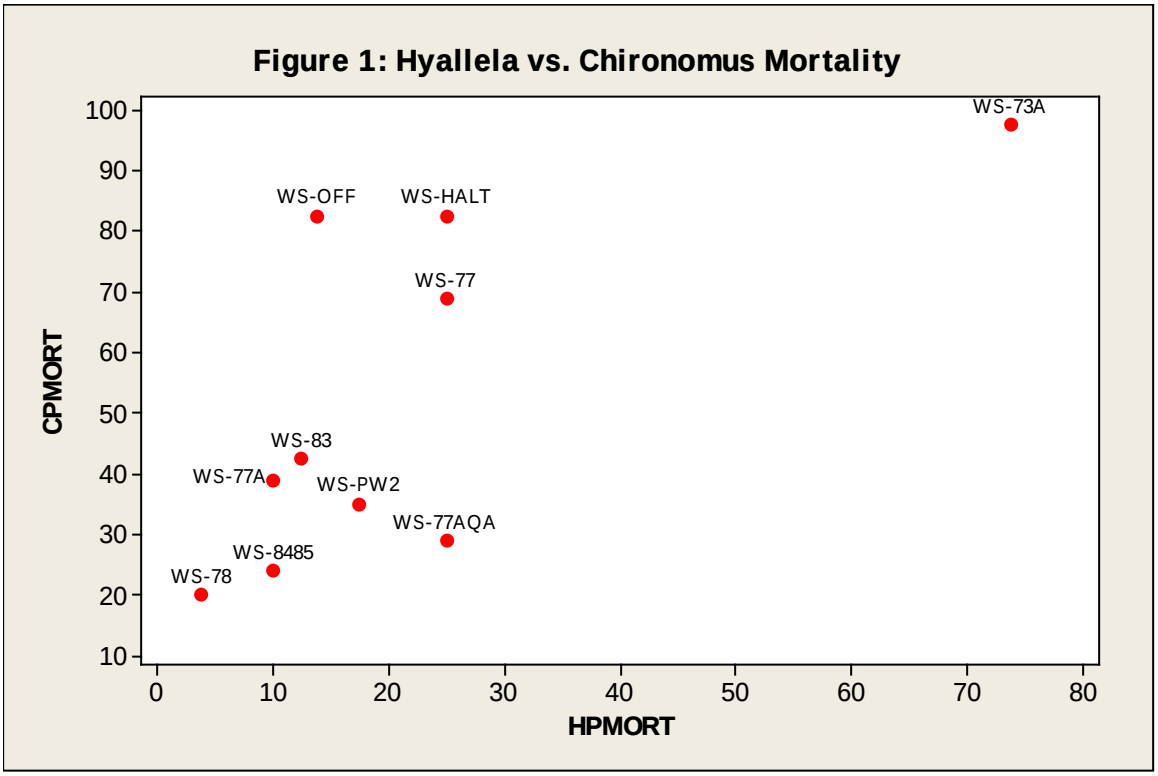

Figure 1: Mean percent mortality between *Hyallela* (HPMORT) and *Chironomus (CPMORT)*

Similar correlations between individual analytes and the bioassay endpoints were attempted, but individual correlations were generally poor with a few exceptions. Scatterplots of two of the more meaningful correlations are shown in Figures 2and 3, which show the relation between zinc, oil and grease and *Chironomus* mortality. A similar relationship to that shown for oil and grease also occurs for diesel fuel. The observation that both oil and grease and diesel have some relation to toxicity suggests that the petroleum methods are detecting petroleum fractions not measured by traditional PAH analysis that have some influence on sediment toxicity.

