FINAL

SEDIMENT RECONTAMINATION ANALYSIS APPROACH

TERMINAL 4 REMOVAL ACTION

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1.0 INTRODUCTION

In 2003, the Port of Portland ("the Port") entered into an Administrative Order of Consent (AOC) with the USEPA to conduct a Non-Time Critical Removal Action (NTCRA) at Terminal 4 to address contaminated sediment.

Under the AOC, the Port conducted an Engineering Evaluation and Cost Analysis (EE/CA) for the Removal Action. The Removal Action objectives (RAOs), as stated in the EE/CA Workplan (BBL, 2004) include:

- reducing the ecological and human health risks associated with sediment contamination within the Removal Action Area to acceptable levels; and
- limiting the likelihood of recontamination of sediments within the Removal Action Area.

The second RAO established in the EE/CA Workplan is "to limit the likelihood of recontamination of sediments within the Removal Action Area". Specifically, the Recontamination Analysis will be the first step in assessing the progress of meeting this objective.

This document describes the proposed approach to assess the potential for recontamination of sediment in the Removal Action Area after actions have been implemented. The recontamination analysis is planned to be completed as part of the final remedy design for Terminal 4, which will be scheduled after the Portland Harbor-wide Record of Decision (ROD).

1.1 Site Description and Project History

The Port owns the Terminal 4 uplands between River Miles (RMs) 4.1 and 4.5 on the Lower Willamette River. The Port acquired Terminal 4 from the City of Portland (City) Commission of Public Docks in 1971. The Port also currently owns a portion of the submersible and submerged lands in Slip 1 and Slip 3 located within the RAA (defined below). The remainder of the submersible or submerged land is owned by the State of Oregon and managed by the Oregon Department of State Lands (DSL).

The Terminal 4 facility itself is within or adjacent to the Portland Harbor Superfund Site. The RAA is defined in the AOC as "that portion of the site adjacent to and within the Port of Portland's Terminal 4 at 11040 North Lombard, Portland, Multnomah County, Oregon, extending west from the ordinary high water line on the northeast bank of the Lower Willamette River to the edge of the navigation channel, and extending south from the

downstream end of Berth 414 to the downstream end of Berth 401, including Slip 1, Slip 3, and Wheeler Bay."

Per the AOC, the Port submitted an Engineering Evaluation/Cost Analysis (EE/CA) in 2005 (BBL, 2005a). The EE/CA had a placeholder for Appendix N, the recontamination analysis. The Draft Appendix N/Recontamination Analysis (BBL/Arcadis, 2006) was submitted to EPA in November 2006. The Draft Recontamination Analysis provided the initial analysis approach to support the design. The document also identified stormwater data gaps that would need to be filled to support the final analysis. In December 2006, EPA submitted comments to the Port regarding the Draft Recontamination Analysis. The Port made several recommendations to EPA in a letter sent January 24, 2007. Among those recommendations were:

1) Complete the field work to collect additional data identified in Section 6 of the Draft Recontamination Analysis in concert with the EPA/DEQ/LWG stormwater technical group that was designing the RI stormwater sampling program;

2) Update the mass loading evaluation with the new data, incorporating the decisions regarding technical process and procedures made in the LWG technical group into the methodology;

3) Submit a revised Recontamination Analysis Report.

The field work for additional data (discussed above in item #1) was conducted in 2007 and 2008. The data collected from 2007 through 2008 was submitted to EPA and DEQ in two ways: (1) all of the data collected by the Port related to the Terminal 4 recontamination analysis, including the City outfalls, was provided to LWG and LWG reported it to EPA and DEQ in the Round 3A and 3B Upland Stormwater Sampling Data Report (LWG, 2008); and (2) The data specific to Terminal 4 USC was submitted to DEQ (with a copy to EPA) in the Final Stormwater Data Summary Report Terminal 4 Slip 1 and Slip 3 Upland Facilities (ACA/Newfields, 2009).

In addition, the Removal Action project was split into two phases in 2007. The Port implemented Phase I of the Removal Action during the 2008 in-water work window. Phase II includes completion of the recontamination analysis and has not been initiated. This report describes the recontamination analysis approach, and provides an example of analysis for one chemical of concern (lead, see Section 4.).

1.2 Description of the Removal Action

The location and main features of Terminal 4 are shown in Figure 1-1.

Figure 1-1: Location and main features of the Terminal 4 Removal Action Area.

The selected removal action was outlined in an Action Memorandum in 2006 (EPA, 2006). As described above, the action is being implemented in phases, in order to align the Terminal 4 Removal Action design and construction with the Portland Harbor-wide Remedial Investigation and Feasibility Study (RI/FS) and ROD. The schedule realignment was proposed in a letter to EPA in August, 2007. The Port also prepared an Abatement Measures Proposal (October 2007), detailing the specific tasks that could be performed in an initial phase to significantly reduce "imminent health and ecological risks" at Terminal 4 (Anchor, 2007). EPA approved the schedule realignment in November, 2007 on the condition that the abatement measures were carried out. Therefore, a Phase I plan was designed and implemented in 2008. Phase I included dredging of three areas showing the highest contaminant concentrations in Terminal 4; adjacent Berth 411, adjacent Pier 5 and north of Berth 414 (former Berth 413). Dredging was also completed adjacent to Berth 410 in Slip 3 in support of water-dependent maritime use. Dredged material was disposed of off-site. A cap was placed at the head of Slip 3 and the shoreline at Wheeler Bay was stabilized and capped to prevent migration of contaminants to the river (Anchor QEA, Ash Creek Associates and Hickey Marine Enterprises, 2009).

The remaining areas of Terminal 4 will be addressed by the Phase II Removal Action, which will proceed based on coordination with the harbor-wide RI/FS and ROD schedule. Phase II of the plan anticipates additional dredging and capping within Slip 3,

additional dredging and capping north of Berth 414 (former Berth 413), additional capping in Wheeler Bay, and capping adjacent to Berth 401 (see Figure 1-2). Phase II also includes the construction of a confined disposal facility (CDF) in Slip 1 and monitored natural recovery (MNR) of the remaining areas. The status of the Phase II Design as of May 2009 is outlined in the draft Design Status Report (Anchor QEA and NewFields, 2009).

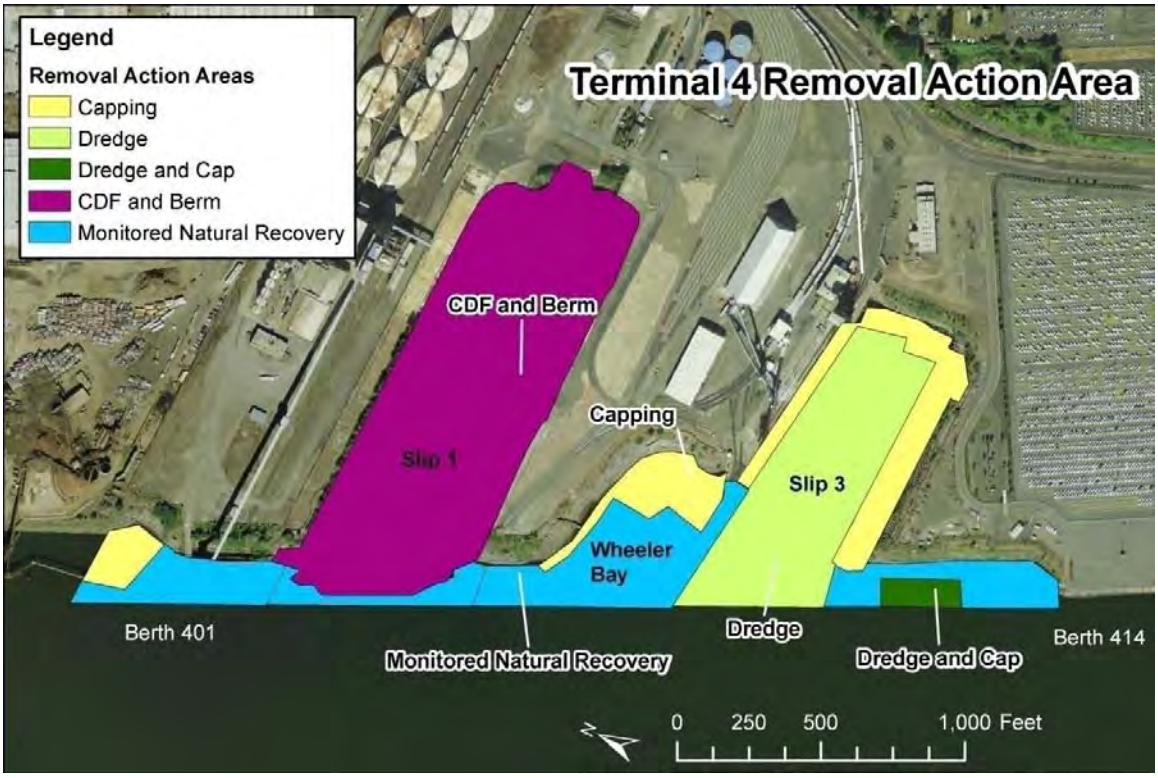


Figure 1-2: Phase II Removal Action Areas (adapted from Anchor QEA and NewFields, 2009).

1.3 Purpose of Recontamination Analysis and Approach

The purpose of this document is to outline the methodology that will be used to assess recontamination potential of sediment in the Terminal 4 Removal Action Area after the removal actions have been implemented. Data gaps that need to be addressed prior to completing the analysis are also reviewed. Comments pertaining to the Draft Recontamination Analysis conducted by BBL/Arcadis in 2006 have been considered and incorporated into the new Recontamination Analysis approach. This document presents the data, methods, and equations to be used in calculations. In addition, an example calculation of recontamination potential is presented for one chemical of interest (COI) and one portion of the Removal Action Area. This calculation is not meant to be a final analysis; rather it is presented to demonstrate the methodology. A final analysis of

recontamination potential for all COIs and the entire Removal Action Area will be presented in the Recontamination Analysis.

1.4 Defining Recontamination

Recontamination is significant if concentrations on the remediated surfaces (e.g., dredged area, caps, and MNR areas) exceed the cleanup goals that are identified in the Harborwide RI/FS process. The final cleanup goals for sediments will be established as a result of the Harborwide Record of Decision (ROD). In the interim, preliminary remediation goals (PRGs) or "hilltopping" values provide the target concentrations for analysis of the recontamination. Hilltopping values are established for bioaccumulative COIs and represent the concentrations that are to be addressed with active remedies in order to reduce average concentrations for a river segment to acceptable levels based on risk to humans and ecological receptors.

In the context of the Recontamination Analysis, the following decision criteria will be addressed:

- If concentrations in surface sediment are predicted to decrease from the initial post-construction value, then recontamination will not occur.
- If concentrations are predicted to increase, then the effectiveness of the source control action(s) will be assessed against cleanup goals to determine if additional action could be necessary.

1.5 Report Structure

Section 2 of this report reviews the site conceptual model, including the removal action, the COIs, and identification of potential sources of recontamination. Section 3 describes the overall methodology for recontamination assessment, including the mathematical model SEDCAM (Jacobs et al., 1988), the model inputs, the primary data sources to be used in the analysis, equations, uncertainties, and data gaps. Finally, Section 4 includes an example application of the described methodology for one COI and one subarea of the Terminal 4 Removal Action Area.

2.0 CONCEPTUAL SITE MODEL

The conceptual site model is described in the following sections. The main pertinent features are the areas of concern (Removal Action Areas), COIs, the potential sources of sediment, and the potential sources of COIs to the sediment.

2.1 Removal Action Area

The Removal Action chosen for Terminal 4 consists of a combination of MNR, capping and dredging, with dredged material being disposed of in a CDF to be built on site (Anchor QEA and NewFields, 2009). Multiple areas of planned MNR, capping and dredging occur in the Removal Action Area. In order to evaluate recontamination, areas affected by different removal actions will be evaluated separately. For example, the post-Removal Action concentration of a particular COI in surface sediment will be different in a capped area than in an area that was dredged. Post-Removal Action concentrations will be generated after Phase II of the Removal Action is complete. The Removal Action Area will be subdivided into nine subareas for the Recontamination Analysis, as shown in Figure 2-1.

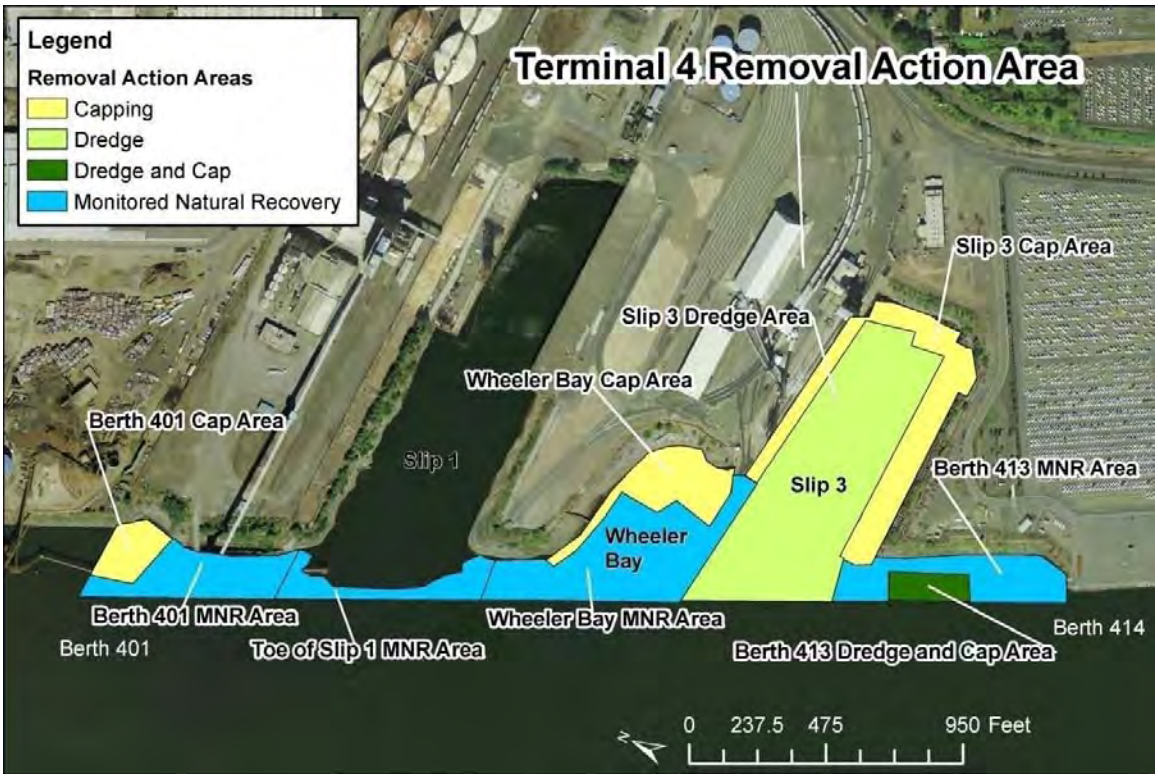


Figure 2-1: Phase II Removal Action sub-areas.

Three areas will be unaffected (MNR), three areas will be capped, one area will be dredged, one area will be dredged and capped, and one area will be converted into a CDF. These subareas are listed in Table 2-1 with their respective areas in square feet.

Table 2-1: Removal Action subareas and their approximate areas in square feet.

Removal Action Subarea	Approximate Area (sq ft)
1 – Berth 413 MNR Area	95,000
2 – Berth 413 Dredge and Cap Area	30,000
3 – Slip 3 Cap Area	165,000
4 – Slip 3 Dredge Area	385,000
5 – Wheeler Bay Cap Area	85,000
6 – Wheeler Bay MNR Area	195,000
7 – Toe of Slip 1 MNR Area	55,000
8 – Berth 401 MNR Area	90,000
9 – Berth 401 Cap Area	40,000

The subareas were delineated based on their different planned actions and their locations relative to potential sources of sediment recontamination (i.e. stormwater outfalls or river influence). All areas will be considered in the Recontamination Analysis, except Slip 1. The design plan for Slip 1 consists of converting it into a CDF to contain dredged material from other areas of Terminal 4 and Portland Harbor.

2.2 Identification of COIs

The COIs that will be considered for the Removal Action Area at Terminal 4 include:

- Benzo(a)pyrene
- Benzo(a)anthracene
- Dibenzo(a,h)anthracene
- Pyrene
- Indo(1,2,3)pyrene
- Cadmium
- Lead
- Total PCBs

These chemicals were identified in the Remedial Investigation and risk assessments as the primary chemicals driving risk in Terminal 4 (LWG, 2009).

2.3 Screening of potential sources

Potential sources of COIs to the Terminal 4 Removal Action Area sediments have been identified as follows:

- upstream suspended sediment,
- stormwater outfalls,
- groundwater,
- bank erosion,
- overland flow,
- existing structures,
- sediment resuspension, and
- atmospheric sources.

These are discussed in more detail in the following subsections.

Upstream Suspended Sediment

Sediment is transported in the river, either in suspended form or as bed load. In general terms, the Willamette River is relatively low energy in the Superfund Site study area and tends to accumulate sediment over time (LWG, 2009). There are various sources of sediment and COIs upstream of Terminal 4. The total effect of these has been characterized by the RI in-river sediment sampling. This potential COI source will be evaluated in the recontamination analysis.

COIs for sediment at Terminal 4 are naturally hydrophobic, causing the majority of the mass to be sorbed to sediment rather than in dissolved phase. Partitioning coefficients between the solid and dissolved phases range from 2.7 to 17,000 L/kg for cadmium, and from 1,500 to 79,000 L/kg for lead, indicating a strong preference for sorption to solids.

Partitioning of organic compounds between sediment and water is represented by their partitioning behavior between organic carbon and water (K_{oc}), for sediment with organic carbon fractions greater than 0.001. High K_{oc} values indicate a strong preference for sorption to the organic carbon fraction. Calculated K_{oc} values for the T4 COIs are shown in Table 2-2.

Table 2-2: Partitioning coefficients for organic COIs (EPA, 2006).

Organic COIs	Calculated Koc
Benzo(a)pyrene	1.02E+06
Benzo(a)anthracene	3.98E+05
Dibenzo(a,h)anthracene	3.80E+06
Pyrene	1.05E+05
Indo(1,2,3)pyrene	3.47E+06
Total PCBs	3.09E+05

Organic compounds sorb strongly to organic carbon, and their adsorption to inorganic solids only becomes important at organic carbon fractions less than 0.001. Organic carbon fractions for stormwater sediment at T4 range from 0.0298 - 0.13 (Winter 2008). Sediment traps within Slips 1 and 3 or near the Toyota Dolphin facility have organic carbon fractions between 0.0206 and 0.038 (Spring 2004). Surface sediment in the T4 area has organic carbon fractions ranging from 0.0004 to 0.0472 (from 1997 to 2007). The mean organic carbon in surface sediments is 0.0166 (for 134 samples). TOC in the mid-Willamette sediment trap was 0.0348 in March 2005. Sediment from in-water traps suggests that the partitioning behavior of the organic compounds can be adequately represented by considering only their sorption to organic carbon.

COIs are primarily sorbed to solids not only at the site, but also upstream. As long as sufficient organic carbon is available upstream, transport of COIs from upstream to the site will occur by transport of suspended sediment rather than the dissolved constituents in water. TOC fractions at upriver sediment traps, including the Toyota Dolphin and mid-Willamette traps, range from 0.0206 to 0.0348 in 2004 through 2005. Surface water chemistry from three upstream sites (from river mile 5.5 to 5.7) taken in 2006 and 2007 confirm that minimal amounts of COIs are dissolved in water upstream. For example, all COIs were found to be below the detection limit, except lead, for which concentrations in filtered surface water samples were approximately 10% of total concentrations.

Further, concentrations on stormwater and upstream river suspended sediments are generally lower than on sediments subject to consideration of remedial actions. This is because historical sources that contributed to current sediment conditions generally had higher concentrations than are present today. Therefore desorption of COIs from suspended sediments in stormwater or in the upstream river to the dissolved phase is possible. However, once in the dissolved phase, the concentration gradient between bed sediment and dissolved phase is always from sediment to water and net transport to the sediments is not possible.

Based on the above explanation, dissolved phase COI concentrations will not be carried forward in the recontamination analysis.

The Draft RI found that while bedload transport may help disperse COIs to nearfield areas, it is not a major contributor of COIs to downstream locations in the Portland Harbor study area compared to suspended sediment loads (LWG, 2009). Additionally, data collected during the EE/CA showed that there were only minimal river-induced currents within the slips of Terminal 4 (BBL, 2005a). Outside slips, such as in Wheeler Bay and downriver, river velocities are approximately 0.5 ft/sec (Appendix G of BBL, 2005a). Whereas in these areas, bedload may be a contributor to sediment transport, bedload particle sizes are larger than the fine-grained suspended sediment that is collected in sediment traps. Since partitioning coefficients for organics and metals suggest that COIs will preferentially sorb to organic material or fine-grained clay particles, the majority of sorbed COI mass will be represented by the fine-grained portion of sediment found in traps. The significance of bedload transport of COIs will be reconsidered if additional evaluations are completed during the RI process (LWG, 2009).