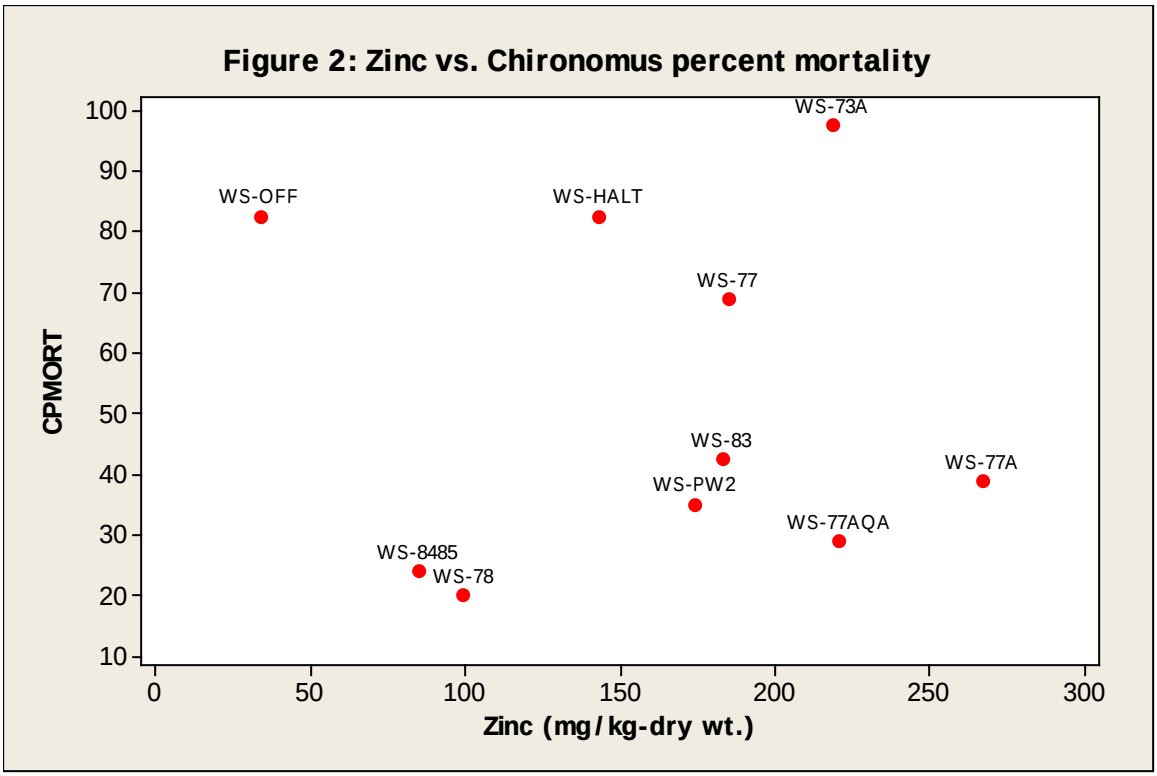

Figure 2: Zinc concentration vs. *chironomus* mean percent mortality (CPMORT).

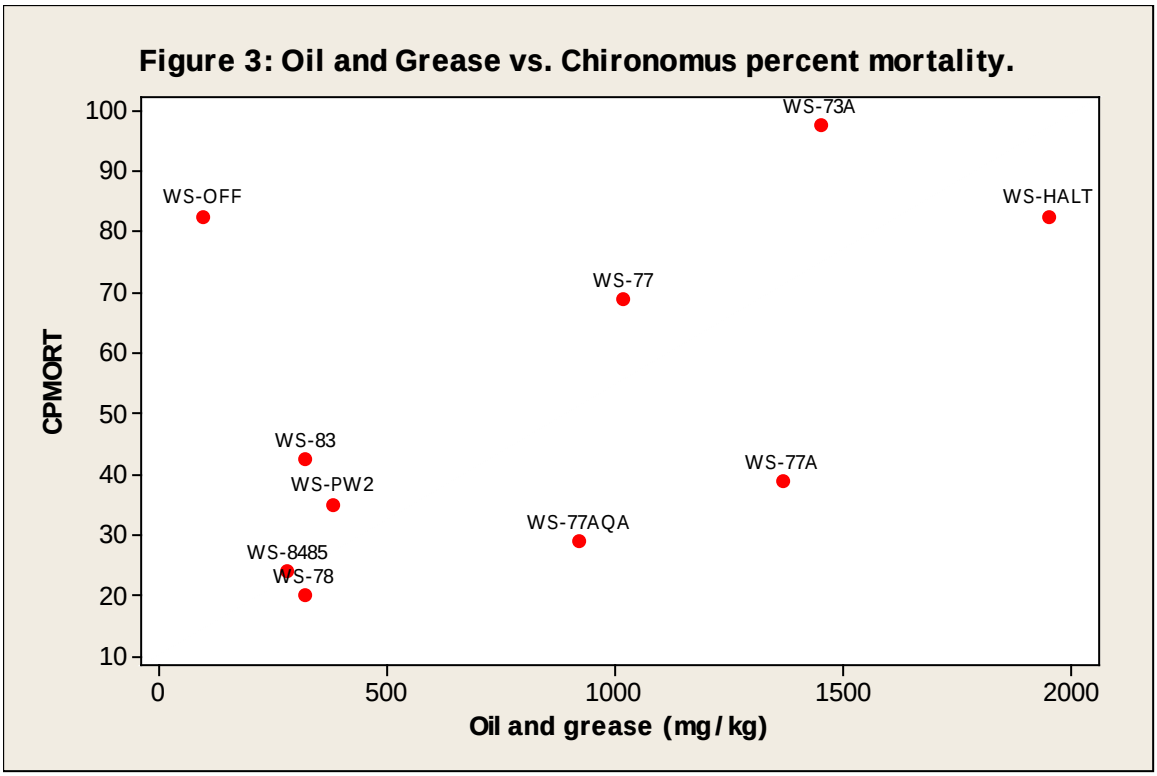

Figure 3: Oil and grease concentration vs. *chironomus* mean percent mortality (CPMORT).

While a small number of individual analytes suggest possible relationships with the toxicity endpoints observed (Figures 2-3), no reliable quantitative correlation can be established that would be able to predict or estimate toxicity in an unknown sample based on analytical chemistry. Because we suspect that toxicity is related to multiple factors in the complex mixtures occurring in sediment, the data were further considered using multivariate approaches.

Introduction to Multivariate Analysis

Multivariate methods may be broadly categorized into groups of methods used for similar objectives. Three common goals of multivariate analysis are exploratory analysis, sometimes referred to as pattern recognition, classification and prediction. Often exploratory analysis will be performed alone as a means of better understanding distinctions within a data set, and is usually performed as a preliminary step to further evaluate the data prior to using other methods for classification and prediction. For the Whitaker slough bioassays and chemistry data, exploratory data analysis was performed followed by a prediction method. The objective of this analysis was to determine if it may be possible to predict the toxicity observed using all analytes in combination. Further, no attempt was made to classify the samples into a binary toxic or non-toxic category for prediction. Rather, the full range of variability within the percent response variable was used to maximize the information available to the regression algorithm.

Multivariate Exploratory Analysis Results

In order to explore which analytes and conventional parameters might be useful in the modeling and consider patterns present in the analytical chemistry data, exploratory analysis was performed using two complementary methods: principle components analysis (PCA) and hierarchical cluster analysis (HCA). The results from these two methods both indicate that the samples separate or "cluster" into three distinct groups as shown in Table 7 of the main report. Graphical depictions of these clusters are also shown in Figures 4 (HCA), and 5 (PCA).

Both of these methods identify samples WS-OFF and WS 84/85 as extreme values that may be multivariate outliers. These two samples are relatively chemically distinct from other samples with respect to grain size (WS-OFF) and PAHs (WS-84/85). The remaining samples can be grouped into two clusters. The first cluster, shown as brown in Figure 4 and 5 contains samples WS-PW2, WS-77a, WS -77QA and WS-HALT. The second cluster, shown in red, contains samples WS-OF 77 WS-73A and WS-78 and WS-83.

Overall, figures 4 and 5 suggest that the sediment samples can be classified into two groups based on the analytical chemistry. Unfortunately, no obvious relation to toxicity outcomes is apparent (Table 7). Therefore, while the samples can apparently be characterized based on chemistry, the toxicity is not clearly predictable based on these categories.