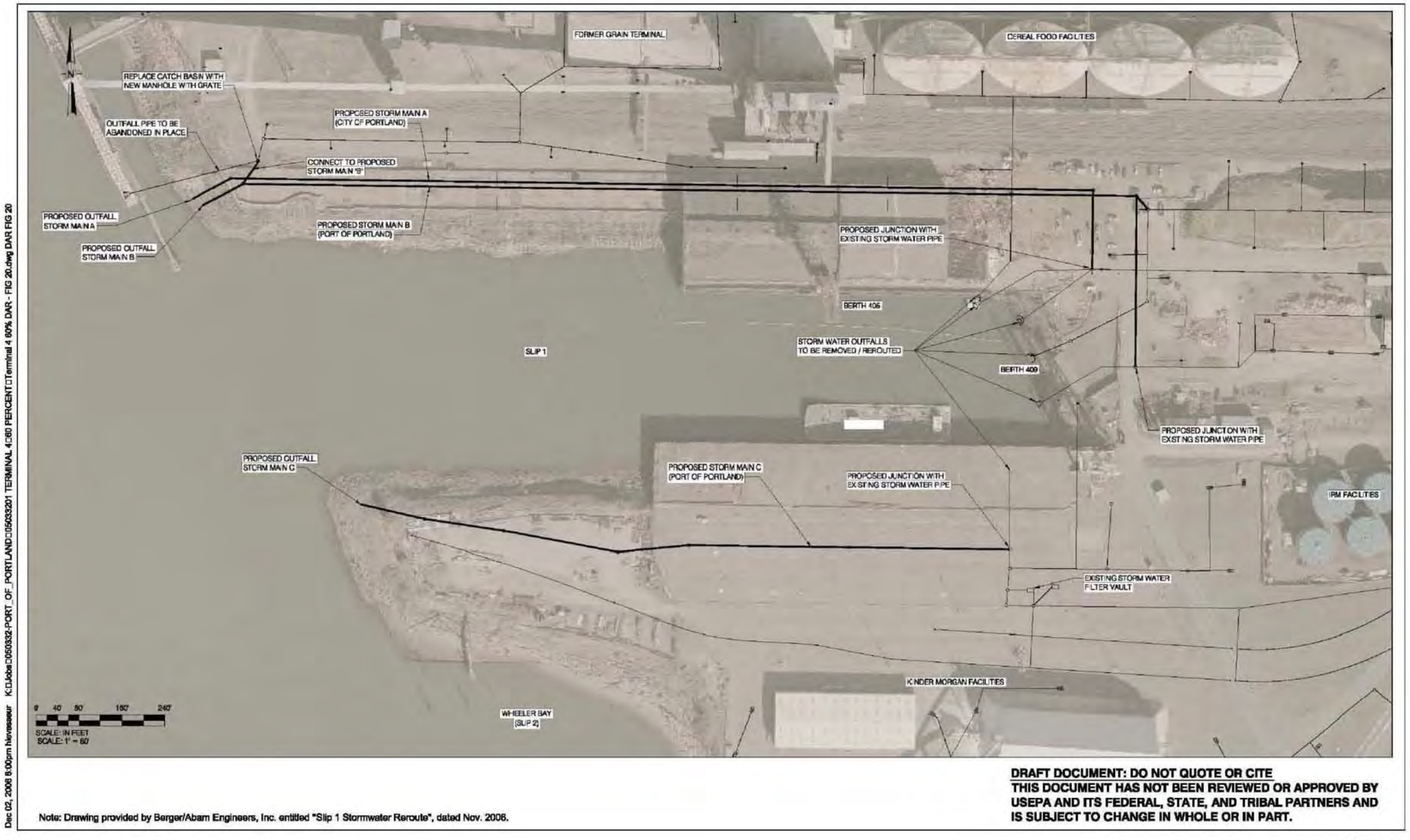
Stormwater Outfalls

Recent in-line stormwater sampling at Terminal 4 and at other locations at the Superfund Site have demonstrated that sediment suspended in stormwater discharge is a potential source of COIs to sediment. In-line stormwater samples did not distinguish between bedload and suspended sediment.

Dredging and construction of a confined disposal facility (CDF) in Slip 1 is a component of the Removal Action for Terminal 4 (Anchor, 2008). Confinement berms and dikes will provide for isolation of dredged material within the slip. Five storm drains that currently discharge to Slip 1 will be rerouted through three realigned storm mains, two north of Slip 1 and one south of Slip 1. The proposed locations of the realigned storm main outfalls are shown in Figure 2-2 (from Anchor, 2006b). The Recontamination Analysis will evaluate the rerouted stormwater outfall locations.

Stormwater outfalls will be evaluated in the recontamination analysis. Discharge from all outfalls will be included except from the three minor basins south of Slip 3. These basins can be considered separate from Basin D. The size of each of these basins is negligible compared to Basins J and K that also discharge to Slip 3.

Figure 2-2: Locations of proposed realigned stormwater outfalls at Terminal 4 (Anchor, 2006b).



Note: Drawing provided by Berger/Abam Engineers, Inc. entitled "Slip 1 Stormwater Reroute", dated Nov. 2008.

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ANCHOR ENVIRONMENTAL, L.L.C.

Figure 20
Slip 1 Stormwater Reroute Locations
Terminal 4 Early Action Pre-Final (60%) Design
Portland, Oregon

Groundwater

Groundwater sources were evaluated in the Terminal 4 Slip 1 Upland Facility (T4S1) RI report (ACA and Newfields, 2007). All groundwater data available when the recontamination analysis is conducted will be utilized.

Groundwater Data at Terminal 4

Appendix B includes copies of selected tables and figures from the Terminal 4 Slip 1 Upland Facility (T4S1) RI report (ACA and Newfields, 2007). Appendix C includes copies of selected tables and figures from Terminal 4 Slip 3 Upland Facility (T4S3) groundwater monitoring reports (ACA, 2009a and 2009e). The tables present groundwater data for COI analyzed as part of the T4S1 and T4S3 Upland Facility investigations and remediation. Locations of monitoring wells are shown on the figures.

Groundwater Gradient at Terminal 4

The groundwater gradient varies from as high as approximately 0.1 adjacent to the slips to as low as approximately 0.001 on the eastern portions of the facilities. Figure 11 in Appendix B and Figure 5 in Appendix C show typical groundwater contours at T4.

Groundwater Discharge to the River or Slips – Terminal 4 Slip 1 Upland Facility

The T4S1 RI report (ACA and Newfields, 2007b) included a source control evaluation of groundwater. Groundwater monitoring well data are included in Appendix B (PAHs and metals – Tables 14A, 14B, 19A, and 19B; PCBs were not detected). Because no plumes were identified at the facility, the evaluation included wells located along the river bank. These wells were: MW-01s, MW-03s, MW-07, MW-08, and MW-26 at OU1; and MW-09 through MW-16 at OU2. See Figure 11 in Appendix B for the well locations. The evaluation followed the Joint Source Control Strategy (JSCS) process (DEQ/EPA, 2005) for evaluating groundwater discharge to the river. The source control evaluation screening identified a few of the COI above JSCS screening levels. The exceedances in groundwater at the Facility are slight and it is likely that this pathway would be considered a “low priority” under the JSCS document. However, a “weight-of-evidence” evaluation was conducted to further assess whether groundwater could possibly adversely affect surface water or sediment in the river, as summarized below.

Ecological Evaluation. Of the COI, only benzo(a)pyrene, benzo(a)anthracene, and total lead were detected in riverbank wells above ecological screening levels. The following conclusions can be derived from the temporal and spatial analyses of the COI data relative to ecological criteria:

- There are no Facility-wide occurrences in groundwater of any of the COI.

- MW-07 and MW-16 are the only downgradient wells with exceedances of PAHs. Spatially, these wells are at opposite ends of the Facility and no wells in-between reported exceedances of PAHs. The exceedances occurred only once out of four quarters of monitoring. At well MW-07, the exceedances are trace concentrations and are below the MRLs. The detections at both wells are likely due to soil entrained in the sample and are not representative of groundwater conditions near the wells. Benzo(a)anthracene and benzo(a)pyrene exceeded their respective SLVs at MW-07 by less than 5 times (February 2005, but did not exceed at that location in May 2005). MW-16 exceeded for benzo(a)anthracene and benzo(a)pyrene by less than 7 times (in May 2005). Due to a small volume of water in the well, the well was not purged and the sample was collected via a bailer in May 2005; the well was purged and sampled using low-flow techniques during previous events. Therefore, the detections in May 2005 are not representative of dissolved-phase PAH concentrations in the MW-16 area.

- MW-15 is the only downgradient monitoring well in OU1 or OU2 with exceedances of total lead. Of four sampling periods at MW-15 in 2004/2005, total lead exceeded the SLV only once (in May 2005). The total lead (10.9 µg/L) concentration detected in May 2005 was less than 5 times the SLV (2.5 µg/L). The dissolved concentration of lead did not exceed the SLV.

Thus, the screening evaluation of groundwater monitoring results and a "weight-of-evidence" evaluation support that there are no COI at the Facility at concentrations that could cause significant, if any, unacceptable risk to mobile or immobile receptors within the river or slips.

Human Health Evaluation. Evaluating the results spatially, temporally, and by frequency of detection, the following conclusions can be derived for screening against human health screening levels:

- There are no Facility-wide occurrences in groundwater of any of the COI.

- MW-07 and MW-16 are the only downgradient wells with exceedances of PAHs. Spatially, these wells are at opposite ends of the Facility and no wells in-between reported exceedances of PAHs. The exceedances occurred only once out of four quarters of monitoring. At well MW-07, the exceedances are trace concentrations and are below the MRLs. The detections at both wells are likely due to soil entrained in the sample and are not representative of groundwater conditions near the wells.

The groundwater monitoring results, screening evaluation of the data obtained, and a "weight-of-evidence" evaluation support that there are no COI at the Facility at concentrations that could cause significant, if any, degradation of water in the river or slips or pose unacceptable risk to human health from fish consumption.

Potential Mass Loading. Regardless of the above analysis, the potential mass loading associated with the concentrations detected above screening levels is negligible. Assuming primarily horizontal flow in the sand fill at the Facility, Darcy's Law is an appropriate model to estimate groundwater flow to the slip/river. Multiplying groundwater flow by concentration yields mass flow (via groundwater). The fundamental equation is:

[1] $m = k * i * w * t * C$

Where

m = mass flow rate

k = hydraulic conductivity (assumed to be 0.02 cm/sec based on RI)

i = hydraulic gradient (measured at each well from Figure 11 in Appendix B)

i = 0.01 at MW-07

i = 0.009 at MW-15

i = 0.011 at MW-16

w = width of flow (total distance between adjacent wells, perpendicular to flow direction on Figure 11 in Appendix B)

w = 500 feet at MW-07

w = 400 feet at MW-15

w = 200 feet at MW-16

t = saturated thickness (corresponding to the location where i was estimated; based on RI cross sections)

t = 7 feet for all

C = concentration (from Tables in Appendix B)

benzo(a)anthracene – 0.067 µg/L at MW-07; 0.075 µg/L at MW-16

benzo(a)pyrene – 0.069 µg/L at MW-07; 0.095 µg/L at MW-16

lead – 10.9 µg/L at MW-15

Inserting these values and converting units, the maximum detected concentrations yield mass flow rates of 2 g/yr for each benzo(a)anthracene and benzo(a)pyrene, and 160 g/yr for lead. In comparison, stormwater loading of these COI has been estimated to be 98 g/yr for benzo(a)anthracene, 100 g/yr for benzo(a)pyrene, and 2,334 g/yr for lead for Slip 1 and Wheeler Bay.

Groundwater Discharge to the River or Slips – Terminal 4 Slip 3 Upland Facility

The T4S3 Upland Facility has undergone remedial actions and source controls to address groundwater discharges to the river/slip. Long-term groundwater monitoring is ongoing to evaluate the effectiveness of these actions. Groundwater monitoring well data are included in Appendix C (PAHs – Table 4). Figure 3 in Appendix C shows the well locations.

Ecological/Human Health Evaluation. Data from the groundwater monitoring were evaluated in a manner similar to that done for T4S1. Data from the slip bank wells were evaluated. These included wells BE-1 through BE-5, HC-2, and HC-5. Except for BE-2/BE-5 (BE-5 is a replacement for BE-2 that was destroyed), the slip bank wells have been below the human health and ecological screening levels or detection limits for more than one year. Concentration trends for the wells are downward. Benzo(a)anthracene, benzo(a)pyrene, and indeno(1,2,3-cd)pyrene were detected at 7 to 16 times the screening levels in the most recent sampling event at BE-5. In August/September 2008, interim action activities in Slip 3 included placing a cap over the area of groundwater discharge represented by BE-2/BE-5 (Anchor QEA, 2009). The cap includes an organoclay amendment designed to remove dissolved phase hydrocarbons from the groundwater discharging to the slip. The cap intercepts groundwater after passing the location of BE-5.

The groundwater monitoring results and screening evaluation of the data obtained support that there are no COI at the Facility at concentrations that could cause significant, if any, degradation of water in the river or slips or pose unacceptable risk to human health or the environment.

Potential Mass Loading. As for Slip 1, the potential mass loading associated with the concentrations detected above screening levels at Slip 3 is negligible. Using the same mass flow analysis, values for Slip 3 are as follows:

k = hydraulic conductivity (assumed to be 0.02 cm/sec based on RI)

i = hydraulic gradient (measured at BE-2/BE-5; see Figure 5 in Appendix C)

i = 0.09 at BE-2

w = width of flow (total distance between adjacent wells BE-1 and BE-3; see Figure 5 in Appendix C)

w = 100 feet at BE-2

t = saturated thickness (corresponding to the location where i measured; based on long-term groundwater monitoring)

t = 1.4 feet at BE-2

C = concentration (from Tables in Appendix B)

benzo(a)anthracene – 0.185 µg/L at BE-5

benzo(a)pyrene – 0.217 µg/L at BE-5

indeno(1,2,3-cd)pyrene – 0.135 µg/L at BE-5

Inserting these values and converting units, the maximum detected concentrations yield mass flow rates of 1 to 1.6 g/yr for each PAH. In comparison, stormwater loading of these COI has been estimated to be 18 g/yr for benzo(a)anthracene, 25 g/yr for benzo(a)pyrene, and 22 g/yr for indeno(1,2,3-cd)pyrene for Slip 3.

Bank Erosion

No significant bank erosion will exist at Terminal 4 following the Phase II Removal Action. The shoreline along Wheeler Bay was stabilized as part of the Phase I Removal Action, and erodible soil and source control work at the head of Slip 3 was completed in November 2009. The observed erosion at former Pier 5 in Slip 3 and former Berth 413

upland source area has been identified for action as described in an approved May 13, 2009 letter to DEQ. The schedules for action are designed to coincide with the in-water remedy. The proposed bank erosion remedies are described in detail in the Revised Source Control Alternatives Evaluation (ACA, 2009d). While erodible soils in Slip 1 were sampled and found to not require any source control action, bank erosion in Slip 1 will be halted by its conversion to a CDF. Bank erosion sources will not be considered in the recontamination analysis.

Overland Flow

The majority of Terminal 4 is drained by stormwater outfalls. Overland flow in the Terminal 4 area is not significant and will not be considered in the recontamination analysis.

Existing Structures

Some creosote-treated pilings exist at the Pier 4 area of Slip 3, and some pilings in the former Pier 5 area also may have been treated with creosote. Creosote is an oil-borne wood treatment product made from coal tar, and is primarily composed of polycyclic aromatic hydrocarbons (PAHs) (Stratus Consulting, 2006). PAHs can leach from treated wood that is exposed in the environment. Numerous laboratory and field studies have been conducted on PAH leaching rates and factors that affect these rates. Studies generally agree that a series of factors can affect the leaching rate:

- wood species,
- density,
- surface area exposed,
- treatment formula,
- PAH compounds present,
- water temperature chemistry,
- temperature and flow,
- disturbance/abrasion, and
- time since treatment.

Multiple models designed to predict leaching rates of creosote from pilings have been developed (for example Brooks, 1994; 1997; Poston, 1996; Xiao et al., 2002). The Brooks (1994, 1997) model (CREOSS) is well-documented, and provides reasonable agreement with field observations. The CREOSS model estimates a leaching rate based on a migration factor (water temperature and salinity), piling retention factor, and a piling age factor. The age factor is 1 at the time of treatment, and decays in an exponential fashion. Leaching rate is proportional to the age factor. The model estimates that after 20 years, the leaching rate would be 14% of the original rate and after 40 years, the

leaching rate would be 2% of the original. Given the much higher rate of leaching in the years just following piling installation, the amount of leachable PAH mass left in the pilings will be greatly reduced. For example, using the numbers above, approximately 96% of the PAH mass that leaches over the lifetime of the pilings would leach within the first 40 years of service. Therefore, even if the pilings were a historical source of PAHs to sediments, the remaining mass and leaching rate would be almost two orders of magnitude lower than initial rates and below levels of concern for future sediment recontamination.

Pilings were installed in 1961 at Pier 5 and in 1959 at Pier 4. Some of the original pilings have been replaced over time with non-creosote treated pilings for maintenance purposes. With respect to the original pilings that remain, given the time that has elapsed, they are not predicted to be a significant potential sources of PAHs in the future and are not considered further in the recontamination analysis.

Sediment Resuspension

Sediment resuspension due to propeller wash has been observed to be a significant process occurring in Slip 3 and the Terminal 4 area (BBL, 2004a; BBL, 2005a). Hydrodynamic measurement conducted as part of the EE/CA (2005) showed that river currents dominated the flow regime in the river channel, and that propeller-induced currents dominated within slips. Comparison of water current measurements in slips and vessel activity logs showed that propeller-induced currents affected water velocity and turbidity levels well outside of the ship travel pathway. However, resuspended sediment in slips is not a significant source of new COI mass to sediment in the Removal Action Area and will not be carried forward in the analysis. Since sediment traps placed within the Removal Action Area collect both resuspended sediment that settles back in the slip and sediment entering the Area from outside sources, the sedimentation rate in the traps was not used to estimate net sedimentation rate for the Removal Action Area.

Sedimentation rates measured in sediment traps placed at Terminal 4 range from approximately 18.3 to 84.3 cm/yr (based on a sediment density of 1.53 g/cc). Sediment trap locations are shown in Figure 2-3. In contrast, the net sedimentation rate for Terminal 4 estimated based on bathymetric surveys is approximately 1.5 cm/yr (see Section 3.1.1.2). This suggests that a significant amount of sediment is disturbed by propeller wash or river currents, which supports the assumption of a mixed surface sediment layer for Removal Action subareas. However, the conceptual model does not assume lateral mixing. Mixing depth at a given location will vary based on many factors, such as physical disturbance and biological activity. Propeller wash is a strong influence on sediment resuspension. Anchor (2006a) predicted maximum propeller wash velocities for different areas of Terminal 4. The results are shown in Table 2-3. In contrast, the harborwide RI modeled river flows under a variety of flood and flow

conditions using the revised Phase 2 HST model. River velocities within the Terminal 4 slips and in the nearshore river channel were consistently predicted to be low, less than 15 cm/sec. This shows that propeller wash velocities are significant.

Table 2-3: Predicted maximum propeller wash velocities for different areas of T4.

Location	Max Predicted Propwash Velocity (cm/s)
Berth 401	146
Wheeler Bay	128
Berth 411 (under pier)	85
Head of Slip 3 (behind bulkhead)	negligible
Head of Slip 3 (in front of bulkhead)	119
Pier 5	98
Berth 414	125

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Legend

In-River Sediment Traps

- April/May 2004
- January 2005
- March 2005
- RAA

Feet

0 500 1,000

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TERMINAL 4

FIGURE 2-3

IN-RIVER SEDIMENT TRAPS From BBL, 2006

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Atmospheric Sources

Chemicals present in the atmosphere as a result of emissions from stationary sources (e.g., industrial smokestacks), mobile sources (e.g., vehicle emissions) and non-point sources (e.g., fugitive dust) produce a load to the river through the processes of dry and wet deposition. Loads can be local or global in source. Dry deposition refers to the deposition of air pollutants from atmospheric suspension in the absence of precipitation. Wet deposition refers to deposition of air pollutants from atmospheric suspension via liquid and/or frozen precipitation.

Deposition occurs throughout the Portland Harbor Superfund Site study area. Particles that are deposited on the land can be transported to the river by stormwater and are thus included in measured stormwater loads. Particles deposited in the river will be represented by sediment load within the river. Atmospheric deposition to the entire Portland Harbor Site is assessed in the Remedial Investigation (RI) Report using the available local or non-local precipitation and air concentrations and literature-based deposition velocities (LWG, 2009). Limited data were available for analysis. On the harborwide scale, atmospheric loads to water surfaces were found to be one to four orders of magnitude smaller than upstream loads, depending on the chemical. Atmospheric loading will not be modeled in the harborwide FS (LWG, 2009).

For Terminal 4, loads calculated in the RI were adjusted for the smaller water surface area of the T4 RAA and compared to the estimated upstream load to T4. The upstream load was preliminarily estimated based on sediment trap concentrations from the mid-Willamette sediment trap (see Section 3.1.3.1) and an average net sedimentation rate of 1.5 cm/yr based on bathymetric data (see Section 3.1.1.2). The results show that the estimated upstream contribution of lead, total PCBs and benzo(a)pyrene is one to three orders of magnitude greater than the “upper” estimate for atmospheric deposition (Table 2-4). Based on this comparison, and the lack of information for estimating loads of other parameters, atmospheric deposition will not be considered in the recontamination analysis at Terminal 4.

Table 2-4: Comparison of estimated atmospheric deposition with upstream loading for available chemicals. PH = Portland Harbor.

	Total Deposition for PH Site*			Percent of total PH water area that is T4 RAA	Total Deposition for T4 RAA			Upstream Load to T4
Analyte	**Lower, kg/yr**	**Central, kg/yr**	**Upper, kg/yr**		**Lower, kg/yr**	**Central, kg/yr**	**Upper, kg/yr**	**kg/yr**
Lead	2.27E-01	1.69E+01	7.49E+02	1.2%	2.71E-03	2.02E-01	8.95E+00	6.12E+01
Total PCBs	5.28E-01	6.25E-01	7.23E-01	1.2%	6.31E-03	7.47E-03	8.64E-03	1.45E-01
Benzo(a)pyrene	2.08E-01	8.10E-01	3.47E+00	1.2%	2.49E-03	9.68E-03	4.15E-02	1.22E-01

**From Table E5-2, Portland Harbor RI Report, October 2009.*

Other

Other potential sources of COIs to the Remedial Action Area are overwater activities, however since these activities do not pose a consistent or regular contribution of COIs, they are not relevant to this report. If a release of this type were to occur, it would be addressed through ongoing operational activities.

Summary

Potential sources to be carried forward for further evaluation in the Recontamination Analysis are as follows:

- Upstream sources, and
- Stormwater sources.

A more detailed screening to eliminate minor or insignificant sources will be performed in the Recontamination Analysis.

2.4 Description of Removal Action Subareas and Primary Potential Sediment Recontamination Sources

As discussed above, the primary sources of potential sedimentation recontamination are anticipated to be upstream sediment and stormwater sediment. Upstream sediment sources will be characterized using the same upstream data for all Removal Action subareas (see Section 3.1.3.1). Stormwater sediment sources, however, will vary in load based upon which stormwater basins discharge to each subarea.

Figure 2-4 shows the locations of stormwater basins and the Removal Action Subareas and the general direction of stormwater drainage for each basin under the revised stormwater line configuration. The approximate areas of the stormwater basins are listed in Table 2-5.

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Legend

Stormwater Basins

- Basin D
- Basin J
- Basin K
- Basin L
- Basin M
- Basin N
- Basin O
- Basin Q
- Basin R
- Basin S
- Basin T
- Removal Action Subareas
- Direction of stormwater discharge (does not represent outfall location)

N

Feet

0 250 500

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TERMINAL 4

FIGURE 2-4

LOCATION OF STORMWATER BASINS AND REMOVAL ACTION AREAS

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Table 2-5: Approximate area of each stormwater basin. From ACA and NewFields, 2009.

Basin	Area (acres)
D	17
J	2.6
K	1.5
L	17.2
M	29.1
N	3.5
O	5.5
Q	18
R	15
S	1
T	25.6

2.4.1 Subarea 1 – Former Berth 413 MNR Area

The MNR Area located adjacent to the former Berth 413 receives sediment input from upstream, in addition to sediment input from the primary outfall of stormwater Basin D (Figure 2-5). Basin D is approximately 17 acres. The former Berth 413 MNR area is the closest Removal Action subarea to the City of Portland stormwater outfall 53, which discharges to the Willamette River main channel approximately 1,800 feet upstream of the former Berth 413. Stormwater from an offsite residential area discharges through this outfall and becomes part of the upstream source component at the former Berth 413 area.

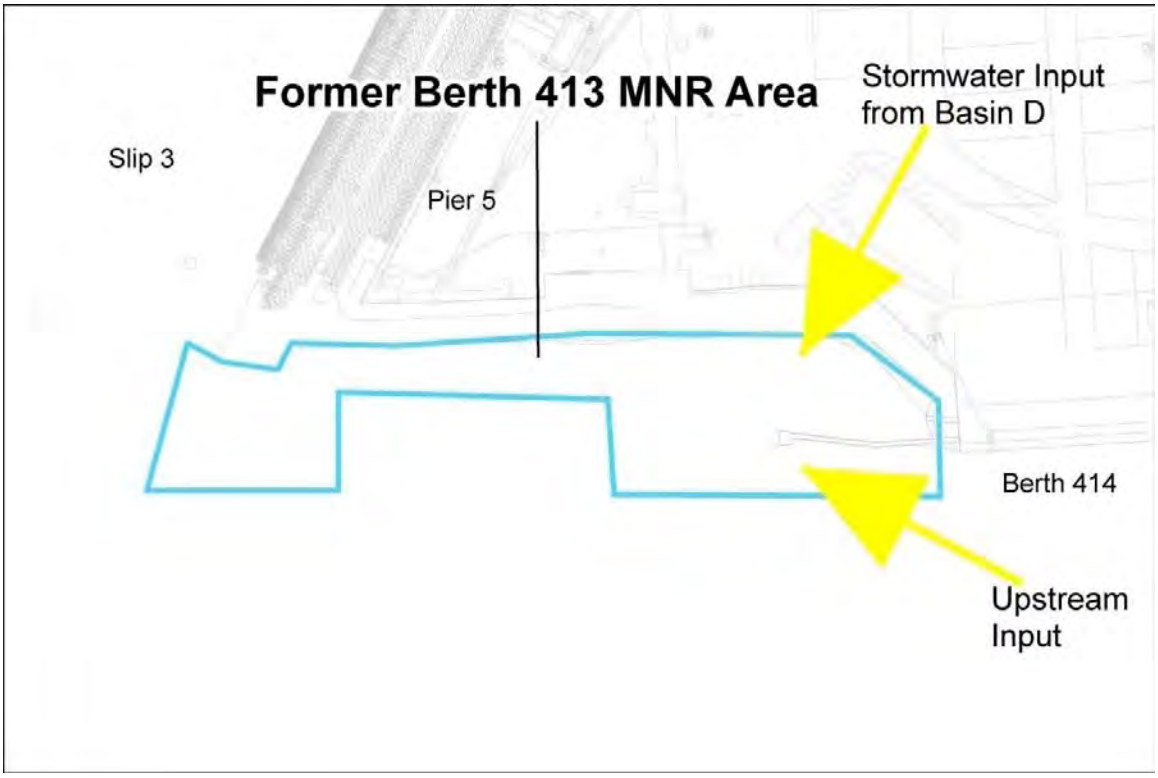

Figure 2-5: Former Berth 413 MNR subarea and potential recontamination sources.

2.4.2 Subarea 2 – Former Berth 413 Dredge and Cap Area

The dredge and cap area located adjacent to the former Berth 413 (north of Berth 414) receives sediment input from upstream, in addition to sediment input from the primary outfall of stormwater Basin D (Figure 2-6). Basin D is approximately 17 acres.

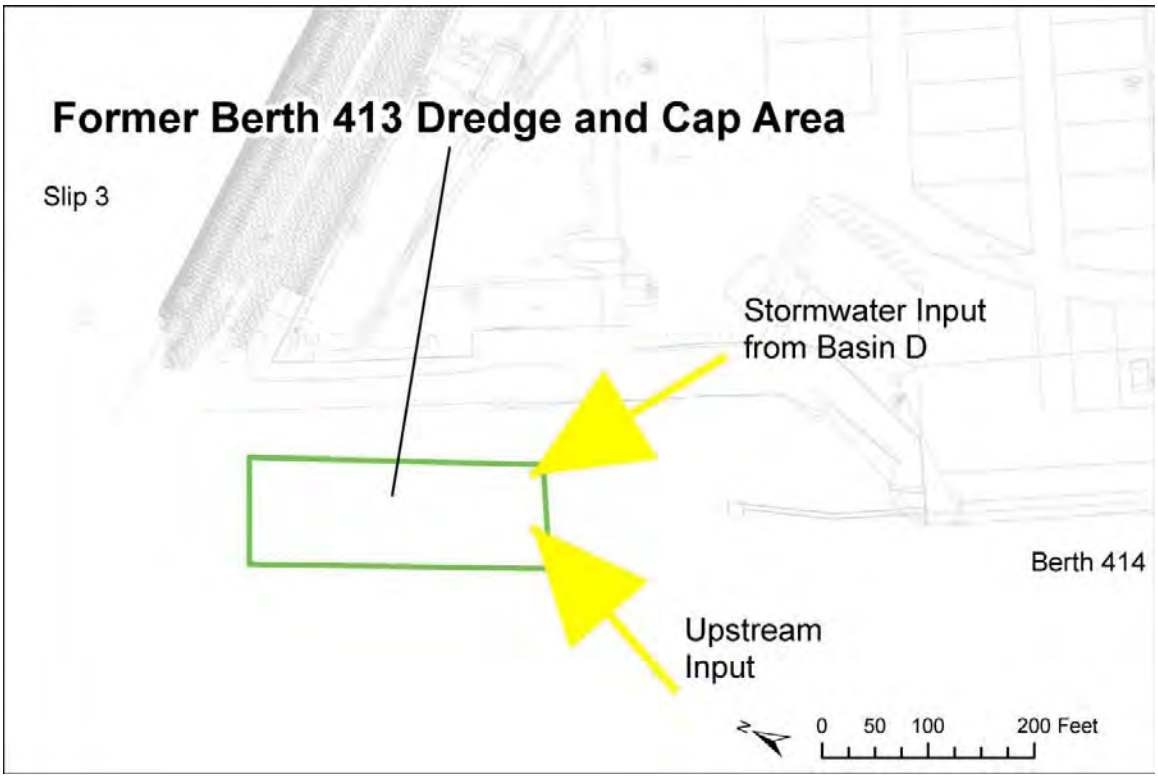

Figure 2-6: Former Berth 413 dredge and cap subarea and potential recontamination sources.

2.4.3 Subarea 3 – Slip 3 Cap Area

The capped area in Slip 3 receives sediment input from upstream and stormwater sediment from outfalls (Figure 2-7). Stormwater sediment in Slip 3 comes from Basins J and K. Outfalls from the south service minor catchment areas and are negligible compared to Basins J and K. Basins J and K are 2.6 and 1.5 acres, respectively.

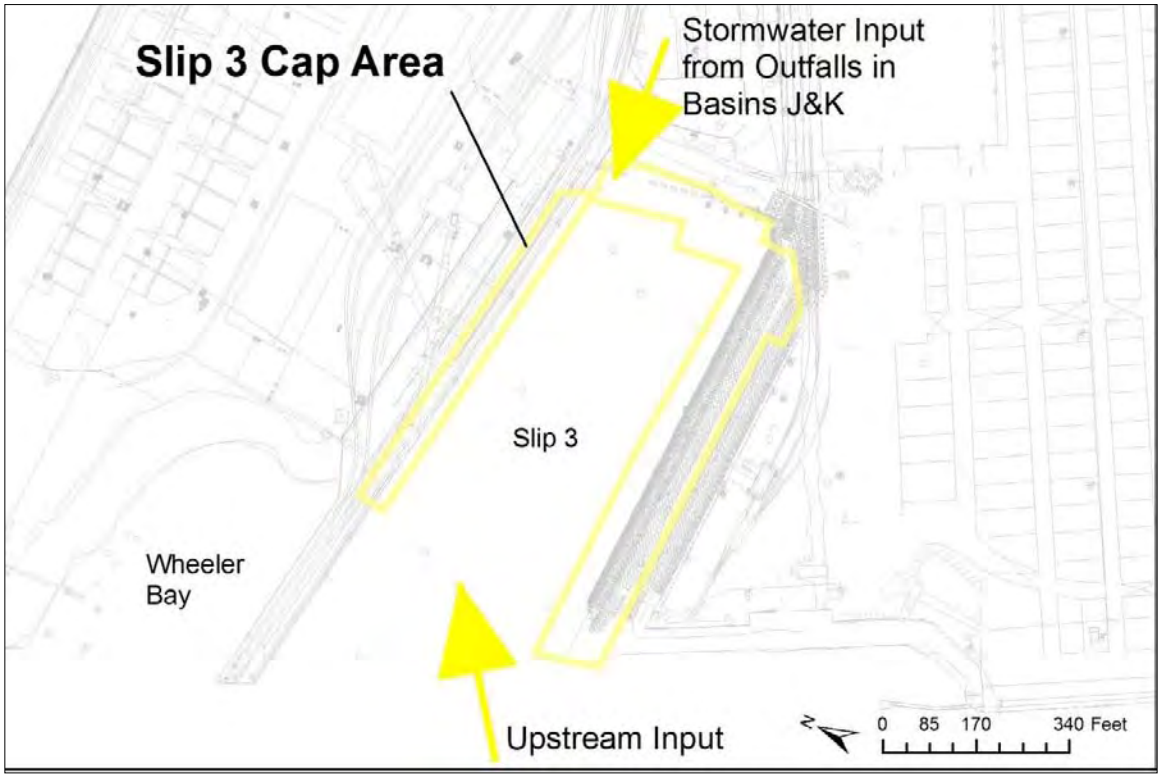

Figure 2-7: Slip 3 cap subarea and potential recontamination sources.

2.4.4 Subarea 4 – Slip 3 Dredge Area

The dredged area in Slip 3 receives sediment input from upstream and stormwater sediment from outfalls (Figure 2-8). Stormwater sediment in Slip 3 comes from Basins J and K. Stormwater sediment in Slip 3 comes from Basins J and K. Outfalls from the south service minor catchment areas and are negligible compared to Basins J and K. Basins J and K are 2.6 and 1.5 acres, respectively.

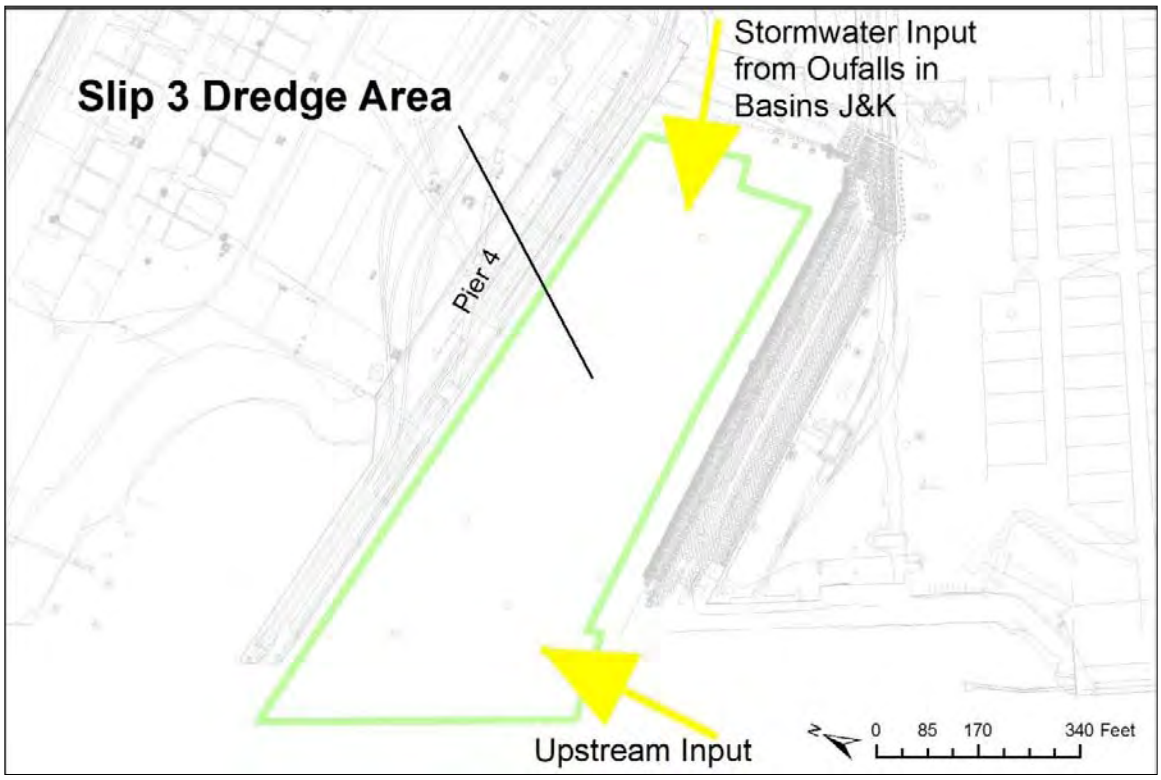

Figure 2-8: Slip 3 dredge subarea and potential recontamination sources.

2.4.5 Subarea 5 – Wheeler Bay Cap Area

The Wheeler Bay capped area receives sediment from upstream and stormwater outfalls (Figure 2-9). The outfall for Basin L discharges to Wheeler Bay. Basin L covers approximately 17.2 acres, and is the third largest stormwater basin in Terminal 4.

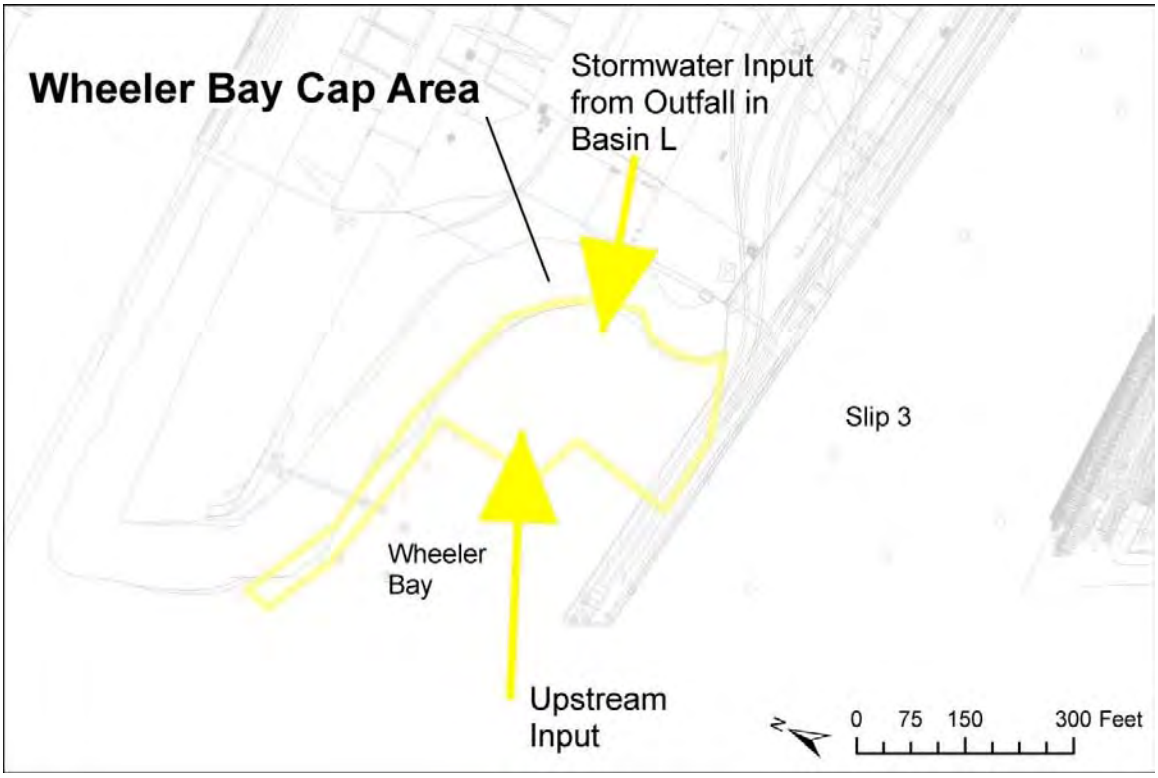

Figure 2-9: Wheeler Bay cap subarea and potential recontamination sources.

2.4.6 Subarea 6 – Wheeler Bay MNR Area

The Wheeler Bay MNR area receives sediment from upstream and stormwater outfalls, and may be affected by sediment input from upstream and stormwater outfalls (Figure 2-10). This area includes all MNR areas downstream of the Slip 3 dredged area. Following the construction of the CDF, the proposed relocation of the outfall for Basin M is downstream of Wheeler Bay. The outfall for Basin L discharges to Wheeler Bay. Basin L covers approximately 17.2 acres, and is the third largest stormwater basin in Terminal 4.

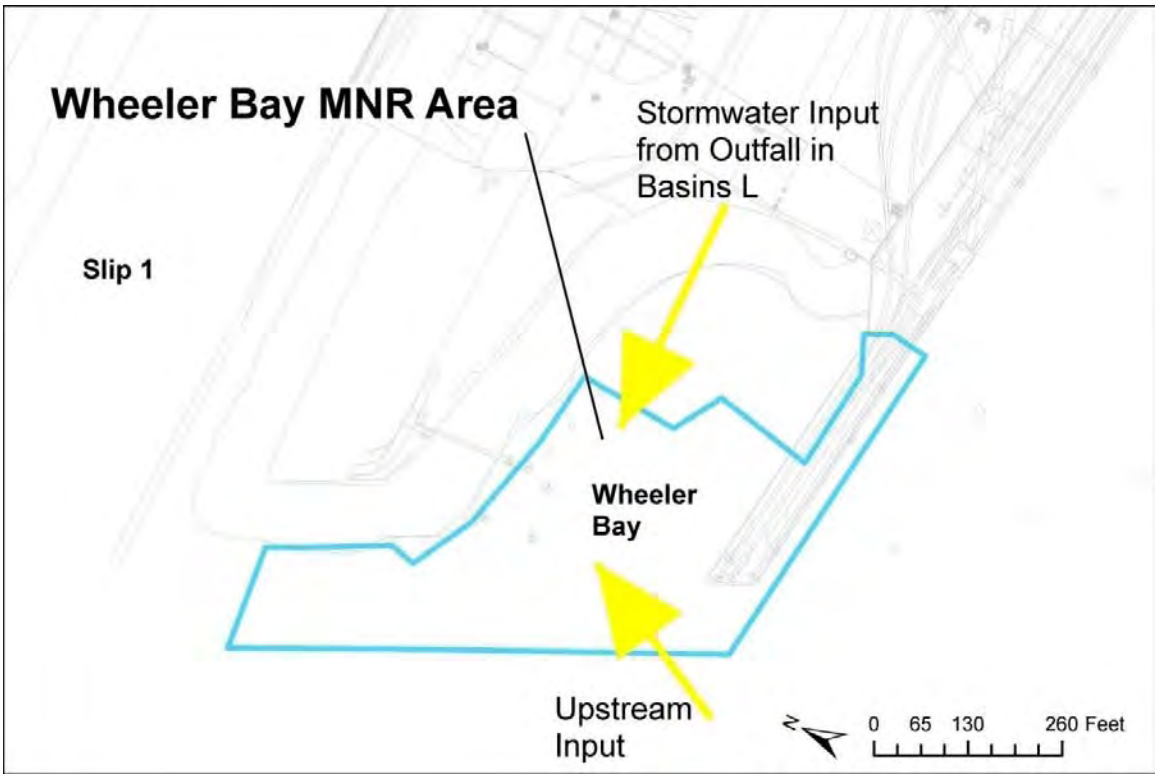

Figure 2-10: Wheeler Bay MNR subarea and potential recontamination sources.

2.4.7 Subarea 7 – Toe of Slip 1 MNR Area

The toe of slip 1 MNR area extends from the proposed reroute location for the stormwater outfall for Basin M to the reroute location for the outfall servicing Basins N, O, Q, R and T (Figure 2-11). Under the rerouted stormwater piping plan, this area will be affected by sediment input from upstream and stormwater from Basin M. Basin M covers approximately 29.1 acres. All of the sediment transported by stormwater will be assumed to affect this area.

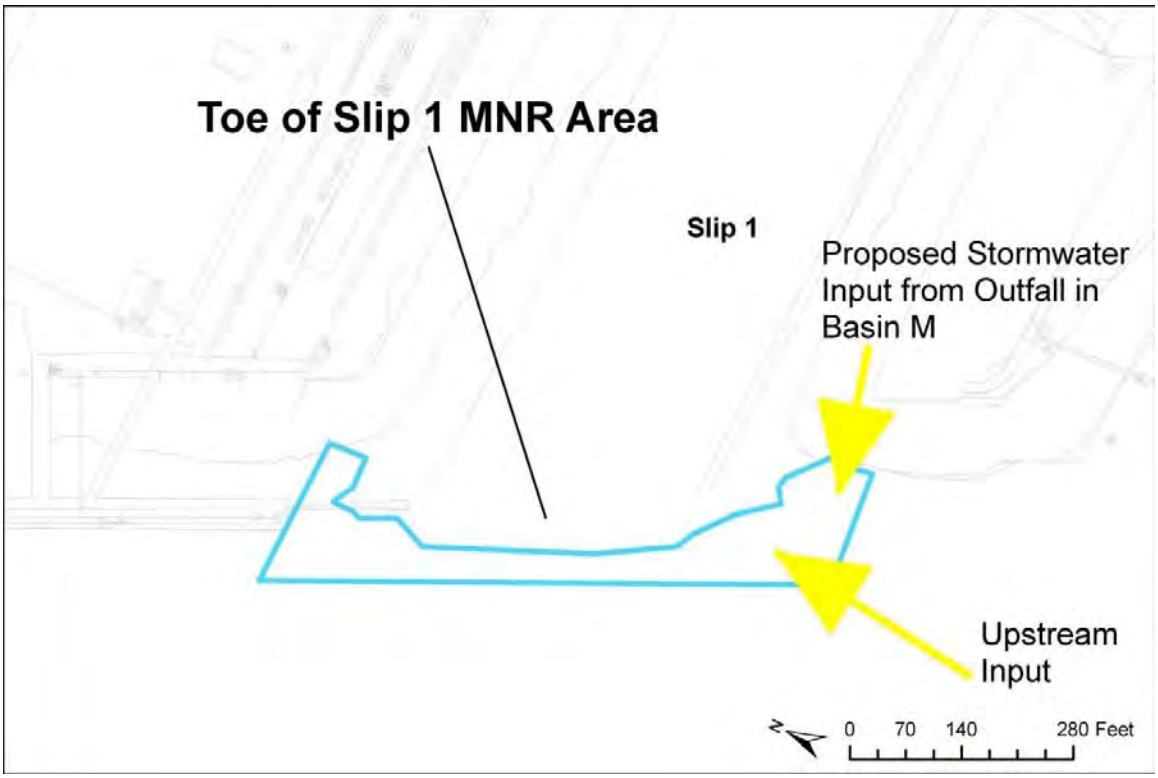

Figure 2-11: Toe of Slip 1 MNR subarea and potential recontamination sources.

2.4.8 Subarea 8 – Berth 401 MNR Area

The Berth 401 MNR area includes the MNR designated area downstream of the proposed reroute location for the stormwater outfall servicing Basins N, O, Q, R, and T (Figure 2-12). This area will also be affected by upstream sources. Basin T is drained by city outfall 52-C. This area ends downstream when the action becomes capping or the Removal Action Area terminates. Stormwater from Basins N, O, Q, R, and T drains approximately 67.6 acres in total.