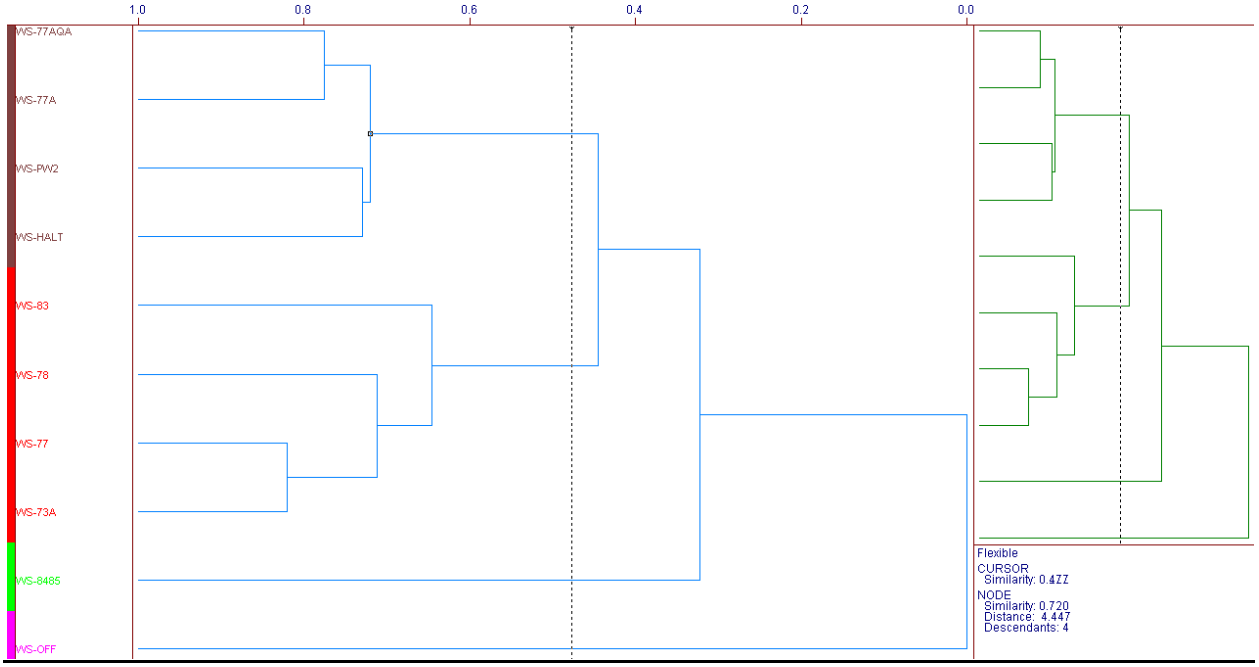

Figure 4: Hierarchical cluster analysis dendrogram of bioassay sample bulk chemistry.

Note: The HCA dendrogram graphically depicts categorical similarity in the chemistry of the samples, based on the variance of all analytes. Here the two major groupings are shown, color coded as brown, and red. The other two samples are unique differ from other samples.

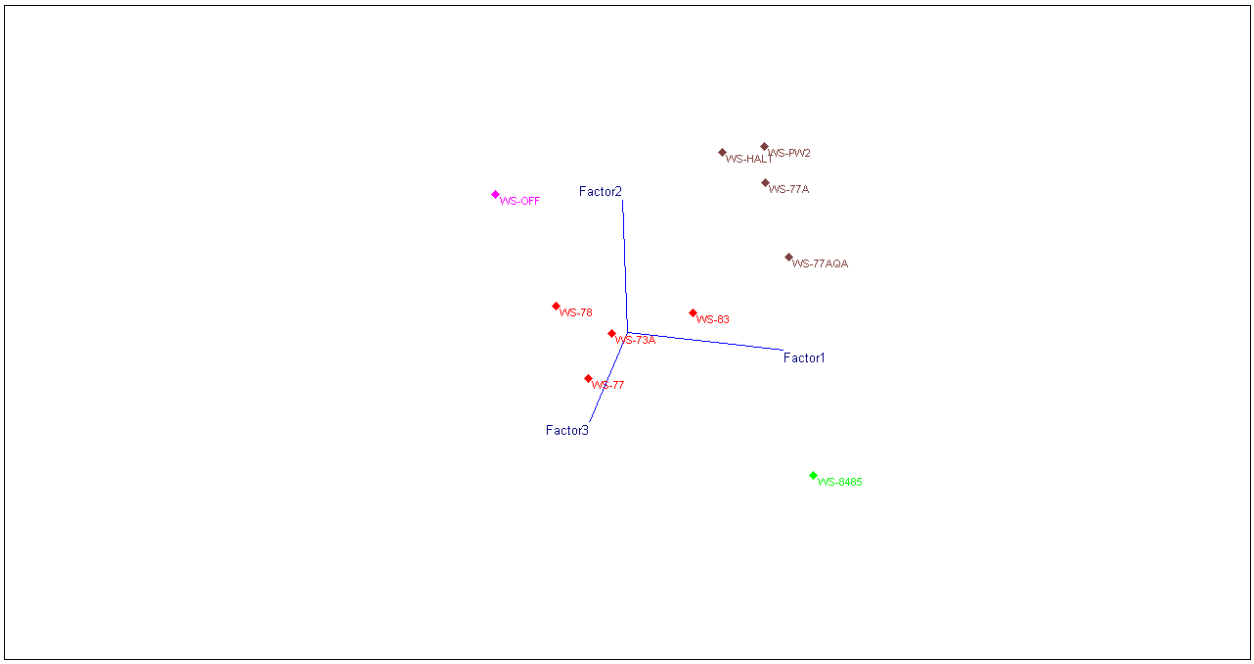

Figure 5: Principle components score plot of bioassay sample bulk chemistry.