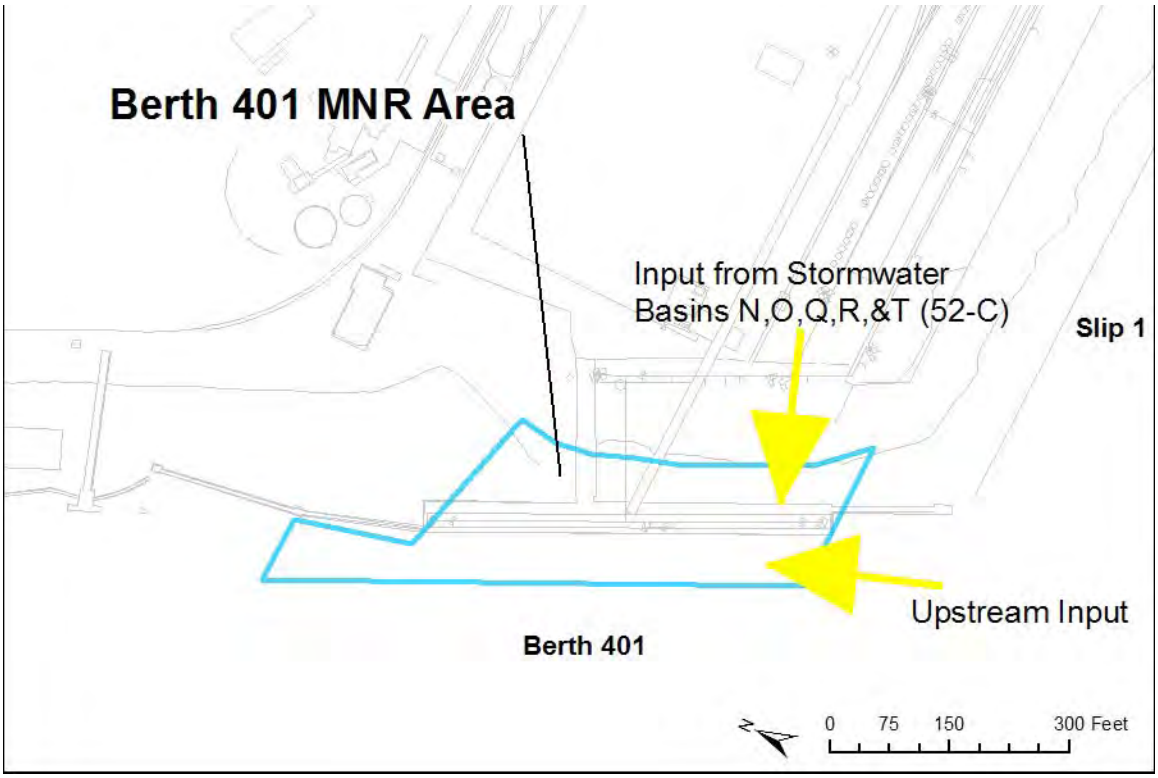

Figure 2-12: Berth 401 MNR subarea and potential recontamination sources.

2.4.9 Subarea 9 – Berth 401 Capped Area

The Berth 401 capped area is the furthest downstream Removal Action subarea. It will be affected by upstream and stormwater deposited sediment (Figure 2-13). Stormwater from the rerouted discharge from Basins N, O, Q, R, T and S drains approximately 68.6 acres in total.

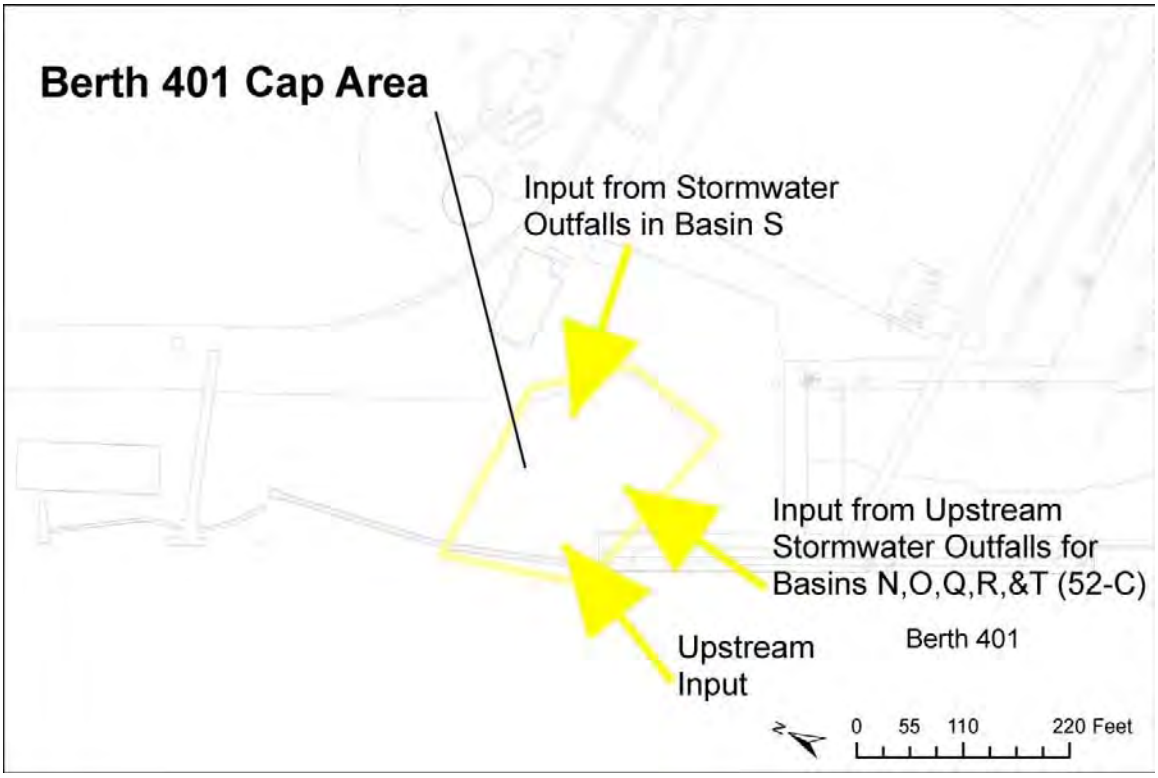

Figure 2-13: Berth 401 cap subarea and potential recontamination sources.

3.0 RECONTAMINATION ANALYSIS METHODOLOGY

The overall methodology for assessing sediment recontamination potential is described in the following sections, including the equations to be used in calculation of predicted COI concentrations in surface sediments after removal action construction is complete.

3.1 Overall Approach

The overall recontamination approach will consist of using the mathematical model, SEDCAM, to predict COI concentrations in surface sediments over time after the removal action construction is complete, considering sediment accumulation, mixing, and contaminant degradation (Jacobs et al., 1988). Source inputs and predicted concentrations over time will depend on the assumption of complete mixing within the Removal Action subarea, however, the recontamination analysis will be conducted on a point-by-point basis. The required inputs to the SEDCAM model are initial COI concentrations in surface sediment present after Phase II Removal Action construction is completed, estimated sediment and COI loads from primary sources, estimated degradation rates for each COI, and an assumed thickness of sediment mixing. Predicted concentrations will be assessed for decreasing trend, and if shown to increase will be compared to harborwide cleanup goals for each COI. It should be noted that, the sediment recontamination analysis evaluates recontamination rate, and not progress toward cleanup goals directly. However, by varying input parameters it will be possible to evaluate relative progress toward cleanup goals due to changes in source and river characteristics.

Model input values and conceptual model assumptions will be revised, as necessary, to remain consistent with the Portland Harbor RI and Feasibility Study.

3.1.1 Sedimentation Rate

The first step in the analysis is to estimate net sedimentation rates in each of the Removal Action subareas. Available bathymetric, sediment trap and sediment stake data will be reviewed to provide an estimate of the annual average net sedimentation rate.

3.1.1.1 *Methodology*

An annual net sedimentation rate will be estimated for the Removal Action Area. The net mass of sediment deposited will be equal to the sum of the mass of sediment contributed by the upstream and stormwater sources:

$$M_{net\ gain,RAA} = M_{upstream} + M_{stormwater}$$

where

$M_{net\ gain,\ RAA}$ is the net mass of sediment gained annually in the RAA,

$M_{upstream}$ is the mass of sediment contributed annually by upstream sources and

$M_{stormwater}$ is the mass of sediment contributed annually by stormwater sources.

The net mass gain of sediment ($M_{net\ gain,\ RAA}$) in the Removal Action Area can be calculated from the deposition rate ($R_{deposition}$), area of the Removal Action subarea (A_{RAA}) and bulk density of sediment (p_b):

$$M_{net\ gain,RAA} = R_{deposition} * A_{RAA} * \rho_b$$

3.1.1.2 *Data to be used*

Data sources available for estimating the annual net sedimentation rate at Terminal 4 primarily include bathymetric surveys. In-water sediment traps were deployed in 2004 to 2005 by BBL (BBL/Arcadis, 2006), however sedimentation in traps will represent both net sedimentation and sediment resuspended due to propeller wash. Since propeller wash is a significant contributor to water velocities in slips and other waters at Terminal 4, these data will not be used to evaluate the net sedimentation, since the combination with resuspended sediment would over-estimate the net sedimentation rate. A sediment stake study was conducted by the LWG (Anchor, 2003) in order to assess sediment elevation changes in near-shore environments, which bathymetric surveys are not able to capture. Sediment stakes were placed at low, medium and high locations relative to the shoreline at eight locations along the Willamette River. One stake was located in Wheeler Bay. Results from the five month sediment stake deployment showed relatively little change. However, no correlation was apparent between sediment stake results and bathymetric surveys. The sediment stake deployment did not capture the high-stage timeframe, and sediment stakes in different locations were subject to varying wetted periods.

Bathymetric surveys have been conducted at Terminal 4 on a regular basis since 2000. There have been multiple studies attempting to evaluate the sedimentation behavior indicated by these surveys (Port of Portland, 2002; Striplin, 2002; Striplin, 2003; Integral Consulting and David Evans Associates, 2004). Only a subset of the data acquired from these studies was available for quantitative review. Bathymetric surveys from December 2001-January 2002 and January 2009 were chosen for analysis in order to provide a long-term net sedimentation rate. These surveys were also evaluated in the harborwide fate and transport modeling being conducted for the RI (i.e. QEA Fate model). Dredged areas within Slip 3 were corrected based on major dredging events that occurred within

this timeframe. Table 3-1 summarizes the sub-area specific net sedimentation rates for the seven year period. These values are considered preliminary, and as additional bathymetric or other datasets become available, this estimate can be revisited.

Table 3-1: Summary of sedimentation rates for Terminal 4 based on bathymetric differences between winter 2001/2 and winter 2008/9.

Subarea	Mean Difference (cm)	Sedimentation Rate (cm/yr)	Net Change
Berth 401 Cap Area	-27.6	-3.5	Erosion
Berth 401 MNR Area	2.4	0.3	Deposition
Toe of Slip 1	19.8	2.5	Deposition
Wheeler Bay (both areas)	5.2	0.6	Deposition
Slip 3 (both areas)*	-12.2	-1.5	Erosion
Berth 414 Dredge and Cap Area	-20.6	-2.6	Erosion
Berth 414 MNR Area	-25.8	-3.2	Erosion
All T4 RAA*	12.3	1.5	Deposition

**Net sedimentation was corrected for major dredging events that occurred between 1/2002 and 1/2009.*

3.1.1.3 *Uncertainty*

Sedimentation rates will be based on bathymetric survey data. Bathymetric surveys were conducted using high-resolution multibeam sonar technology. Horizontal positioning was conducted using GPS. Vertical accuracy of the survey data is within +/- 0.25 ft. Post-processing errors may include positioning differences of vessels over time, outer sonar beam noise, and errors near vertical structures (Integral and David Evan Associates, 2004). Data processing produced contoured bathymetry grids with 3 ft by 3 ft cells using inverse distance weighting and beam grazing angle algorithms (Integral and David Evan Associates, 2004). Areas selected for analysis were chosen in order to minimize the inclusion of data errors near vertical or overlying structures. However, significant uncertainty exists, especially since net sedimentation rates are within the margin of survey error (+/- 7.62cm).

3.1.2 Sediment Mass Balance

While COI mass can be input to the system from various sources (see Section 2.3 for an example list), the primary sources of sediment are typically limited to upstream river sediment and suspended sediment in stormwater runoff. For the Terminal 4 removal action areas, stormwater sediment loads can be estimated from the recent sampling effort, which included in-line sediment traps and collection of water samples for analysis of COIs and TSS. Therefore the sediment input from the upstream river can be estimated by subtracting the stormwater sediment load from the total sediment load (from the average sedimentation rate and depositional area). As well as providing

necessary input parameters for the SEDCAM model, this step provides an indication of the relative sediment load coming from upstream.

3.1.3 Quantify Primary Potential Recontamination Sources

Initial screening (Section 2.3) suggests that upstream and stormwater sediment are potentially significant sources. The load of sediment contributed by stormwater can be calculated based on TSS measurements collected during the recent sampling events. Stormwater sediment contributions to Removal Action subareas located in the main channel of the Willamette River (i.e. Berth 401 and Berth 414) will be adjusted based on their proximity to the outfall. As an initial analysis, all sediment from stormwater outfalls will be assumed to land in the adjacent Removal Action subarea. This will provide a conservative estimate of recontamination potential. If no recontamination is predicted, the analysis will stop here. If the potential for recontamination is predicted by this conservative approach, the proportion of stormwater sediment that actually settles in the particular Removal Action sub-area will be estimated based on factors such as outfall configuration, river flow velocity and depth, and particle settling rates. Using the net mass of sediment gained/lost and the stormwater sediment load, the upstream sediment contribution can be calculated, as described above.

Next, concentrations of COIs in stormwater and upstream sediment inputs will be assigned. A combined input concentration to Removal Action subareas will be calculated based on a weighted average of the source input concentrations and relative sediment loading. Stormwater COI concentrations were measured in 2007 through 2008 (ACA, 2008). An upstream in-water sediment trap (dry weather data) and stormwater data from immediately upstream will be used to estimate the concentration of COIs in the upstream suspended sediment.

3.1.3.1 *Upstream*

The upstream source includes all sediment originating upstream of Terminal 4 that gets deposited in the Removal Action Areas. Upstream sediment may have been impacted by other site activities, including stormwater runoff, atmospheric deposition, bank erosion, overwater spills, or other activities occurring upstream of Terminal 4.

Data to be used

COI concentrations for the upstream contribution will be obtained from the mid-Willamette and Toyota Dolphin sediment traps. The mid-Willamette sediment trap was located toward the center of the river, slightly upstream of Berth 414 and Terminal 4. The Toyota Dolphin trap is located closer to the shoreline, within the Berth 414 sub-area. The proximity of the Toyota Dolphin trap to stormwater outfalls discharging from Basin D presents uncertainty when using this data to represent upstream concentrations.

Likewise, uncertainty is present in using the mid-Willamette data, as this trap is located in the center of the river channel and may not represent the type of sediment being deposited in the Removal Action Area. Data from these two locations are similar, however, to address these uncertainties data from both traps will be combined to obtain an estimate of upstream concentrations. The locations of the mid-Willamette and Toyota Dolphin sediment traps are shown in Figure 2-3.

Deployment of the Toyota Dolphin sediment trap was conducted as part of the Terminal 4 Early Action Characterization Report (BBL, 2004). The trap was deployed for two periods of three weeks each, from March to April and again from April to May. Deployment of the mid-Willamette sediment trap was conducted as part of the BBL Supplemental Field Work (BBL, 2005b). Details regarding the location selection, sediment trap deployment, preparation and trap recovery can be found in the Supplemental Field Work Summary Memorandum, as Attachment N-3 to the Draft Appendix N: Terminal 4 Recontamination Analysis (BBL, 2005b). The trap was deployed from January to March 2005, however, this deployment interval represents primarily dry weather conditions. COI concentrations in the river may be higher during wet weather conditions, primarily due to increases in upstream inputs to the river (i.e. upstream stormwater outfalls). Data from outfall 53, located upstream of the mid-Willamette sediment trap, will be used to determine if the mid-Willamette and Toyota Dolphin concentrations would be impacted during wet weather conditions. COI concentrations from the mid-Willamette, Toyota Dolphin and outfall 53 sediment traps are shown in Tables 3-2, 3-3 and 3-4.

Table 3-2: Upstream COI concentrations measured in the mid-Willamette sediment trap from the January to March 2005 deployment.

COI	Mid-Willamette Sed Trap, Jan-Mar 2005
Benzo(a)pyrene	54 µg/kg
Benzo(a)anthracene	52 µg/kg
Dibenzo(a,h)anthracene	6 µg/kg
Pyrene	110 µg/kg
Indo (1,2,3) pyrene	57 µg/kg
Cadmium	0.48 mg/kg
Lead	27.1 mg/kg
Total PCBs	64 µg/kg

Table 3-3: Upstream COI concentrations measured in the Toyota Dolphin sediment trap from the April and May 2004 deployments.

COI	Toyota Dolphin Sed Trap, April 2004	Toyota Dolphin Sed Trap, May 2004
Benzo(a)pyrene	50 µg/kg	81 µg/kg*
Benzo(a)anthracene	41 µg/kg	59 µg/kg*
Dibenzo(a,h)anthracene	11 µg/kg*	9.4 µg/kg*
Pyrene	99 µg/kg	110 µg/kg*
Indo (1,2,3) pyrene	48 µg/kg*	76 µg/kg*
Cadmium	0.3 mg/kg	0.3 mg/kg
Lead	14.6 mg/kg	18.4 mg/kg
Total PCBs	32 µg/kg	27 µg/kg

** Estimated value.*

Table 3-4: Stormwater COI concentrations measured in the Outfall 53 sediment trap in 2007 and 2008.

COI	Outfall 53 Sed Trap, 2007	Outfall 53 Sed Trap, Feb 2008
Benzo(a)pyrene	1,000 µg/kg	830 µg/kg
Benzo(a)anthracene	540 µg/kg	510 µg/kg
Dibenzo(a,h)anthracene	160 µg/kg	150 µg/kg
Pyrene	1,200 µg/kg	1,100 µg/kg
Indo (1,2,3) pyrene	820 µg/kg	790 µg/kg
Cadmium	1.13 mg/kg	1.04 mg/kg
Lead	109 mg/kg	97.3 mg/kg
Total PCBs	N/A	377 µg/kg

The COI concentrations in stormwater sediment from outfall 53 are higher than those measured in the mid-Willamette and Toyota Dolphin traps. The mid-Willamette and Toyota Dolphin sediment traps were deployed during 2005 and 2004, respectively. These years were somewhat drier than average at Terminal 4 and therefore may not reflect annual average conditions. Outfall 53 is located upstream of the site and may directly contribute to upstream COI concentrations during runoff events. All available data from outfall 53 will be used to adjust the in-river sediment trap data to account for wet-weather flow in the annual average upstream load estimate. Composite stormwater samples were also obtained from outfall 53 in 2007 and early 2008 as part of the Terminal 4 Stormwater Data Summary Report (ACA and NewFields, 2009) and by the City of Portland respectively, however, the significant majority of the COI load will be represented by the concentration sorbed to sediment rather than the dissolved portion (see Section 2.3). Composite stormwater samples will also be used to estimate loads and compared with sediment trap estimates. Precipitation records for the 2004 and 2005 deployment periods will be reviewed and if the periods were drier than average the upstream sediment concentrations will be corrected to better represent annual average

conditions. This will be performed by estimating the average flow from outfall 53 and average flow in the nearshore portion of the river (i.e. upstream of the site that contributes sediment) and performing a mass balance on TSS and COI concentrations to generate average annual values for use in the recontamination analysis.

Evaluating load

The contribution of COIs by upstream sources will be calculated by first estimating the sediment load due to upstream sources. The net sedimentation rate estimated for the subarea can be used to calculate a net mass of sediment gained/lost from the subarea on an annual basis, as:

$$M_{net\ gain,RAA} = R_{deposition} * A_{slip} * \rho_b$$

where the net gain of sediment in the Removal Action subarea is $M_{net\ gain,\ RAA}$,

$R_{deposition}$ is the average annual rate of sediment deposition,

A_{RAA} is the area of the Removal Action subarea, and

p_b is the sediment bulk density.

The net sediment gain should then equal the sum of the individual source sediment contributions:

$$M_{net\ gain,RAA} = \sum M_{sources}$$

The primary sources of sediment to the Removal Action Areas are upstream and stormwater. The load of sediment contributed by upstream sources can be deduced by subtracting the sediment load from stormwater sources from the total net sediment gain for the Removal Action subarea.

Uncertainty

Use of the average annual sedimentation rate to calculate the net sediment gained in the Removal Action subarea and ultimately to deduce the sediment load contributed by the upstream sources make this source load term dependent on the accuracy of the average annual net sedimentation rate. Uncertainties related to this value are described in Section 3.1.1.1. Deployment of the mid-Willamette sediment trap extended from January to March 2005 only. This time interval does not span the season flow changes in the river, when more or less sediment may be transported. However, since the sediment trap data is being used for the COI concentration only, and not the mass loading, the extent of this uncertainty should be minimized.

3.1.3.2 *Stormwater*

Stormwater runoff suspends sediment from paved and unpaved areas and transports this sediment through the stormwater drainage system to the Removal Action Areas. The effects of stormwater discharge will be evaluated based on the revised configuration proposed as discussed in the 60% Design Analysis Report (see Figure 2-2). Table 3-5 summarizes which basins discharge stormwater to which Removal Action subareas under the reconfigured plan.

Table 3-5: Summary of stormwater basins and the Removal Action subareas that they may affect.

Removal Action Subarea	Stormwater Basin
1 – Berth 414 MNR Area	D
2 – Berth 414 Dredge and Cap Area	D
3 – Slip 3 Cap Area	J, K
4 – Slip 3 Dredge Area	J, K
5 – Wheeler Bay Cap Area	L
6 – Wheeler Bay MNR Area	L
7 – Toe of Slip 1 MNR Area	M
8 – Berth 401 MNR Area	N, O, Q, R, S, T
9 – Berth 401 Cap Area	N, O, Q, R, S, T

Data to be used

Stormwater and stormwater sediment was sampled as part of a stormwater characterization program conducted by the Port between 2007 and 2008. This program is presented in the Final Terminal 4 Slips 1 and 3 Stormwater Data Summary Report (ACA and NewFields, 2009) and summarized in Tables 3-6 and 3-7. The stormwater characterization program was conducted in response to stormwater data gaps identified in the Recontamination Analysis prepared by BBL in 2006. Sampling procedures were based on the field sampling plan developed by Anchor Environmental and Integral Consulting for the LWG Round 3A stormwater sampling (LWG, 2007). In-line sediment traps were deployed twice in Basins D, L, M, and R for a period of approximately five months (January to June 2007) and another period of approximately five months (September/October 2007 to February 2008). Bulk stormwater samples were retrieved from drainage lines in Basins D, L, M, Q and R using programmable composite samplers. The composite samplers collected samples on a flow- or time-weighted basis to capture multiple storm events throughout the sampling period. Stormwater from basins J, K, O, N, and S was not sampled, based on a combination of the following factors: similar land use to other basins, limited historical and current land use, a small percentage of the overall drained area, and a lack of surface sources. The rationale for

selection of basins for additional sampling is due to their potential to be significant sources of COIs and is described further in the DEQ approved Storm Water Evaluation Work Plan (ACA and NewFields, 2007b). Composite storm water and sediment trap samples from the city outfall 53 were obtained in 2007 and by the City of Portland in early 2008, but will be considered when evaluating the upstream load (see Section 3.1.3.1).

BBL also collected stormwater sediment data for the Recontamination Analysis conducted in 2006, however, since the 2007-2008 dataset is more complete and seasonally non-biased, this data will be utilized for the analysis. Annual rainfall was measured by the Portland HYDRA network data. The average annual rainfall from the 50th percentile flow year, 2002, was used in the loading calculation (Anchor QEA, 2009). The land cover impervious fraction is estimated in the Removal Action Area EE/CA (BBL, 2005a). Basin areas are provided in the Final Terminal 4 Slips 1 and 3 Stormwater Data Summary Report (ACA and NewFields, 2009).

Table 3-6: Summary of stormwater composite water data.

Monitoring Location	Date Sampled	Cadmium		Lead		Pyrene		Benz(a)anthracene		Benzo(a)pyrene		Indeno(1,2,3-cd)pyrene		Dibenz(a,h)anthracene		Total PCB		TSS
		Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	
		Concentrations in µg/L (ppb)														Concentrations in pg/L (ppq)		Concentrations in mg/L (ppm)
Basin D	3/24/2007	0.13	0.03	31.4	0.168	0.082	0.0065 J	0.040	0.0047 J	0.052	<0.020	0.057	<0.020	0.013 J	<0.020	--	--	14
Basin D	4/7/2007	--	--	--	--	0.081	0.032	0.067	0.019 J	0.054	0.018 J	0.089	0.020	0.041	0.0070 J	--	--	6
Basin D	5/3/2007	0.125	0.056 J2	40.3	0.843 J2	0.037	0.049	0.019 J J3	0.022 J2 J3	0.019 J J3 J6	0.03 J2 J6	0.027 J3	0.037 J2	0.0094 J J3 J2	0.0092 J J2 J3	--	--	19
Basin D - Dup	5/3/2007	0.105	0.077 J2	37.5	2.69 J2	0.037	0.040	0.017 J J3	0.015 J J2 J3	0.021 J3 J6	0.018 J J2 J3 J6	0.020 J3	0.017 J J2 J3	0.0050 J J3 J2	0.0042 J J2 J3	--	--	--
Basin D	5/20/2007	0.115	0.042 B	26.2 N	0.60 N	--	--	--	--	--	--	--	--	--	--	--	--	--
Basin D	11/16/2007	0.079	0.051	9.03	0.372	0.052	--	<0.0028	--	0.023	--	0.03	--	<0.0027	--	8,830 B	2,000 B	6
Basin D - Dup	11/16/2007	--	--	--	--		--	--	--	--	--	--	--	--	--	8,590 B	--	--
Basin D	1/15/2008	--	--	--	--	--	--	--	--	--	--	--	--	--	--	14,900 B	569	--
Basin D	1/26/2008	--	--	--	--	--	--	--	--	--	--	--	--	--	--	12,200 B	1,210 B	--
Basin L	3/24/2007	0.42	< 0.02	31	0.111	2.7	0.08	1.6	0.048	2.2	0.05	2.7	0.063	0.54	0.014 J	112,000	--	108
Basin L	5/3/2007	0.576	0.036 B	43	0.36	2.4	1.6	1.3	0.80	2.0 J6	1.3 J6	2.5	1.7	0.56	0.36	104,000 I	11,300 B I	207
Basin L	5/20/2007	1.81	0.336	50.3 N	0.328 N J4	3.9	1.1	2.7	0.58	3.7	0.86	3.8	0.93	0.84	0.18	231,000 B	--	309
Basin L	9/28/2007	0.968	0.036 J2	47.4	0.447	1.0	--	0.57	--	0.87	--	0.97	--	0.21	--	135,000	--	80
Basin M	3/24/2007	0.79	< 0.02	104	0.35	1.2	0.41	0.5	0.2	0.36	0.15	0.3	0.12	0.068	0.024	103,000	--	117
Basin M	4/7/2007	--	--	--	--	0.25	0.25	0.15	0.17	0.19	0.27	0.18	0.31	0.038	0.061	505,000 B	--	35
Basin M	5/3/2007	0.36	0.122	36.1	0.984	0.16	0.25	0.096	0.14	0.15 J6	0.23 J6	0.19	0.26	0.041	0.058	204,000 I	--	66
Basin M	5/20/2007	0.434	0.152	26.4 N	0.871 N	--	--	--	--	--	--	--	--	--	--	--	--	
Basin M	9/28/2007	0.262	0.057	26.3	0.281	0.14	--	0.062	--	0.072	--	0.08	--	0.018 J	--	44,100	--	39
Basin Q	3/24/2007	0.61 J2	0.13	19.2 J2	0.149	0.83	--	0.29	--	0.39	--	0.47	--	0.094	--	95,600	--	89
Basin Q - Dup	3/24/2007	0.39 J2	0.16	13.7 J2	0.15	0.81	--	0.31	--	0.42	--	0.50	--	0.097	--		--	--
Basin Q	4/7/2007	--	--	--	--	0.16	0.20	0.069	0.089	0.078	0.11	0.083	0.12	0.018 J	0.026	38,600 B	--	15
Basin Q	9/28/2007	0.451	0.28	21.5	0.584	0.083	0.03	0.033	0.014 J J3	0.044	0.016 J	0.053	0.02	0.012 J	0.0049 J	28,900	2970	572
Basin R	3/24/2007	0.68	0.30	9.26	0.586	0.021 J	0.011 J	0.011 J	0.0062 J	0.0077 J	<0.024	0.0059 J	0.0042 J	<0.027	<0.024	28,400 I	--	50
Basin R	4/7/2007	--	--	--	--	0.049	0.025	0.018 J	0.011 J	0.017 J	0.0070 J	0.032	0.0089 J	0.0080 J	<0.020	63,100 B I	--	90
Basin R	5/3/2007	39.8	0.92	2,480	4.35	0.60	0.098	0.29	0.044	0.37 J6	0.050 J6	0.43	0.059	0.11	0.014 J J3	1,660,000	7,770 B	2,300
Basin R	5/20/2007	16.2	0.11	1,070 N	6.11 N	--	--	--	--	--	--	--	--	--	--	--	--	--
Basin R	11/16/2007	0.537	0.296	13.8 J2	0.527	0.065 J2	--	0.031	--	0.033	--	0.033	--	<0.0026	--	34,900 B	--	15
Basin R - Dup	11/16/2007	0.416	0.288	7.04 J2	0.531	0.041 J2	--	<0.0027	--	<0.0045	--	<0.0027	--	<0.0026	--	--	--	--
Basin T	3/24/2007	0.21 J1	0.07	25 J1	0.10	0.20	0.0051 J	0.082	<0.020	0.092	<0.020	0.12	<0.020	0.029	<0.020	81,600	--	80
Basin T	4/7/2007	--	--	--	--	--	--	--	--	--	--	--	--	--	--	38,500 B	--	--
Basin T - Dup	5/3/2007	--	--	--	--	--	--	--	--	--	--	--	--	--	--	52,500 I J2	1,290 B	--
Basin T	5/20/2007	0.232	0.101	13.8 N	0.384 N	0.056	0.067	0.022 J1	0.026 J2 J1	0.024 J3	0.028 J2 J3	0.027 J1	0.030 J2 J1	0.0062 J J1 J2	0.0076 J J2 J1			68
Basin T	11/16/2007	0.109	0.045	6.15	0.612	0.057	--	<0.003	--	<0.0049	--	<0.003	--	<0.0029	--	25,100 B	"--	7

Data from Terminal 4 Stormwater Data Summary Report, Ash Creek and NewFields, 2009.

Notes:

1. Metals analysis by EPA Method 6020.
2. Mercury analysis by EPA Method 7470 A
3. Polynuclear Aromatic Hydrocarbons by EPA Method 8270 C SIM
4. PCB Congeners by EPA Method 1668
5. Total Suspended Solids (TSS) by EPA Method 160.2 or SM 2540D.
6. µg/L (ppb) = micrograms per liter (part per billion)
7. pg/L (ppq) = picograms per liter (part per quadrillion)
8. mg/L (ppm) = milligrams per liter (parts per million)
9. Bolded values indicate detected concentrations
10. B = This result is an estimated concentration that is less than the Method Reporting Limit (MRL) and greater than the Method Detection Limit (MDL)
11. J = The results is an estimated concentration that is below the Method Reporting Limit (MRL) and above the Method Detection Limit (MDL)
12. J2 = The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample. The precision goal of 30% was exceeded for this analyte by the results from the field duplicate or the lab duplicate.
13. J3 = The detected concentration of this analyte is equal to or less than 5 times the concentration detected in the method blank.
14. J4 = The detected concentration of this analyte is equal to or less than 5 times the concentration detected in the filter blank.
15. J6 = The laboratory control sample/laboratory control sample duplicate (LCS/LCSD) recovery for this analyte exceeded the control criteria.
16. N = The Matrix Spike sample recovery is not within control limits
17. I = Chemical interference.
18. * = Sample specific detection limit. Detection limits were calculated for non-detected toxic congeners.

Table 3-7: Summary of stormwater sediment trap data.

Monitoring Location	Date Sampled	Cadmium	Lead	Pyrene	Benz(a)anthracene	Benzo(a)pyrene	Indeno(1,2,3-cd)pyrene	Dibenz(a,h)anthracene	Total PCB
		Concentrations in mg/kg (ppm)		Concentrations in μg/kg (ppb)					Concentrations in ng/kg (ppt)
Basin D	1/22/2007 - 6/27/2007 9/20/2007 - 2/15/2008	1.37	713	3,200	2,200	2,500	1,900	1,300	264,000
Basin L	1/25/2007 - 6/27/2007 9/20/2007 - 2/15/2008	4.00	190	33,000	22,000	31,000	27,000	5,300	852,000
Basin M	1/23/2007 - 6/27/2007 9/20/2007 - 2/15/2008	1.39	140	5,000	3,100	4,500	3,600	690	304,000
Basin R	1/23/2007 - 6/27/2007 10/5/2007 - 2/15/2008								1,400,000
Basin T	1/25/2007 - 6/27/2007 10/5/2007 - 2/15/2008	1.56	432 J	2,400	1,200	1,500	2,200	610	661,000

From the Terminal 4 Slips 1 and 3 Stormwater Data Summary Report (Ash Creek, 2009)

Notes:

1. Polynuclear Aromatic Hydrocarbons by EPA Method 8270 C SIM
2. PCB Congeners by EPA Method 1668
3. Metals analysis by EPA Method 6020. Aluminum analysis by EPA Method 6010. Mercury analysis by EPA Method 7470A.
4. μg/kg (ppb) = micrograms per kilogram (part per billion)
5. ng/kg (ppt) = nanograms per kilogram (part per trillion)
6. mg/kg (ppm) = milligrams per kilogram (part per million)
7. **Bolded** values indicate detected concentrations
8. J = The amount detected is below the Lower Calibration Limit of the instrument.
9. * = Sample specific detection limit. Detection limits were calculated for non-detected toxic congeners.

Evaluating load

The SIMPLE method (Schueler, 1987) is a runoff model that estimates pollutant loading. The SIMPLE method is a simple spreadsheet model that is appropriate for smaller watersheds (less than 640 acres) with limited site data. The entire Terminal 4 facility covers less than 300 acres. The SIMPLE model is the runoff model being used in the harborwide RI/FS for Portland Harbor (LWG, 2009) and is described in detail in the Stormwater Loading Calculation Methods (Anchor, 2009). The SIMPLE model will be used to estimate the volume of stormwater discharging to the river. The load of COIs in stormwater will be calculated based on composite water samples and sediment trap concentrations. Storm events are assumed to produce most of the COI load. The SIMPLE method modifies the volume of water or suspended sediment produced by rainfall events by a runoff coefficient and a fraction of annual rainfall that produces runoff. The runoff coefficient takes the surface cover type into account (i.e. fraction that is impervious).

Runoff can be described as:

$$RO = R * R_v * 0.9$$

where R is the annual rainfall, R_v is the runoff coefficient, and 0.9 is a standard factor representing the percentage of rainfall that produces runoff. The runoff coefficient can be described as:

$$R_v = 0.05 + 0.9 * I_a$$

where I_a is the fraction of surface area in the basin that is impervious.

Loads will be estimated from composite water COI concentrations as follows:

$$L = C_w * V$$

where L is the load, C_w is the COI concentration in water and V is the volume of water discharging per unit time. For sediment trap solids concentrations, the load will be calculated as:

$$L = C_s * TSS * V$$

where L is the COI load, C_s is the COI concentration in stormwater sediment trap solids, TSS is the TSS concentration in water and V is the volume of water discharging per unit time. Concentrations of organic COIs can be normalized to the organic carbon content in sediment. These methods are consistent with the LWG approach described in the Stormwater Loading Calculation Methods (Anchor, 2009). The assumption that all of the stormwater sediment from the outfall lands in the nearby Removal Action subareas provides a conservative estimate of its recontamination potential.

Uncertainty

The sediment trap deployment period was extended based on data gaps identified during the Recontamination Analysis conducted by BBL in 2006. Two deployment periods were used in order to obtain enough sample mass for analysis and to capture the “first flush” storm events that occur in the fall season. The deployment periods adequately (January through June and September/October through February) cover seasonal variations. The dataset used represents only one year, so annual variations may still exist. Uncertainties in the sediment trap concentrations will be balanced by also calculating loads using composite water samples. Both calculation methods will be used in order to obtain a full range of values to be considered. These methods are discussed in more detail in the Round 3A Stormwater Sampling Rationale report (Anchor and Integral, 2007).

The SIMPLE model is based on urban land use so the runoff coefficient contains uncertainty when applied to an industrial site, however the harborwide RI/FS has determined that the SIMPLE model is the most appropriate for the site (LWG, 2009). COI loads from stormwater basins that were not directly sampled were estimated from other basins with similar land use. Basin sampling was determined based primarily on areas that were likely sources of contamination due to historical activities (ACA/NewFields, 2007). Therefore, when substituting these values for other basins, the resulting total COI load estimate will be conservative. The rationale for selection of basins for additional sampling is due to their potential to be significant sources of COIs and is described further in the DEQ approved Storm Water Evaluation Work Plan (ACA and NewFields, 2007b).

3.2 SEDCAM Recontamination Model for Removal Action Areas

The recontamination analysis assesses the potential for post-Removal Action recontamination of surface sediment within the Removal Action Area using the SEDCAM model (Jacobs et al., 1988). The model estimates COI concentrations in surface sediments (a “mixed layer” of defined thickness) by considering initial conditions (i.e., concentrations immediately after removal action construction is complete) and changes with time due to accumulation, burial and loss from diffusion and chemical degradation (see Figure 3-1).

The model contains several simplifying assumptions or limitations, such as a well-mixed surface sediment layer of defined thickness and a single term covering both chemical degradation and diffusion. It also does not consider advection of pore water explicitly. However, the model’s relative simplicity is one of its main strengths. Use of the SEDCAM model is consistent with the harborwide Feasibility Study approach.

The SEDCAM model was developed for the Washington Department of Ecology to estimate natural recovery of contaminated sediments. It has also been used to give a preliminary estimate of natural recovery of sediments in the Portland Harbor RI/FS (Anchor, 2005). The Pacific Northwest National Laboratory used a form of the SEDCAM model as a screening step to determine if more complex modeling was required for certain contaminants. It has also been used for sediment evaluations at other sites (Jacobs et al., 1988; Ecology, 1991). These previous applications support the use of the SEDCAM model for a screening step at the T4 Removal Action Area.

The SEDCAM model was chosen for the Terminal 4 Recontamination Analysis since it is a conservative model and simple model. Based on the level of detail of available data for model input, a more complex model is not expected to yield more accurate results. The SEDCAM model is easy to implement and will provide a quantitative estimate of many physical processes occurring at the site (LWG, 2005). The SEDCAM model will be utilized as a “first step” as described in Section 1.0, to provide an initial estimate of the potential for each source to cause recontamination of sediments using input values that represent a range of realistic values. The pertinent results of the modeling exercise will be concentration trends and ranges, not specific values predicted based on finite input parameters. If estimates show that recontamination of a particular COI is unlikely, then performance monitoring can be prescribed at an appropriate level. If modeling indicates that recontamination will occur for a COI or if long term sediment monitoring shows higher COI concentrations than predicted by the SEDCAM model, the model will allow for identification of the key sources and/or physical processes influencing the potential for recontamination. In this event, review of input parameters, additional data collection or more complex modeling may be performed to assess whether source controls are warranted. Also, more detailed fate and transport modeling is being conducted as part of the harborwide FS and these results will contribute to the understanding of physical processes at T4. The results from the harborwide fate and transport modeling will be reviewed before additional modeling of recontamination potential at the T4 Removal Action Area is considered. Although more detailed modeling could better represent local hydrodynamic conditions, performance monitoring will guide further action at the site. The extent of modeling needed will be based on the level of information needed to support site risk management decisions.

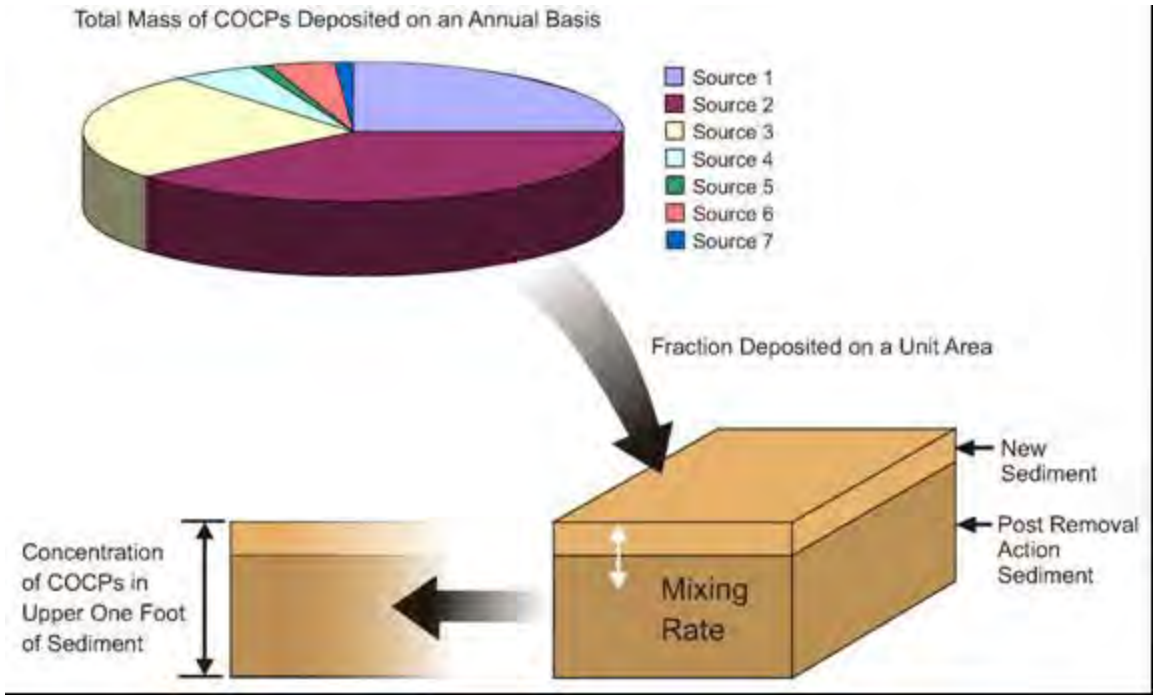

Figure 3-1: Schematic explaning the SEDCAM model.

The form of the SEDCAM model equation presented in the draft Recontamination Analysis (BBL/Arcadis, 2006) was:

$$M_C(t) = \frac{M}{(M+kS)} M_p \left[1 - e^{\frac{-(kS+M)t}{S}} \right] + M_o e^{\frac{-(kS+M)t}{S}}$$

where:

$M_C(t)$ = mass of COI in surface sediment at time t (mg or µg)

M = sedimentation rate (g/cm^2 -yr)

k = combined first-order rate constant for contaminant loss through decay and diffusion processes (yr-1)

M_p = mass of COI in particles being deposited on the sediment (mg or µg)

t = time (yr)

M_o = initial mass of COI in surface sediment (mg or µg)

S = sediment accumulation in the mixed layer (g/cm^2)

To provide clarity on how collected data are used in the analysis, this equation has been converted as follows (see Appendix A):

$$C_C(t) = \frac{1}{(1+kTs)} C_p \left[1 - e^{\frac{-(1+kTs)t}{Ts}} \right] + C_o e^{\frac{-(1+kTs)t}{Ts}}$$

Ts = ML/Rs

where:

$C_c(t)$ = concentration of COI is surface sediment (mixed layer) at time t (mg/kg or µg/kg)

C_p = average concentration of COI in particles being deposited on the sediment (mg/kg or µg/kg)

C_o = average concentration of COI in surface sediment (mixed layer) at time zero (i.e., immediately after sediment removal or capping activities are completed) (mg/kg or µg/kg)

ML = thickness of mixed layer (cm)

Rs = sedimentation rate (cm/year)

C_p represents the average COI in new particles deposited on the sediment. The mass of COI in particles being deposited on the sediment (M_p) is related to concentration (C_p) as follows:

$$M_p = C_p \; M_s$$

where C_p = Average COI concentration on sediment particles

M_s = Mass of sediment particles deposited.

Further

$$C_p = \Sigma C_i M_i / \Sigma M_i$$

where C_i = COI concentration on sediment particles from source "i" (mg/kg)

M_i = mass of sediment particles from source "i" (kg)

And $\Sigma C_i M_i$ is therefore the sum of particulate-based COI load (COI concentration on the particulate multiplied by mass of particulate) for all sources (i.e., individual stormwater upstream sources etc.)

The sediment mass input to the system is equal to the sum of all inputs (i.e., $M_s = \Sigma M_i$) and further for an individual area, the sum of the sediment particle inputs must balance with the total sedimentation rate, such that

$$M_s = Rs \ A_{dep} \ \rho_b$$

3.2.1 SEDCAM Model Parameters

The following sections discuss the remaining input parameters necessary for the SEDCAM model.