Note: The PCA score plot graphically depicts categorical similarity in the chemistry of the samples, based on the variance of all analytes in multi-dimensional space. Here the two major groupings are shown, color coded as brown, and red. The other two samples are unique and dis-similar from the other samples. The axes, labeled as "factors" are the principle components. Mathematically, they are termed eigenvectors and have no units. They provide the reference to which the multidimensional sample scores may be plotted.

Multivariate Modeling Methods

The results from exploratory analysis were used to understand patterns in the chemical data and identify which chemical and physical parameters might be related to observed toxicity. The results of the exploratory analysis do suggest that the chemistry of samples can be organized in groups, which do not present any clearly obvious relation to toxicity. Moreover, the heterogeneity of these sample groupings are not ideally suited to regression-based prediction methods. This problem notwithstanding, some preliminary plots were made with the goal of determining if any general observations may be made. The multivariate prediction methods were selected because they have the following characteristics that make them candidates for use in this situation:

1) They can use multiple chemical analytes to predict a single, difficult to measure response variable (e.g., toxicity);
2) They can handle predictor variables that are correlated (i.e., the chemical analytes);
3) They tend to be effective on relatively small sample sizes.

There are several published methods for which commercial and free software are available. The two most commonly cited methods are known as principle components regression (PCR) and

partial least squares regression (PLS). Both methods are conceptually similar. For this work, both the PCR and PLS methods were compared, and found to provide similar results. PLS methods are reported to derive similar results with fewer components because the method accounts for variation in the variable to be predicted, not just the predictor variables. Essentially, the methods are factor-based and use matrix algebra to reduce the measured analytes to a smaller number of linear combinations that explain most of the variation in the original variables (PCR) or most of the covariance between the measured variables and the response variable (PLS). The components or factors so derived are then used in regression modeling to predict the responses from the derived linear components.

Data Preprocessing

In order to develop the most informative model, several steps were required to process the data. First, only those measured parameters that were detected were used. In some cases, non-detects were estimated using US EPA ProUCL software for select polycyclic aromatic hydrocarbons (PAHs). Secondly, because the methods used are variance-based, all analytes had to be put on a similar scale, so no one or few analytes would dominate the results. This was done by autoscaling, also known as standardization. This involves subtraction of the mean concentration from each result and dividing by the standard deviation. Lastly, in order to address extreme values, the standardized analytical data were log-transformed. These data were then used in the PCA and HCA exploratory analyses, as well as the subsequent prediction methods.

Normalization and Model Parameters

Because organic carbon and percent fines may have a bearing on the mass of contaminants that could be bioaccessible for uptake by benthic invertebrates, different models were attempted normalizing the contaminant concentrations separately by total organic carbon (TOC) and percent fines, defined as the sum of clay and silt. In both cases, the modified models offered no significant improvements in model fits over a model applied with no normalization. In addition, TOC was found not to be an important predictor of bioassay toxic response. In the final model, fines were retained as a separate parameter as the proportion of clay and silt. The final model used the following predictor variables:

2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, fluoranthene, fluorene, indeno(1,2,3-c,d)pyrene, dibenzo(a,h)anthracene, chrysene, arsenic, chromium, copper, clay, gravel, percent Moisture, diesel fuel, lead, mercury, naphthalene, nickel, oil and grease, organic carbon, sand, silt, zinc, and manganese.

Regression Analysis Results

Regressions were performed using cross-validation. In the cross-validation mode, the model run using all samples is compared (internal to the software) to other model runs with one sample

removed. This is done in sequence until many different versions of the model have been run, each with a different sample "left out". The left out samples are predicted and compared to the actual observations. This procedure is a form of internal validation, which can be used to approximate a model validation in the absence of a separate data set not used in model development that could be used to validate or verify the accuracy of model predictions.

Overall, results of the PLS analysis suggest that a predictive relationship between sediment chemistry and bioassay response may be possible. The model fits tend in the right direction but overall are generally poor. The three model fits for each of the four endpoints are illustrated in figures 6-9 which show plots of measured versus predicted response with a regression line through the data points. Figure 6 through 9 are for *Hyallela* biomass , *Chironomus* mortality, *Chironomus* biomass, and *Hyallela* mortality respectively. The samples are color coded in the graphics according to the categories assigned in the multivariate analyses. The *Chironomus* endpoints may be somewhat better fit to the "brown" cluster: WS-PW2, WS-77a, WS -77QA and WS-HALT, and these samples tended to have relatively higher metals concentrations. However, this interpretation is somewhat speculative.