3.2.1.1 *Sediment mixed layer thickness*

The mixed layer thickness depends on water velocities, ship traffic, activity of benthic organisms and geochemical processes. This value typically ranges between 0 and 25 cm thick (Ecology, 1991). A range of mixed layer thicknesses will be evaluated based on findings from the RI, as well as site-specific water velocity information. Sediment profile images (SPI) taken of sediment cores collected in late fall 2001 show that bioturbation is commonly found in the first 5 cm of sediment, and that surface sediment disturbance appears to be limited to 30 cm harborwide (LWG, 2009). Bathymetric data also show widespread variability in bed elevation up to 30 cm, suggesting that the top 30 cm of sediment is unconsolidated and susceptible to resuspension and erosion (LWG, 2009). This range is similar to that suggested by Ecology (1991) and this will be evaluated for Terminal 4. The entire range will be evaluated for each sub-area initially. If needed, sub-areas will be assigned mixed layer thicknesses based on the observed pattern of water velocity and shipping patterns. However, the conceptual model does not assume lateral mixing.

3.2.1.2 *Sediment density*

The estimated sediment density used in the Recontamination Analysis will be based on the analysis presented in the harborwide RI/FS (LWG, 2009). As a preliminary estimate, all available sediment specific gravity measurements from river mile 4 to 5 of the Willamette River were considered. An average of 100 specific gravity measurements for surface sediment, represented by sediment from 0 to 30 cm deep, was calculated to be 1.53 g/cc. This preliminary value was calculated from surface sediment only, and so should represent lower density material than the underlying material which has been further compacted, however this value will be revised based on the results of the RI/FS (LWG, 2009).

3.2.1.3 *Initial COI concentration in surface sediment*

The initial COI concentration in surface sediment will be characterized by sampling after the Phase II Removal Action construction is complete. Recontamination will be assessed on a point-by-point basis using the maximum observed value for each COI by subarea.

3.2.1.4 *Degradation Rate*

Degradation rates will be consistent with the most current values used in the harborwide fate and transport modeling being conducted for the RI (i.e. QEA Fate model). For organic analytes in the final analysis, COI concentrations will be evaluated based on the applicable cleanup goal. For example, if the PRG for benzo(a)pyrene is applicable to benzo(a)pyrene equivalent units, the equivalent unit concentration will be calculated for input data from the appropriate PAHs. Degradation rates for each individual PAH will be applied and the final predicted concentration converted into the same units as the applicable PRG, providing that the necessary data is available. To the extent possible, units and degradation rates will be consistent with the RI Feasibility Study.

3.2.1.5 *Area*

The area of each sub-area used for calculation in the SEDCAM model will be estimated in ArcGIS.

3.3 Primary data sources

Data sources to be used for the Recontamination Analysis may include previous reports, site field data, and bathymetric survey data. The following list provides the main data sources available for use in the Recontamination Analysis, organized by data type:

Sedimentation:

- Port of Portland, 2002. Sedimentation at the Port of Portland Terminals. February.
- Anchor Environmental, LLC, 2003. Draft Sediment Stake Erosion/Accretion Monitoring Report, Round 1A, Portland Harbor RI/FS. May.
- Striplin, 2002. Draft Integration of Sediment Trend Analysis Survey Results with Historic Bathymetry in the Lower Willamette River. Striplin Environmental Associates, Inc. April 26.
- Striplin, 2003. Draft Lower Willamette River May 2003 Multibeam Bathymetry Survey Report. Stripling Environmental Associates, Inc. October 8.
- Integral Consulting, Inc. and David Evans Associates, Inc., 2004. Lower Willamette River, Winter 2004, Multibeam Bathymetric Survey Report. September.
- Field sediment trap data acquired by BBL from 2004 to 2005 for Terminal 4.
- Bathymetric surveys conducted in 2001-2002 and 2009

River dynamics:

- BBL, 2004a. Terminal 4 Early Action Characterization Report. September.
- Appendix G: Summary of Hydraulics and Sedimentation Characteristics, in BBL, 2005a. Engineering Evaluation and Cost Analysis.
- Draft RI Report, Lower Willamette Group, October 2009.

River COI concentrations:

- In-water sediment traps (Mid-Willamette, Toyota Dolphin and Outfall 53 sediment traps).

Stormwater COI concentrations:

- Stormwater in-line sediment traps deployed during 2007 and 2008 (ACA and NewFields, 2009).

Additional data sources regarding the evaluation of additional sources of COIs will be evaluated as needed. For example, the Port prepared a storm water source control evaluation report for the Oregon Department of Environmental Quality on the Terminal 4 Slip 1 and Slip 3 Upland Facilities in September 2009.

4.0 EXAMPLE RECONTAMINATION ANALYSIS

To show how the methods and data explained above will be used to estimate sediment recontamination potential at Terminal 4, an example calculation is described below. Although the example follows the prescribed methodology, it is included only for demonstrative purposes and does not represent the final recontamination analysis for this subarea. In many cases, input data in the example calculation are based on preliminary values where data are unavailable. As additional data are acquired, implementation of the methodology will adapt to accommodate the new information.

4.1 Example Setup

The recontamination assessment example was conducted for the main area of Slip 3 to demonstrate implementation of the methodology. Since post-Phase II Removal Action Area surface sediment concentrations have not yet been obtained, the maximum post-Phase I Removal Action dredging in Slip 3 was used as a conservative initial level for this example. The recontamination methodology calls for comparison of sediment concentrations predicted by the SEDCAM model to harborwide cleanup goals, however, since these were not available, the Terminal 4 PRG value from March 2010 was used for the example.

A net average sedimentation rate of 1.0 cm/yr was estimated for the Slip 3 area of Terminal 4 based on review of the available local bathymetric survey data over the time period from 2002 to 2009. The data were corrected for major dredging events that occurred during that time. Although the sedimentation patterns in Slip 3 consist of preferential scour near Pier 4 and accumulation toward Pier 5, the average net sedimentation rate for the slip should represent long-term conditions. Using this rate, a net annual sediment load was calculated for Slip 3 as:

$$M_s = R_s * A * \rho_b$$

where M_s is the annual net mass of sediment deposited, R_s is the average sedimentation rate, A is the area of the Removal Action sub-area and p_b is the sediment bulk density. Using this equation, a net sediment load of 547,245 kg/yr was estimated based on a preliminary estimate of sediment density of 1.53 g/cc (see Section 3.2.1.2).

Sediment load due to stormwater was estimated based on Basins J and K which discharge to Slip 3. Three minor basins also discharge to Slip 3 from the south, however, these will not be evaluated in the example since their size is negligible compared for Basins J and K. The total annual sediment load from stormwater was calculated from measured total suspended solids concentration from a stormwater trap in Basin L (see Section 3.1.3.2). The total sediment load was estimated to be 769 kg/yr. Subtracting the stormwater sediment load from the net sedimentation leaves an upstream sediment

input of 546,476 kg/yr. This indicates that upstream sediment contributes 99.85% of the sediment to Slip 3, while stormwater contributes 0.15%. Because the upstream source dominates, determining the distribution of stormwater sediment that settles in the RAA is unnecessary. In particular, conservatively assuming that all stormwater sediment settles in a particular area does not affect the outcome of the analysis and therefore detailed modeling to refine those estimates is not required.

The example calculation was conducted for lead. The input concentrations of lead from stormwater (190 mg/kg) and upstream sources (27 mg/kg from the mid-Willamette sediment trap) were used to calculate a weighted average lead concentration based on their relative sediment contributions. The SEDCAM model was conducted for 30 years on a 1-year time step.

4.2 Recontamination Analysis for Slip 3 dredged area

The following sections describe the data input into the SEDCAM model as well as the example model results, uncertainties and a brief sensitivity analysis. Input values used in this example are not necessarily the final input values for this subarea. The example is to demonstrate the implementation of the methodology, not to provide recontamination analysis results.

4.2.1 Summary of model inputs

Model inputs are summarized in Table 4-1. The mixed layer thickness is an assumed value of approximately 0.5 feet (15 cm). No degradation rate was used for lead, which is consistent with the harborwide fate and transport modeling being conducted for the RI (i.e. QEA Fate model).

Since grain size information has not been acquired for stormwater transported sediment, a conservative assumption was made that all stormwater solids from the applicable basins would land in the Slip 3 dredged area.

Table 4-2 shows the calculation used to estimate the weighted average COI concentration from the two input sources: stormwater and upstream. Stormwater loading in this example was calculated based on sediment trap solids concentrations only. This value was more conservative than the composite water estimate. As the Table 4-2 shows, the estimated sediment input from upstream sources is three orders of magnitude larger than the measured stormwater sediment input. Based on the relative magnitude of the upstream and stormwater sources, the upstream sediment input will dominate the sedimentation in the Removal Action Area, thus detailed stormwater sediment deposition modeling is not warranted.

Table 4-1: Summary of model input values for the example calculation.

Model Input Values		
Area of Removal Action sub-area	385,000	ft^2
Total load of sediment to sub-area[1]	547,245	kg/yr
Weighted average input Lead concentration[2]	27.33	mg/kg
Mixing layer thickness[3]	15	cm
Lead degradation rate	0.00E+00	yr^{-1}
Initial concentration at maximum point in sub-area[4]	1,850	mg/kg
Time step	1	yr

[1]*Based on an annual net sedimentation rate of 1 cm/yr.*
[2]*Weighted average of stormwater and upstream source inputs based on relative magnitude of sediment load.*
[3]*Assumed value.*
[4]*Maximum post-Phase I construction concentration for Slip 3.*

Table 4-2: Weighted average COI concentration calculation.

	Sedimentation Rate (kg/yr)	**COPC Concentration (mg/kg)**	**Weighted COPC load (kg/yr)**
Stormwater sedimentation input rate	769	190	0.146
Upstream sedimentation input rate	546,476	27.1	14.81
Net sedimentation	547,245	***27.33***	15.0

4.2.2 SEDCAM modeling results

The SEDCAM model was conducted for a 30 year time period on a 1-year time step. Table 4-3 summarizes the predicted surface sediment concentration by year. Figure 4-1 shows the results graphically, compared to the Terminal 4 March 2010 PRG value.

The results show that for lead, surface sediment concentration will decrease from the initial concentration used in this example. The initial lead concentration exceeded the PRG, however decreasing concentrations will require a significant amount of time before the goal concentration can be achieved. This result is conservative and consistent with site observations. Based on the definition of recontamination presented in Section 1.4, decreasing concentrations indicate no recontamination.

Table 4-3: SEDCAM model predicted sediment concentrations of lead in the Slip 3 dredged area.

Years elapsed	Maximum concentration of Lead at any point in Slip 3, $C_c(t)$ (mg/kg)
0	1,850
1	1,673
2	1,514
3	1,370
4	1,239
5	1,122
6	1,016
7	920
8	833
9	755
10	685
11	621
12	563
13	511
14	464
15	422
16	384
17	349
18	318
19	290
20	264
21	241
22	221
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24	185
25	170
26	156
27	143
28	132
29	122
30	113

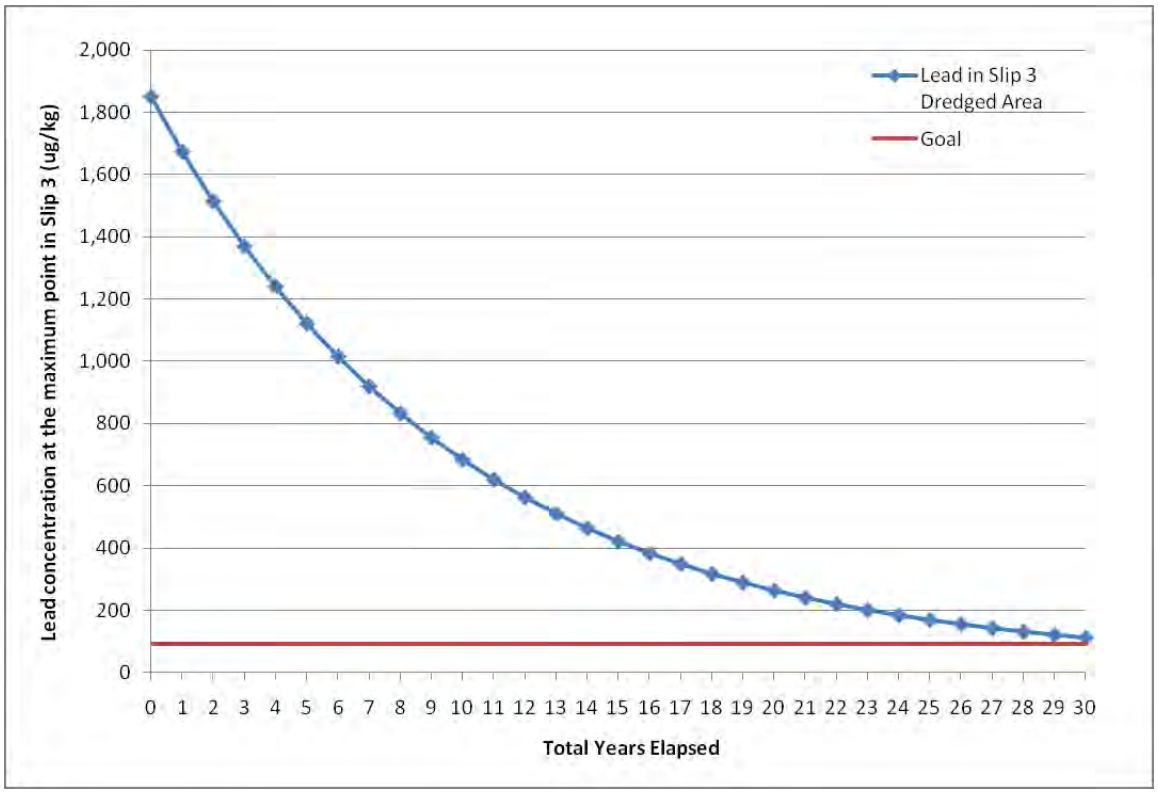

Figure 4-1: Results of example SEDCAM recontamination analysis for lead in the dredged area of Slip 3. The goal level indicates the Terminal 4 PRG value from March 2010.

4.2.3 Uncertainties

The SEDCAM model requires that a number of assumptions be made. It was assumed that sediment in the top 0.5 feet throughout the Removal Action subarea would be completely mixed. This assumption is supported by observations indicating that propeller wash affects areas within the slip beyond the direct line of vessel traffic, and may be responsible for significant sediment resuspension (BBL, 2005a). The weighted average input concentration also assumes that stormwater sediment input and upstream sediment input is completely mixed within the Removal Action subarea. Degradation rates will be consistent with the harborwide fate and transport modeling. Loading of upstream sediment into Slip 3 was estimated based on the net sedimentation rate, calculated by comparison of available bathymetric surveys over time. The multibeam sonar technology used for obtaining bathymetric measurements has a vertical measurement error of +/- 0.25 ft. The value of 1 cm/yr was estimated as a conservative value based on the available data. Other data uncertainties were reviewed in Section 3.

4.2.4 Sensitivity analysis

A simple sensitivity analysis was performed on the SEDCAM model using the example from the previous sections. The mixed layer thickness, COI degradation rate, input COI concentration and net sedimentation rate were tested. Table 4-4 summarizes the results of the sensitivity analysis.

The results show that the model is moderately sensitive to decreases in mixed layer thickness, input concentration and sedimentation rate and to increases in the degradation rate. However, for the sensitive variables, an overall reduction in recontamination potential is predicted. The results suggest that the estimated values used in the example analysis provide a conservative estimation of recontamination potential.

Table 4-4: Results of sensitivity analysis performed on SEDCAM model using lead as an example COI and the Slip 3 dredged area as an example analysis subarea. N/A indicates that the resulting change was less than one order of magnitude.

Sensitivity analysis	Increase/Reduction in predicted concentration and number of orders of magnitude of change from original scenario after:
	30 years
Mixed layer thickness	
Minimum of range (5 cm)	Reduction, 1
Maximum of range (30 cm)	N/A
Degradation rate	
Increase (0.001 yr-1)	Reduction, 1
Input Concentration	
Decrease 10x (185 mg/kg)	Reduction, 1
Increase 10x (18,500 mg/kg)	N/A
Net sedimentation rate	
Decrease 10x (0.1 cm/yr)	N/A
Increase 10x (10 cm/yr)	Reduction, 1

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APPENDIX A

SEDCAM Model Equation Conversion

APPENDIX A – SEDCAM Model Equation Conversion

For this analysis, the SEDCAM model was used to estimate future sediment COI mass. The mass of COI at some time after natural recovery begins can be estimated as follows (Jacobs et al., 1988):

$$M_C(t) = \frac{M}{(M + kS)} M_p \left[1 - e^{\frac{-(kS+M)t}{S}} \right] + M_o e^{\frac{-(kS+M)t}{S}}$$

Where:

$M_C(t)$ = mass of COI in surface sediment at time t (mg or µg)

M = sedimentation rate (g/cm^2-yr)

k = combined first-order rate constant for contaminant loss through decay and diffusion processes (yr^{-1})

M_p = mass of COI in particles being deposited on the sediment (mg or µg)

t = time (yr)

M_o = initial mass of COI in surface sediment (mg or µg)

S = sediment accumulation in the mixed layer (g/cm^2)

The total accumulation of sediment in the mixed layer (S) is calculated as follows:

$$S = ML \times \rho_b$$

Where:

ML = thickness of mixed layer (cm)

ρ_b = bulk density of sediment (g/cm^3)

Bulk density is related to particle density (ρ_p) as follows

$$\rho_p = \rho_b \times (1-\Phi)$$

where Φ = porosity of sediment (cm^3 voids/cm^3 material)]

This equation was converted to physical/chemical parameters that are directly measured or estimated in the recontamination study:

$C_C(t)$ = concentration of COI in surface sediment at time t (mg/Kg or µg/Kg)

C_p = concentration of COI in particles being deposited on the sediment (mg/Kg or µg/Kg)

C_o = initial concentration of COI in surface sediment (mg/Kg or µg/Kg)

Rs = sedimentation rate (cm/year)

The relationships used in the conversions were:

$$Mc\ (t) = Cc(t) \times A_{dep} \times ML \times \rho_b$$

$$M = Rs \times \rho_b$$

Where:

Cc(t) = concentration of a contaminant in sediment at time t (mg/kg or µg/kg)

A_{dep} = area of the sediment deposition in Removal Action Subarea (cm^2)

ML = thickness of mixed layer (cm)

Conversion of the individual terms is as follows:

$$M/(M + kS) = Rs\ \rho_b / (Rs\ \rho_b + k\ ML\ \rho_b)$$

$$= Rs/(Rs + k\ ML)$$

Defining a parameter that is the number of years of sedimentation that corresponds to the thickness of the mixed layer:

$$Ts = ML/Rs$$

Therefore

$$M/(M + kS) = 1/(1 + kTs)$$

Similarly

$$(kS + M)/S = (k\ ML\ \rho_b + Rs\ \rho_b)/ ML\ \rho_b$$

$$= (k\ ML + Rs)/ML$$

$$= (k\ Ts + 1)/ Ts$$

Inserting these terms into the SEDCAM equation yields.

$$C_C(t) = \frac{1}{(1+kTs)} C_p \left[1 - e^{\frac{-(1+kTs)t}{Ts}} \right] + C_o e^{\frac{-(1+kTs)t}{Ts}}$$

The mass of COI in particles being deposited on the sediment (Mp) is related to concentration (Cp) as follows:

Mp = Cp Ms

Where Cp = Average COI concentration on sediment particles

Ms = Mass of sediment particles deposited.

Further

Cp = Σ Ci Mi / Σ Mi

And Ms = Σ Mi

Where Ci = COI concentration on sediment particles from source i (mg/Kg)

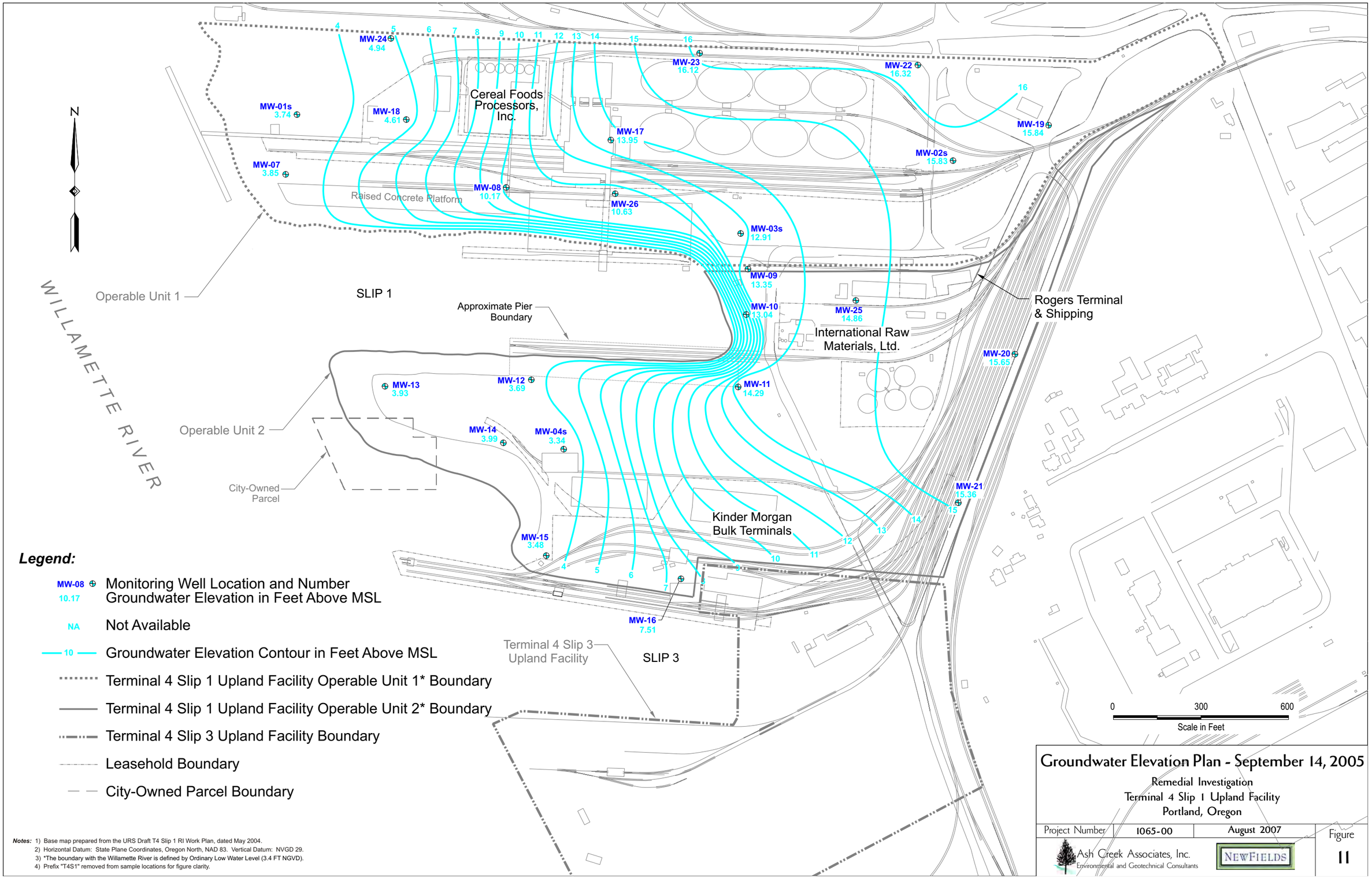
Mi = mass of sediment particles from source i (Kg)

The sum of the sediment particle inputs must balance with the total sedimentation rate, such that

$Ms = Rs \ A_{dep} \ \rho_b$

APPENDIX B

Groundwater Chemistry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WILLAMETTE RIVER
Operable Unit 1
Operable Unit 2
City-Owned Parcel
SLIP 1
SLIP 3
Approximate Pier Boundary
Raised Concrete Platform
Cereal Foods Processors, Inc.
International Raw Materials, Ltd.
Kinder Morgan Bulk Terminals
Rogers Terminal & Shipping
Terminal 4 Slip 3 Upland Facility
MW-01s 3.74
MW-07 3.85
MW-18 4.61
MW-24 4.94
MW-08 10.17
MW-26 10.63
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MW-23 16.12
MW-22 16.32
MW-19 15.84
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MW-09 13.35
MW-10 13.04
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MW-11 14.29
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MW-13 3.93
MW-14 3.99
MW-04s 3.34
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MW-21 15.36
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Legend:
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Terminal 4 Slip 1 Upland Facility Operable Unit 2* Boundary
Terminal 4 Slip 3 Upland Facility Boundary
Leasehold Boundary
City-Owned Parcel Boundary
Notes: 1) Base map prepared from the URS Draft T4 Slip 1 RI Work Plan, dated May 2004.
2) Horizontal Datum: State Plane Coordinates, Oregon North, NAD 83. Vertical Datum: NVGD 29.
3) *The boundary with the Willamette River is defined by Ordinary Low Water Level (3.4 FT NGVD).
4) Prefix "T4S1" removed from sample locations for figure clarity.
Groundwater Elevation Plan - September 14, 2005
Remedial Investigation
Terminal 4 Slip 1 Upland Facility
Portland, Oregon
Project Number 1065-00
August 2007
Figure 11
Ash Creek Associates, Inc.
Environmental and Geotechnical Consultants
NEWFIELDS

TABLE 14A
GROUNDWATER CHEMISTRY RESULTS: POLYNUCLEAR AROMATIC HYDROCARBONS - OU1

REMEDIAL INVESTIGATION
PORT OF PORTLAND - TERMINAL 4 SLIP 1

			PAHs (µg/L)																			
Sample Location:	**Sample ID:**	**Date Sampled:**	Naphthalene	1-Methylnaphthalene	2-Methylnaphthalene	Acenaphthylene	Acenaphthene	Dibenzofuran	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benz(a)anthracene	Chrysene	Benzo(b)fluoranthene	Benzo(k)fluoranthene	Benzo(a)pyrene	Indeno(1,2,3-cd)pyrene	Dibenz(a,h)anthracene	Benzo(g,h,i)perylene
T4S1MW01s	T4S1MW01s-GW-1	4/21/2004	0.0078 J	--	--	0.025 U	0.025 U	--	0.025 U	0.0036 J	0.0078 J	0.0041 J	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U
T4S1MW01s	T4S1MW01s-GW-1	9/1/2004	0.033	--	0.016 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.0098 J	0.020 U	0.0043 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U
T4S1MW01s	T4S1MW01s-GW-1	2/3/2005	0.0087 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.0060 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U
T4S1MW01s	T4S1MW01s-GW-1	5/4/2005	0.0075 J	0.020 U	0.0029 J	0.020 U	0.020 U	0.020 U	0.020 U	0.0044 J	0.0045 J	0.0052 J	0.0054 J	0.0022 J	0.0028 J	0.0026 J	0.0018 J	0.0018 J	0.020 U	0.020 U	0.020 U
T4S1MW02s	T4S1MW02s-GW-1	4/20/2004	0.011 J	--	--	0.0028 J	0.0033 J	--	0.0054 J	0.015 J	0.010 J	0.011 J	0.010 J	0.0073 J	0.0062 J	0.0043 J	0.0043 J	0.0032 J	0.0024 J	0.023 U	0.023 U
T4S1MW02s	T4S1MW02s-GW-1	9/2/2004	0.021	--	0.0067 J	0.020 U	0.020 U	0.020 U	0.020 U	0.0058 J	0.002 J	0.0038 J	0.0052 J	0.020 U	0.0018 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U
T4S1MW02s	T4S1MW02s-GW-1	2/2/2005	0.040 U	0.040 U	0.040 U	0.040 U	0.040 U	0.040 U	0.040 U	0.040 U	0.040 U	0.040 U	0.040 U	0.040 U	0.040 U	0.040 U	0.040 U	0.040 U	0.040 U	0.040 U	0.040 U
T4S1MW02s	T4S1MW02s-GW-1	5/5/2005	0.029 U	0.02 U	0.011 J	0.020 U	0.020 U	0.020 U	0.020 U	0.0075 J	0.0043 J	0.0058 J	0.005 J	0.020 U	0.0014 J	0.020 U	0.020 U	0.020 U	0.020 U, J	0.020 U, J	0.020 U
T4S1MW03s	T4S1MW03s-GW-1	4/21/2004	0.0058 J	--	--	0.0022 J	0.025 U	--	0.0044 J	0.014 J	0.056	0.01 J	0.0082 J	0.0038 J	0.0042 J	0.0035 J	0.025 U	0.0023 J	0.0023 J	0.025 U	0.025 U
T4S1MW03s	T4S1MW03s-GW-1	8/30/2004	0.020	--	0.0072 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.051	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U
T4S1MW03s	T4S1MW03s-GW-1	1/31/2005	2.0 U	--	0.012 U	0.011 U	0.0088 U	0.014 U	0.012 U	0.023 J	0.090 J	0.013 U	0.015 U	0.012 U	0.014 U	0.020 U	0.020 U	0.016 U	0.024 U	0.031 U	0.020 U
T4S1MW03s	T4S1MW03s-GW-1	5/5/2005	0.02 U	0.02 U	0.0038 J	0.002 J	0.020 U	0.020 U	0.020 U	0.0038 J	0.076	0.0055 J	0.0042 J	0.0034 J	0.0028 J	0.0025 J	0.020 U	0.0022 J	0.020 U, J	0.020 U, J	0.020 U
T4S1MW07	T4S1MW07-GW-1	4/20/2004	0.0072 J	--	--	0.025 U	0.025 U	--	0.025 U	0.0089 J	0.021 J	0.0079 J	0.0065 J	0.0029 J	0.025 U	0.0027 J	0.025 U	0.0021 J	0.025 U	0.025 U	0.025 U
T4S1MW07	T4S1MW07-GW-1	8/27/2004	0.0087 J	--	0.02 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.014 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U
T4S1MW07	T4S1MW07-GW-1	2/2/2005	2.0 U	--	0.012 U	0.011 U	0.0088 U	0.014 U	0.012 U	0.022 J	0.036 J	0.027 J	0.030 J	0.067 J	0.051 J	0.11 J	0.084 J	0.069 J	0.024 U	0.031 U	0.034 J
T4S1MW07	T4S1MW07-GW-1	5/4/2005	0.042	0.02 U	0.0084 J	0.020 U	0.020 U	0.020 U	0.020 U	0.0036 J	0.014 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U, J	0.020 U, J	0.020 U
T4S1MW08	T4S1MW08-GW-1	4/21/2004	0.0082 J	--	--	0.024 U	0.0088 J	--	0.01 J	0.04	0.065	0.034	0.031	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U
T4S1MW08	T4S1MW08-GW-1	8/30/2004	0.032	--	0.013 J	0.020 U	0.0057 J	0.020 U	0.0055 J	0.014 J	0.015 J	0.014 J	0.011 J	0.0026 J	0.0031 J	0.0022 J	0.0015 J	0.0016 J	0.020 U	0.0028 J	0.020 U
T4S1MW08	T4S1MW08-GW-1	2/3/2005	0.071	0.028	0.029	0.0042 J	0.020 U	0.020 U	0.020 U	0.0044 J	0.056	0.0060 J	0.0062 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U
T4S1MW08	T4S1MW08-GW-1	5/4/2005	0.0048 J	0.2 U	0.023	0.0022 J	0.0041 J	0.020 U	0.0079 J	0.025	0.036	0.024	0.019 J	0.0051 J	0.0068 J	0.0036 J	0.0047 J	0.0033 J	0.0031 J	0.020 U, J	0.020 U
T4S1MW15	T4S1MW15-GW-1	5/4/2005	0.02 U	0.020 U	0.0029 J	0.020 U	0.020 U	0.020 U	0.020 U	0.0044 J	0.0045 J	0.0052 J	0.0054 J	0.0022 J	0.0028 J	0.0026 J	0.0018 J	0.0018 J	0.020 U, J	0.020 U, J	0.020 U
T4S1MW17	T4S1MW17-GW-1	4/20/2004	0.0046 J	--	--	0.023 U	0.023 U	--	0.023 U	0.023 U	0.0056 J	0.023 U	0.023 U	0.023 U	0.023 U	0.023 U	0.023 U	0.023 U	0.023 U	0.023 U	0.023 U
T4S1MW17	T4S1MW17-GW-1	9/2/2004	0.017 J	--	0.0046 J	0.0019 J	0.020 U	0.020 U	0.020 U	0.020 U	0.014 J	0.020 U	0.020 U	0.020 U	0.0013 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U
T4S1MW17	T4S1MW17-GW-1	2/1/2005	2.0 U	--	0.012 U	0.011 U	0.0088 U	0.014 U	0.012 U	0.020 J	0.016 J	0.027 J	0.022 J	0.012 U	0.014 U	0.020 U	0.020 U	0.016 U	0.024 U	0.031 U	0.020 U
T4S1MW17	T4S1MW17-GW-1	5/4/2005	0.02 U	0.0036 J	0.02 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.013 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U, J	0.020 U, J	0.020 U
T4S1MW18	T4S1MW18-GW-1	4/21/2004	0.0080 J	--	--	0.025 U	0.025 U	--	0.025 U	0.0071 J	0.011 J	0.006 J	0.005 J	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U
T4S1MW18	T4S1MW18-GW-1	9/1/2004	0.026	--	0.0083 J	0.020 U	0.020 U	0.020 U	0.020 U	0.0036 J	0.0034 J	0.020 U	0.0028 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U
T4S1MW18	T4S1MW18-GW-1	2/1/2005	2.0 U	--	0.012 U	0.011 U	0.0088 U	0.014 U	0.012 U	0.026 J	0.020 J	0.034 J	0.015 U	0.012 U	0.014 U	0.020 U	0.020 U	0.016 U	0.024 U	0.031 U	0.019 U
T4S1MW18	T4S1MW18-GW-1	5/6/2005	0.020 U	0.0050 J	0.0040 J	0.020 U	0.020 U	0.020 U	0.020 U	0.0053 J	0.0078 J	0.0056 J	0.0042 J	0.0029 J	0.0022 J	0.0023 J	0.0017 J	0.0021 J	0.0025 J	0.0022 J	0.020 U
T4S1MW19	T4S1MW19-GW-1	9/15/2004	0.018 J	--	0.017 J	0.020 U	0.0043 J	0.020 U	0.0061 J	0.01 J	0.015 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U
T4S1MW19	T4S1MW19-GW-1	2/9/2005	0.065	0.015 J	0.020 J	0.0047 J	0.020 U	0.020 U	0.0058 J	0.012 J	0.014 J	0.0068 J	0.0092 J	0.0041 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U
T4S1MW19	T4S1MW19-GW-1	5/9/2005	0.027	0.0090 J	0.0062 J	0.020 U	0.0020 J	0.020 U	0.0035 J	0.011 J	0.0065 J	0.011 J	0.010 J	0.0033 J	0.0050 J	0.0039 J	0.0040 J	0.0044 J	0.0035 J	0.020 U, J	0.020 U
T4S1MW22	T4S1MW22-GW-1	9/2/2004	0.015 J	--	0.0057 J	0.0034 J	0.020 U	0.020 U	0.020 U	0.011 J	0.012 J	0.0079 J	0.006 J	0.020 U	0.0022 J	0.0022 J	0.002 J	0.0018 J	0.0026 J	0.0018 J	0.020 U
T4S1MW22	T4S1MW22-GW-1	2/4/2005	0.051	0.0081 J	0.013 J	0.0034 J	0.020 U	0.020 U	0.020 U	0.0048 J	0.021	0.020 U	0.0042 J	0.0045 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U
T4S1MW22	T4S1MW22-GW-1	5/6/2005	0.11 J	0.033	0.025	0.0029 J	0.0027 J	0.020 U	0.0041 J	0.0043 J	0.0096 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U, J	0.020 U, J	0.020 U
T4S1MW23	T4S1MW23-GW-1	9/2/2004	0.012 J	--	0.0053 J	0.002 J	0.019 U	0.019 U	0.0035 J	0.023	0.014 J	0.016 J	0.014 J	0.019 U	0.019 U	0.019 U	0.019 U	0.019 U	0.019 U	0.019 U	0.019 U
T4S1MW23	T4S1MW23-GW-1	2/4/2005	0.045	0.0067 J	0.010 J	0.020 U	0.020 U	0.020 U	0.020 U	0.0041 J	0.032	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U
T4S1MW23	T4S1MW23-GW-1	5/6/2005	0.020 U	0.0037 J	0.0039 J	0.020 U	0.020 U	0.020 U	0.020 U	0.0048 J	0.023	0.0065 J	0.0053 J	0.020 U	0.0024 J	0.0022 J	0.0017 J	0.0020 J	0.020 U, J	0.020 U, J	0.020 U
T4S1MW24	T4S1MW24-GW-1	9/1/2004	0.041	--	0.018 J	0.020 U	0.020 U	0.020 U	0.003 J	0.008 J	0.0051 J	0.0072 J	0.0058 J	0.02 U	0.0027 J	0.0026 J	0.0017 J	0.0018 J	0.020 U	0.020 U	0.020 U
T4S1MW24	T4S1MW24-GW-1	2/3/2005	0.29 U	--	0.012 U	0.011 U	0.0088 U	0.014 U	0.012 U	0.044 J	0.043 J	0.049 J	0.056 J	0.036 J	0.038 J	0.14 J	0.13 J	0.14 J	0.057 J	0.042 J	0.062 J
T4S1MW24	T4S1MW24-GW-1	5/6/2005	0.020 U	0.0086 J	0.0058 J	0.020 U	0.020 U	0.020 U	0.0026 J	0.0054 J	0.013 J	0.0062 J	0.0048 J	0.0025 J	0.0027 J	0.0032 J	0.0023 J	0.0025 J	0.0027 J	0.020 U, J	0.020 U
T4S1MW26	T4S1MW26-GW-1	9/16/2005	0.100 U	--	--	0.100 U	0.100 U	--	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.200 U	0.100 U
	Preliminary	**Fish Consumption SLV**	--	--	--	--	990	--	5,300	--	40,000	140	4,000	0.018	0.018	0.018	0.018	0.018	0.018	0.018	--
	Screening Levels	**Aquatic SLV**	620	--	--	--	520	3.7	3.9	6.3	13	6.16	--	0.027 [a.]	--	--	--	0.014	--	--	--

Notes:
1. Only detected compounds are reported in the table. The complete analyte list is presented in the Sampling and Analysis Plan (Appendix A) of the RI Work Plan (Hart Crowser, 2004a).
2. PAHs = Polynuclear Aromatic Hydrocarbons by EPA Method 8270C (SIM).
3. µg/L = Micrograms per liter.
4. Fish Consumption SLV = EPA National Recommended Water Quality Criteria: 2002 Human Health for Consumption of Fish.
5. Aquatic SLV = EPA National Recommended Water Quality Criteria: 2002 for CCC Freshwater Biota (noted with [a.]). Where CCC values are not available, Oregon Department of Environmental Quality Level II Screening Level Values (SLVs) for Surface Water Aquatic are listed.
6. -- = No screening level available or not analyzed.
7. J = The result is an estimated concentration that is less than the method reporting limit (MRL) but greater than or equal to the method detection limit (MDL).
8. U = The compound was analyzed for but was not detected at or above the MRL/MDL.
9. Boxed values indicate that the detected concentration exceeds the Ecological Screening Criteria.
10. Shaded values indicate that the detected concentration exceeds the EPA AWQC criteria.

TABLE 14B
GROUNDWATER CHEMISTRY RESULTS: POLYNUCLEAR AROMATIC HYDROCARBONS - OU2

REMEDIAL INVESTIGATION
PORT OF PORTLAND - TERMINAL 4 SLIP 1

			PAHs (µg/L)																		
Sample Location:	**Sample ID:**	**Date Sampled:**	Naphthalene	1-Methylnaphthalene	2-Methylnaphthalene	Acenaphthylene	Acenaphthene	Dibenzofuran	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benz(a)anthracene	Chrysene	Benzo(b)fluoranthene	Benzo(k)fluoranthene	Benzo(a)pyrene	Indeno(1,2,3-cd)pyrene	Dibenz(a,h)anthracene	Benzo(g,h,i)perylene
T4S1MW04s	T4S1MW04s-GW-1	4/19/2004	0.0083 J	--	0.025 U	0.025 U	0.025 U	--	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U
T4S1MW04s	T4S1MW04s-GW-1	8/31/2004	0.019 J	--	0.008 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U
T4S1MW04s	T4S1MW04s-GW-1	2/8/2005	0.0082 J	--	0.019 U	0.019 U	0.019 U	0.019 U	0.019 U	0.019 U	0.019 U	0.019 U	0.019 U	0.019 U	0.019 U	0.019 U	0.019 U	0.019 U	0.019 U	0.019 U	0.019 U
T4S1MW04s	T4S1MW04s-GW-1	5/9/2005	0.017 J	0.0085 J	0.013 J	0.0019 J	0.0020 U	0.0071 U	0.0031 J	0.0061 J	0.0019 J	0.014 J	0.014 J	0.0076 J	0.0086 J	0.0060 J	0.0065 J	0.0048 J	0.0043 J	0.0017 U, J	0.0040 J
T4S1MW09	T4S1MW09-GW-1	4/20/2004	0.0087 J	--	--	0.0026 J	0.0028 J	--	0.004 J	0.0075 J	0.05	0.0081 J	0.0078 J	0.0062 J	0.0045 J	0.0043 J	0.0045 J	0.003 J	0.0025 J	0.022 U	0.0036 J
T4S1MW09	T4S1MW09-GW-1	9/1/2004	0.022	--	0.013 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.03	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U
T4S1MW09	T4S1MW09-GW-1	2/9/2005	0.0080 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.0043 J	0.043	0.020 U	0.0042 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U
T4S1MW09	T4S1MW09-GW-1	5/9/2005	0.033	0.0076 J	0.012 J	0.0022 J	0.0020 U	0.0071 U	0.0026 U	0.0081 J	0.025	0.018 J	0.017 J	0.010 J	0.013 J	0.011 J	0.010 J	0.011 J	0.0090 J	0.0017 U, J	0.0094 J
T4S1MW10	T4S1MW10-GW-1	4/19/2004	0.011 J	--	--	0.0019 J	0.027 U	--	0.027 U	0.0047 J	0.087	0.0064 J	0.0050 J	0.027 U	0.027 U	0.027 U	0.027 U	0.027 U	0.027 U	0.027 U	0.027 U
T4S1MW10	T4S1MW10-GW-1	9/1/2004	0.025	--	0.014 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.094	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U
T4S1MW10	T4S1MW10-GW-1	2/4/2005	0.0014 J	0.0039 J	0.0057 J	0.0062 J	0.020 U	0.020 U	0.020 U	0.020 U	0.076	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U
T4S1MW10	T4S1MW10-GW-1	5/9/2005	0.037	0.0090 J	0.014 J	0.0022 J	0.0020 U	0.0071 U	0.0026 U	0.0032 U	0.070	0.0024 U	0.0023 U	0.0021 U	0.0013 U	0.0020 U	0.0014 U	0.0016 U	0.0021 U, J	0.0017 U, J	0.020 U
T4S1MW11	T4S1MW11-GW-1	4/19/2004	0.0068 J	--	--	0.0018 J	0.025 U	--	0.0037 J	0.028	0.027	0.024 J	0.025 J	0.0038 J	0.0041 J	0.025 U	0.025 U	0.0019 J	0.025 U	0.025 U	0.025 U
T4S1MW11	T4S1MW11-GW-1	9/1/2004	0.043	--	0.024	0.0034 J	0.020 U	0.020 U	0.020 U	0.013 J	0.032	0.020	0.028	0.013 J	0.012 J	0.005 J	0.0071 J	0.0089 J	0.0043 J	0.020 U	0.020 U
T4S1MW11	T4S1MW11-GW-1	2/8/2005	0.012 J	--	0.0073 J	0.019 U	0.019 U	0.019 U	0.019 U	0.0059 J	0.015 J	0.019 U	0.0056 J	0.019 U	0.019 U	0.019 U	0.019 U	0.019 U	0.019 U	0.019 U	0.019 U
T4S1MW11	T4S1MW11-GW-1	5/10/2005	0.02 U	0.020 U	0.0030 J	0.0026 J	0.020 U	0.020 U	0.020 U	0.0094 J	0.025	0.016 J	0.023	0.011 J	0.0098 J	0.0053 J	0.0064 J	0.0070 J	0.0062 J	0.0023 J	0.0050 J
T4S1MW12	T4S1MW12-GW-1	4/19/2004	0.0063 J	--	--	0.025 U	0.025 U	--	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U
T4S1MW13	T4S1MW13-GW-1	4/16/2004	0.011 J	0.022 U	0.022 U	0.022 U	0.022 U	--	0.022 U	0.020 J	0.025	0.014 J	0.025	0.0037 J	0.022 U	0.022 U	0.022 U	0.022 U	0.022 U	0.0030 J	0.0044 J
T4S1MW13	T4S1MW13-GW-1	8/31/2004	0.029	--	0.017 J	0.020 U	0.020 U	0.020 U	0.020 U	0.0048 J	0.018 J	0.006 J	0.0097 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U
T4S1MW14	T4S1MW14-GW-1	4/16/2004	0.0067 J	0.023 U	0.023 U	0.023 U	0.023 U	--	0.023 U	0.023 U	0.023 U	0.023 U	0.023 U	0.023 U	0.023 U	0.023 U	0.023 U	0.023 U	0.023 U	0.0032 J	0.0034 J
T4S1MW14	T4S1MW14-GW-1	8/31/2004	0.035	--	0.024	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.0049 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U
T4S1MW14	T4S1MW14-GW-1	2/8/2005	0.0099 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.013 J	0.019 J	0.0058 J	0.0078 J	0.0046 J	0.020 U	0.0048 J	0.020 U	0.0084 J	0.0043 J	0.020 U	0.0043 J
T4S1MW14	T4S1MW14-GW-1	5/10/2005	0.02 U	0.020 U	0.0028 J	0.020 U	0.020 U	0.020 U	0.020 U	0.0042 J	0.0036 J	0.0061 J	0.0055 J	0.0024 J	0.0031 J	0.0030 J	0.0029 J	0.0033 J	0.0041 J	0.020 U	0.020 U
T4S1MW15	T4S1MW15-GW-1	4/16/2004	0.0089 J	0.0056 J	0.020 U	0.020 U	0.0052 J	--	0.020 U	0.0075 J	0.028	0.0085 J	0.022	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U
T4S1MW15	T4S1MW15-GW-1	2/3/2005	0.0087 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.0060 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U
T4S1MW16	T4S1MW16-GW-1	4/19/2004	0.010 J	--	--	0.0045 J	0.0066 J	--	0.0098 J	0.018 J	0.024 J	0.023 J	0.021 J	0.012 J	0.010 J	0.0087 J	0.0084 J	0.0069 J	0.0062 J	0.0058 J	0.0091 J
T4S1MW16	T4S1MW16-GW-1	8/27/2004	0.012 J	--	0.0044 J	0.020 U	0.020 U	0.020 U	0.020 U	0.0042 J	0.027	0.0076 J	0.008 J	0.0048 J	0.0044 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U
T4S1MW16	T4S1MW16-GW-1	2/10/2005	0.056	0.011 J	0.016 J	0.0037 J	0.020 U	0.020 U	0.020 U	0.0067 J	0.027	0.0071 J	0.0081 J	0.0049 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U
T4S1MW16	T4S1MW16-GW-1	5/10/2005	0.0062	0.011 J	0.015 J	0.0052 J	0.0096 J	0.020 U	0.0086 J	0.079	0.027	0.15	0.13	0.075	0.11	0.096	0.087	0.095	0.094 J	0.019 J	0.079
T4S1MW20	T4S1MW20-GW-1	9/2/2004	0.14	--	0.015 J	0.0099 J	0.018 J	0.020 U	0.018 J	0.075	0.022	0.023	0.024	0.0074 J	0.0076 J	0.0045 J	0.0043 J	0.0059 J	0.0034 J	0.020 U	0.020 U
T4S1MW20	T4S1MW20-GW-1	2/10/2005	0.074	0.024	0.024	0.020 U	0.020 U	0.020 U	0.0072 J	0.015 J	0.031	0.012 J	0.016 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U
T4S1MW20	T4S1MW20-GW-1	5/11/2005	0.025	0.0029 J	0.0040 J	0.020 U	0.020 U	0.020 U	0.020 U	0.0071 J	0.020	0.017 J	0.016 J	0.0092 J	0.010 J	0.010 J	0.0062 J	0.0088 J	0.0086 J	0.0022 J	0.0076 J
T4S1MW21	T4S1MW21-GW-1	9/2/2004	0.015 J	--	0.0058 J	0.0022 J	0.0056 J	0.020 U	0.0046 J	0.021	0.011 J	0.013 J	0.012 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U
T4S1MW21	T4S1MW21-GW-1	2/10/2005	0.072	0.026	0.027	0.0038 J	0.0058 J	0.0050 J	0.0075 J	0.0098 J	0.027	0.0066 J	0.0089 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U
T4S1MW21	T4S1MW21-GW-1	5/11/2005	0.0088 J	0.020 U	0.0027 J	0.020 U	0.020 U	0.020 U	0.020 U	0.0044 J	0.026	0.020	0.018 J	0.020 U	0.0019 J	0.020 U	0.020 U	0.020 U	0.020 U, J	0.020 U, J	0.020 U
T4S1MW25	T4S1MW25-GW-1	11/9/2005	0.476 U	--	--	0.476 U	0.476 U		0.244 J, D	0.0952 U	0.0952 U	0.0952 U	0.0952 U	0.0952 U	0.0952 U	0.0952 U	0.0952 U	0.0952 U	0.0952 U	0.190 U	0.0952 U
	Preliminary	**Fish Consumption SLV**	--	--	--	--	990	--	5,300	--	40,000	140	4,000	0.018	0.018	0.018	0.018	0.018	0.018	0.018	--
	Screening Levels	**Aquatic SLV**	620	--	--	--	520	3.7	3.9	6.3	13	6.16	--	0.027 [a]	--	--	--	0.014	--	--	--