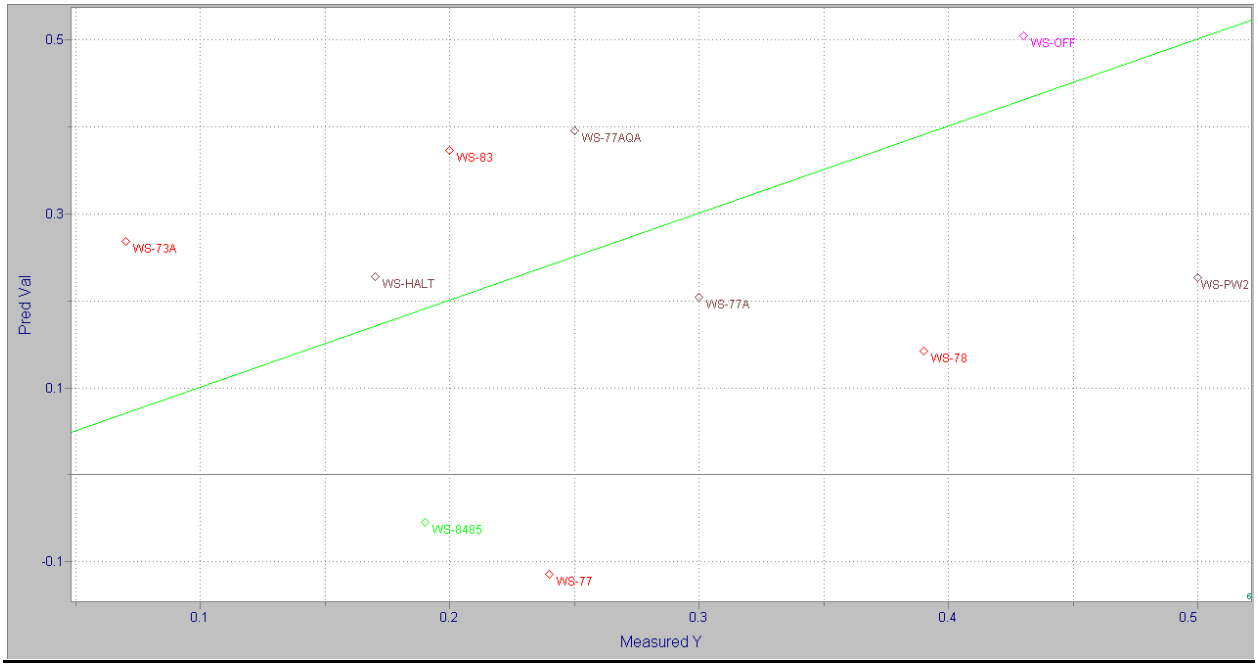

Figure 6: PLS Regression fit of mean *Hyallela* growth.

Note: Figure 6 depicts the relation between mean Hyallella growth (Measured Y) to cross-validated model predicted Hyallela growth in the same sample. A perfect fit would be indicated by samples occurring on the green line. A general trend is indicated but model fit and prediction accuracy is poor.

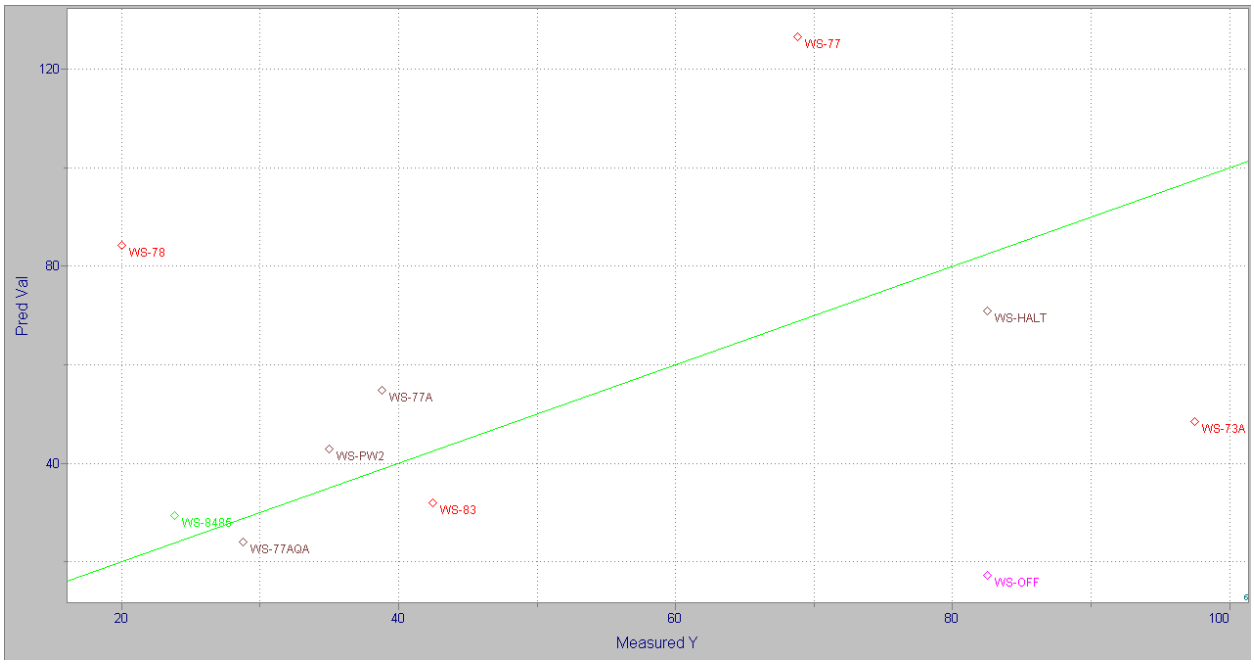

Figure 7: PLS Regression fit of mean *Chironomus* Mortality.

Note: Figure 7 depicts the relation between mean Chironomus mortality (Measured Y) to cross-validated model predicted Chironomus mortality in the same sample. A perfect fit would be indicated by samples occurring on the green line. A general trend is indicated but model fit and prediction accuracy is poor.

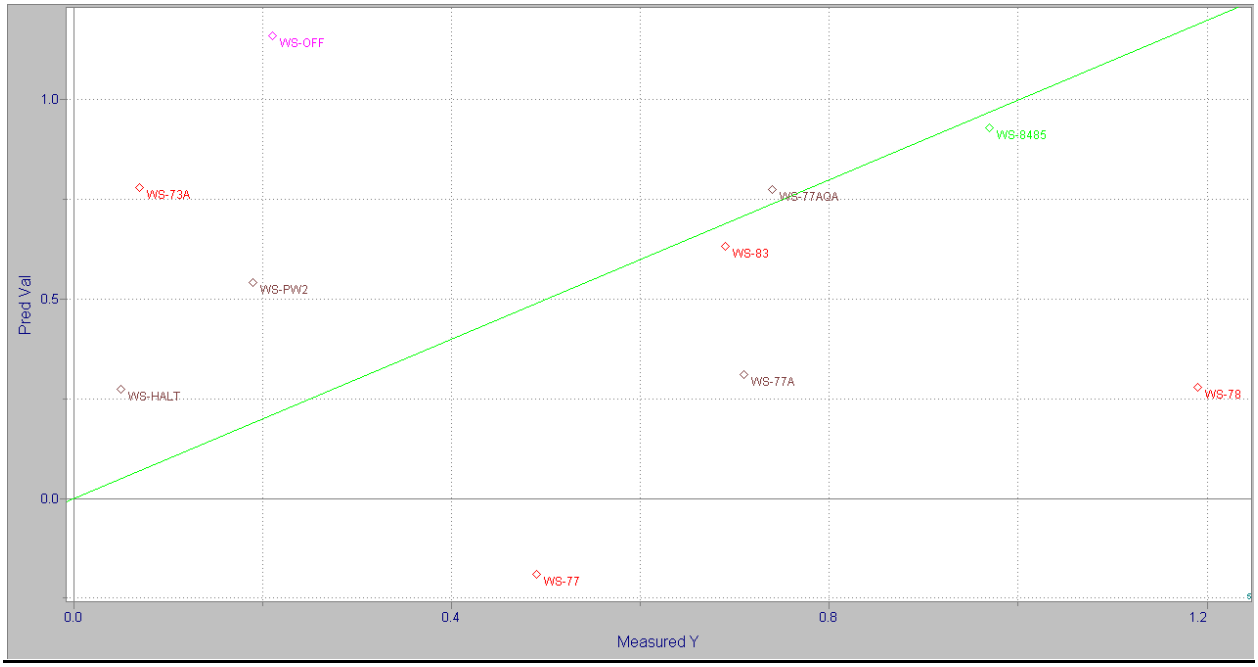

Figure 8: PLS Regression fit of mean *Chironomus* Growth.

Note: Figure 8 depicts the relation between mean Chironomus growth (Measured Y) to cross-validated model predicted Chironomus growth in the same sample. A perfect fit would be indicated by samples occurring on the green line. A general trend is indicated but model fit and prediction accuracy is poor.

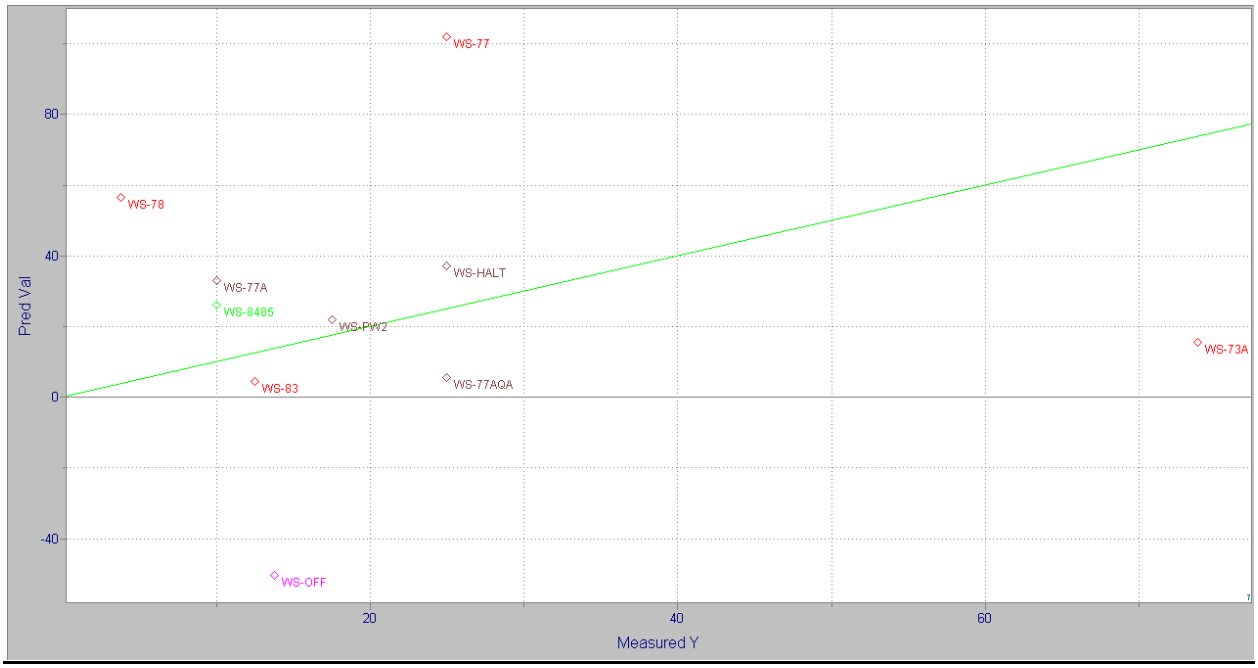

Figure 9: PLS Regression fit of mean *Hyallella* Mortality.

Note: Figure 9 depicts the relation between mean Hyallella mortality (Measured Y) to cross-validated model predicted Hyallella mortality in the same sample. A perfect fit would be indicated by samples occurring on the green line. Data do not fit the model.

Conclusions

Overall, the findings of the bioassays and multivariate analysis for associated analytical chemistry indicate that:

1) The longer-term chronic bioassays appear to be more sensitive than the corresponding acute tests with a significant proportion of the samples having been identified as toxic. The *Chironomus* tests appear to be more sensitive than the *Hyallella*. However, the reason for the measurable *Chironomus* mortality in most samples is unclear and in some samples the result is not consistent with the *Hyallela*.

2) The toxicity in *Hyallela*, and in some samples the *Chironomus*, appears to be related to a mixture of sediment contaminants, but is not predictable by any individual contaminant.

3) Petroleum fractions not commonly measured in sediment investigation (oil and grease, diesel) appear to be related to sediment toxicity, while the commonly measured PAHs do not appear to be related to toxicity.

4) Multivariate modeling approaches appear to adequately classify sediment samples according to chemistry, but cannot adequately predict toxicity in this data set. Our hypothesis is that the data set is too small to adequately capture what appears to be substantial heterogeneity in the samples. Additional work on more comprehensive data sets would be required to assess the utility of this approach for predicting sediment toxicity.

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