Notes:

1. Only detected compounds are reported in the table. The complete analyte list is presented in the Sampling and Analysis Plan (Appendix A) of the RI Work Plan (Hart Crowser, 2004a).
2. PAHs = Polynuclear Aromatic Hydrocarbons by EPA Method 8270C (SIM).
3. µg/L = Micrograms per liter.
4. Fish Consumption SLV = EPA National Recommended Water Quality Criteria: 2002 Human Health for Consumption of Fish.
5. Aquatic SLV = EPA National Recommended Water Quality Criteria: 2002 for CCC Freshwater Biota (noted with [a]). Where CCC values are not available, Oregon Department of Environmental Quality Level II Screening Level Values (SLVs) for Surface Water Aquatic are listed.
6. -- = No screening level available or not analyzed.
7. J = The result is an estimated concentration that is less than the method reporting limit (MRL) but greater than or equal to the method detection limit (MDL).
8. U = The compound was analyzed for but was not detected at or above the MRL/MDL.
9. Boxed values indicate that the detected concentration exceeds the Ecological Screening Criteria.
10. Shaded values indicate that the detected concentration exceeds the EPA AWQC criteria.

TABLE 19A
GROUNDWATER CHEMISTRY RESULTS: METALS - OU1

REMEDIAL INVESTIGATION
PORT OF PORTLAND - TERMINAL 4 SLIP 1

			Total Metals (µg/L)												
Sample Location:	**Sample ID:**	**Date Sampled:**	Antimony	Arsenic	Beryllium	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Thallium	Zinc
T4S1MW08	T4S1MW08-GW-1	5/4/2005	0.05 U	0.38 B	0.033	0.02 J	14.6	3.76 U	0.52 U	0.2 U	12.5	1.0 U	0.006 B	0.02	9.38
T4S1MW08	T4S1MW08-GW-1	9/16/2005	3.0 U	1.00 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	0.20 U	0.540 J	0.400 J	1.0 U	1.0 U	3.26 J
T4S1MW17	T4S1MW17-GW-1	5/4/2005	0.03 B	0.24 B	0.020 U	0.02	0.94	2.6 J	0.11	0.14 B	8	0.1 B	0.02 U	0.02 U	6.18
T4S1MW17	T4S1MW17-GW-1	9/16/2005	3.0 U	1.00 U	1.0 U	1.0 U	1.0 U	0.530 J	1.0 U	0.20 U	5.64	0.370 J	1.0 U	1.0 U	5.15 J
T4S1MW19	T4S1MW19-GW-1	9/15/2004	0.04 B,N	2.4	0.014 B	0.02	0.66	0.82	0.133	0.2 U	4.83	5 U	0.01 B	0.02 U	3.1
T4S1MW19	T4S1MW19-GW-1	2/9/2005	0.02 B	2.1	0.076	0.148	5.92	5.24	1.160	0.20 U, J	10.2	0.9 B	0.015 B	0.011 B	10.7
T4S1MW19	T4S1MW19-GW-1	5/9/2005	0.03 B	1.81	0.018 B	0.26	7.34	3.55	0.35	0.2 U	7.76	1 B	0.020 U	0.017 B	14.1
T4S1MW22	T4S1MW22-GW-1	9/2/2004	0.05 U	0.3 B	0.008 B	0.04	0.22	0.79	0.056	0.2 U	8.75	1 U	0.02 U	0.009 B	2.5
T4S1MW22	T4S1MW22-GW-1	2/4/2005	0.02 B	0.2 B	0.010 B	0.111	0.22	0.63 J	0.082	0.2 U	5.95	1.0 U	0.020 U	0.011 J	1.5
T4S1MW22	T4S1MW22-GW-1	5/6/2005	0.037 B	0.2 J	0.006 B	0.108	0.27 U	0.45 B	0.153	0.20 U	2.96 J	1.0 U	0.020 U	0.02 U	1.63 J
T4S1MW23	T4S1MW23-GW-1	9/2/2004	0.05 U	3.6	0.02 U	0.02 U	0.27	0.39	0.089	0.2 U	3.73	1 U	0.024	0.02 U	3.3
T4S1MW23	T4S1MW23-GW-1	2/4/2005	0.02 B	4.3	0.020 U	0.02 U	0.2 U	0.27 J	0.044	0.2 U	2.32	1.0 U	0.020 U	0.020 U, J	1.3
T4S1MW23	T4S1MW23-GW-1	5/6/2005	0.042 B	3.4 J	0.011 B	0.287	1.72	1.01	0.282	0.20 U	2.13 J	1.0 U	0.02 U	0.02 U	3.87 J
T4S1MW24	T4S1MW24-GW-1	9/1/2004	0.06	1.4	0.01 B	0.03	0.74	1.1	0.268	0.2 U	13.4	3 B	0.02 U	0.011 B	7.5
T4S1MW24	T4S1MW24-GW-1	2/3/2005	0.02 B	0.5 U	0.011 B	0.052	0.41	1.69 J	0.034	0.20 U	10.5	1.0 U	0.020 U	0.020 U, J	4.4
T4S1MW24	T4S1MW24-GW-1	5/6/2005	0.264 B	0.2 J	0.009 B	0.120	1.44	2.16	0.211	0.20 U	9.94 J	0.2 B	0.020 U	0.020 U	5.34 J
T4S1MW26	T4S1MW26-GW-1	9/16/2005	3.0 U	9.80	1.0 U	1.0 U	1.0 J	1.0 J	1.0 J	0.20 U	3.23	1.35	1.0 U	1.0 U	5.70 J
	Preliminary	**Fish Consumption SLV**	640	0.14	--	--	--	--	--	--	4,600	4,200	--	6.3	26,000
	Screening Levels	**Aquatic SLV**	1,600	150 [a.]	5.3	0.25	74 [III.], 11 [VI.]	9 [a.]	2.5 [a.]	0.77 [a.]	52 [a.]	5 [a.]	0.12	40	120 [a.]

			Dissolved Metals (µg/L)												
Sample Location:	**Sample ID:**	**Date Sampled:**	Antimony	Arsenic	Beryllium	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Thallium	Zinc
T4S1MW08	T4S1MW08-GW-1	5/4/2005	0.05 U	0.13 B	0.020 U	0.02 U	1.4	0.18 U	0.02 U	0.2 U	6.89	1.0 U	0.020 U	0.020 U	4.68 U
T4S1MW08	T4S1MW08-GW-1	9/16/2005	1.01 J	0.230 J	0.110 U	0.100 U	0.0800 J	0.120 J	0.0800 U	0.0500 U	0.460 J	0.320 U	0.0800 U	0.0800 U	2.99 J
T4S1MW17	T4S1MW17-GW-1	5/4/2005	0.03 B	0.17 B	0.020 U	0.03 J	0.79	2.75 J	0.08	0.20 U	7.94	1.0 U	0.020 U	0.02 U	7.62
T4S1MW17	T4S1MW17-GW-1	9/16/2005	0.0400 U	0.310 J	0.110 U	0.100 U	0.390 J	0.440 J	0.0800 U	0.0500 U	5.11	0.320	0.0800 U	0.0800 U	0.800 J
T4S1MW19	T4S1MW19-GW-1	9/15/2004	0.04 B,N	3.1	0.02 U	0.02	2.89	0.51	0.02 U	0.2 U	4.89	5 U	0.02 U	0.02 U	2.3
T4S1MW19	T4S1MW19-GW-1	2/9/2005	0.05 U	1.9	0.006 B	0.083	0.72	0.64	0.461	0.20 U, J	6.95	0.9 B	0.020 U	0.020 U	5.0
T4S1MW19	T4S1MW19-GW-1	5/9/2005	0.03 B	1.85	0.009 B	0.06	2.53	0.75	0.02	0.20 U	7.71	0.8 B	0.007 B	0.015 B	11.5
T4S1MW22	T4S1MW22-GW-1	9/2/2004	0.03 B	0.4 B	0.014 B	0.03	0.66	0.79	0.019 B	0.2 U	8.67	0.4 B	0.02 U	0.009 B	2.8
T4S1MW22	T4S1MW22-GW-1	2/4/2005	0.05 U	0.2 B	0.020 U	0.082 U	0.28	0.54 J	0.069	0.2 U	5.83	1.0 U	0.020 U	0.020 U, J	1.6
T4S1MW22	T4S1MW22-GW-1	5/6/2005	0.028 B	0.2 J	0.020 U	0.067	0.2 U	0.32 B	0.028 U	0.20 U	2.7 J	1.0 U	0.020 U	0.02 U	1.51 J
T4S1MW23	T4S1MW23-GW-1	9/2/2004	0.05 U	3.9	0.02 U	0.02 U	0.36	0.37	0.01 B	0.2 U	4.02	0.5 B	0.02 U	0.004 B	2.7
T4S1MW23	T4S1MW23-GW-1	2/4/2005	0.05 U	3.7	0.020 U	0.039 U	0.2 U	0.32 J	0.067	0.2 U	2.42	1.0 U	0.020 U	0.020 U, J	1.4
T4S1MW23	T4S1MW23-GW-1	5/6/2005	0.023 B	2.1 J	0.020 U	0.158	0.61	0.32 B	0.08	0.20 U	2.98 J	1.0 U	0.020 U	0.02 U	3.07 J
T4S1MW24	T4S1MW24-GW-1	9/1/2004	0.06	1.6	0.011 B	0.06	1.37	1.86	1.78	0.2 U	15	3.6	0.02 U	0.006 B	15.4
T4S1MW24	T4S1MW24-GW-1	2/3/2005	0.02 B	0.5 U	0.010 B	0.057	0.58	1.82 J	0.042	0.2 U	10.4	1.0 U	0.020 U	0.020 U, J	4.0
T4S1MW24	T4S1MW24-GW-1	5/6/2005	0.251 B	0.2 J	0.007 B	0.098	1.12	1.97	0.082	0.20 U	10.5 J	1.0 U	0.020 U	0.02 U	6.36 J
T4S1MW26	T4S1MW26-GW-1	9/16/2005	0.0500 J	10.8	0.110 U	0.100 U	0.990 J	0.420 J	0.120 J	0.0500 U	3.52	0.710 J	0.0800 U	0.080 U	4.82 J
	Preliminary	**Fish Consumption SLV**	640	0.14	--	--	--	--	--	--	4,600	4,200	--	6.3	26,000
	Screening Levels	**Aquatic SLV**	1,600	150 [a.]	5.3	0.25 [a.]	74 [III.], 11 [VI.]	9 [a.]	2.5 [a.]	0.77 [a.]	52 [a.]	5 [a.]	0.12	40	120 [a.]

Please refer to notes at end of table.

TABLE 19A
GROUNDWATER CHEMISTRY RESULTS: METALS - OU1

REMEDIAL INVESTIGATION
PORT OF PORTLAND - TERMINAL 4 SLIP 1

Notes:
1. All analytes are reported in the table.
2. Total/Dissolved Metals using EPA 6000-7000 Series Methods.
3. µg/L = Micrograms per liter.
4. Fish Consumption SLV = EPA National Recommended Water Quality Criteria: 2002 Human Health for Consumption of Fish.
5. Aquatic SLV = EPA National Recommended Water Quality Criteria: 2002 for CCC Freshwater Biota (noted with [a]). Where CCC values are not available, Oregon Department of Environmental Quality Level II Screening Level Values (SLVs) for Surface Water Aquatic are listed.
6. -- = No screening level available or not analyzed.
7. B = The result is an estimated concentration that is less than the MRL but greater than or equal to the method detection limit (MDL).
8. U = The compound was analyzed for but was not detected at or above the MRL/MDL.
9. N = The matrix spike sample recovery is not within control limits. The case narrative suggests that this sample may be biased low.
10. [III.] = SLV for Chromium III.
11. [VI.] = SLV for Chromium VI.
12. Boxed values indicate that the detected concentration exceeds the Ecological Screening Criteria (for chromium, Chromium III used).
13. Shaded values indicate that the detected concentration exceeds the EPA AWQC criteria.

TABLE 19B
GROUNDWATER CHEMISTRY RESULTS: METALS - OU2

REMEDIAL INVESTIGATION
PORT OF PORTLAND - TERMINAL 4 SLIP 1

			Total Metals (µg/L)												
Sample Location:	**Sample ID:**	**Date Sampled:**	Antimony	Arsenic	Beryllium	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Thallium	Zinc
T4S1MW09	T4S1MW09-GW-1	9/1/2004	0.05 U	8.3	0.02 U	0.02 U	0.23	0.52	0.016 B	0.04 B	3.36	0.4 B	0.02 U	0.009 B	0.8
T4S1MW09	T4S1MW09-GW-1	2/9/2005	0.03 B	11.2	0.015 B	0.069 U	2.65	1.30	0.190	0.20 U	5.49	1.0 U	0.027 U	0.008 J	2.6
T4S1MW09	T4S1MW09-GW-1	5/9/2005	0.05 B	10.6	0.052	0.16	6.29	2.88	0.8	0.2 U	7.82	0.1 B	0.006 B	0.015 B	8.11
T4S1MW10	T4S1MW10-GW-1	9/1/2004	0.05 U	0.6	0.024	0.02 U	0.6	1.9	0.156	0.05 B	5.7	0.3 B	0.02 U	0.004 B	2.3
T4S1MW10	T4S1MW10-GW-1	2/4/2005	0.05 U	0.4 B	0.020 U	0.06	0.81	0.62	0.046	0.05 B	3.6	0.3 B	0.020 U	0.020 U	5.5
T4S1MW10	T4S1MW10-GW-1	5/9/2005	0.02 B	0.35 B	0.020 U	0.08	0.43	0.79	0.06	0.2 U	4.61	0.2 B	0.020 U	0.007 B	2.53
T4S1MW11	T4S1MW11-GW-1	04/19/2004	0.03 B	7.6	0.02 U	0.05	0.43	2.13	0.26	0.10 U	4.95	0.8 B	0.01 U	0.018 U	9
T4S1MW11	T4S1MW11-GW-1	9/1/2004	0.04 B	17	0.02 B	0.02	0.37	1.24	0.092	0.04 B	4.64	1 U	0.02 U	0.014 B	2.3
T4S1MW11	T4S1MW11-GW-1	2/8/2005	0.05 U	10.0	0.020 U	0.03	0.26	0.44	0.017 B	0.20 U	3.1	0.2 B	0.020 U	0.020 U	0.6
T4S1MW11	T4S1MW11-GW-1	5/10/2005	0.05 U	6.9 J	0.02 U	0.02 U	0.96	1 U	0.075 U	0.20 U	1.85 J	1.0 U	0.02 U	0.02 U	1.95 U
T4S1MW12	T4S1MW12-GW-1	04/19/2004	0.03 B	2.1	0.03	0.02	0.56	6.36	0.2	0.10 U	3.96	1.2	0.01 U	0.017 B	3.56
T4S1MW12	T4S1MW12-GW-1	8/31/2004	0.05 U	10 U	0.01 B	0.02 U	2.71	0.87	0.13	0.2 U	3.47	5 U	0.02 U	0.02 U	1.6
T4S1MW12	T4S1MW12-GW-1	2/7/2005	0.04 B	1.1	0.006 B	0.03	0.84	0.87	0.062	0.06 B	2.6	0.3 B	0.015 B	0.020 U	6.5
T4S1MW12	T4S1MW12-GW-1	5/9/2005	0.14	3.1	0.036	0.15	12.3	3.74	2.27	0.2 U	11.9	0.2 B	0.020 U	0.008 B	11.5
T4S1MW13	T4S1MW13-GW-1	04/16/2004	0.03 B	15.4	0.02 U	0.02 B	0.66	0.72	0.03	0.10 U	2.3	0.3 B	0.01 B	0.041	1.2
T4S1MW13	T4S1MW13-GW-1	8/31/2004	0.05 U	5.8 B	0.02 U	0.02 U	2.55	0.39	0.02 U	0.2 U	3.51	5 U	0.02 U	0.02 U	0.5 B
T4S1MW13	T4S1MW13-GW-1	2/8/2005	0.05 U	14.2	0.020 U	0.02 U	0.47	0.29	0.030	0.05 B	2.1	1.0 U	0.020 U	0.020 U	1.2
T4S1MW13	T4S1MW13-GW-1	5/10/2005	0.05 U	15.4 J	0.02 U	0.024 U	1.63	0.83 B	0.292	0.20 U	1.97 J	1.0 U	0.02 U	0.02 U	2.73 U
T4S1MW15	T4S1MW15-GW-1	04/16/2004	0.02 U	0.02 U	0.02 U	0.01 B	0.43	1.34	0.05	0.10 U	0.3 B	0.2 U	0.01 U	0.006 B	0.6
T4S1MW15	T4S1MW15-GW-1	8/27/2004	0.05 U	10 U	0.01 B	0.02 U	4.12	1.91	1.1	0.2 U	9.56	5 U	0.02 U	0.02 U	3.1
T4S1MW15	T4S1MW15-GW-1	2/9/2005	0.05 U	0.3 B	0.008 B	0.086	1.36	1.32	0.425	0.20 U, J	9.44	1.0 U	0.020 U	0.020 U	2.3
T4S1MW15	T4S1MW15-GW-1	5/10/2005	0.1 U	2.7 J	0.112	0.056	21.9	9.23	10.9	0.20 U	20.4 J	2.0 U	0.04 U	0.04 U	31.5
T4S1MW16	T4S1MW16-GW-1	04/19/2004	0.06	0.9	0.04	0.18	0.23	4.98	0.11	0.10 U	7.34	1.8	0.03	0.072	9.68
T4S1MW16	T4S1MW16-GW-1	8/27/2004	0.33	0.8	0.058	0.06	1.65	14.3	1.12	0.2 U	4.62	0.5 B	0.02 U	0.01 B	13.7
T4S1MW16	T4S1MW16-GW-1	2/10/2005	0.11	0.5 B	0.011 B	0.222	0.57	3.89	0.689	0.20 U	2.52	0.5 B	0.02 U	0.020 U, J	10.3
T4S1MW20	T4S1MW20-GW-1	9/2/2004	0.05 U	1.9	0.027	0.03	0.85	0.95	0.186	0.2 U	10.8	0.8 B	0.02 U	0.005 B	4.4
T4S1MW20	T4S1MW20-GW-1	2/10/2005	0.05 U	1.5	0.011 B	0.095 U	0.21 U	0.64	0.133	0.20 U	10.1	0.7 B	0.02 U	0.008 J	2.3
T4S1MW20	T4S1MW20-GW-1	5/11/2005	0.05 U	1.1 J	0.02 U	0.038 U	1.37	0.69 B	0.176	0.20 U	7.14 J	1.0 U	0.02 U	0.02 U	2.74 U
T4S1MW21	T4S1MW21-GW-1	9/2/2004	0.05 U	0.2 B	0.017 B	0.04	0.48	0.59	0.056	0.2 U	20.3	0.3 B	0.011 B	0.007 B	3.1
T4S1MW21	T4S1MW21-GW-1	2/10/2005	0.05 U	0.5 U	0.015 B	0.113	0.24 U	0.68	0.100	0.20 U	18.0	0.2 B	0.02 U	0.009 J	4.5
T4S1MW21	T4S1MW21-GW-1	5/11/2005	0.063 U	0.4 J	0.035 U	0.397	3.25	1.48	1.110	0.20 U	11.7 J	1.0 U	0.02 U	0.02 U	5.78 U
	Preliminary	**Fish Consumption SLV**	640	0.14	--	--	--	--	--	--	4,600	4,200	--	6.3	26,000
	Screening Levels	**Aquatic SLV**	1,600	150 [a.]	5.3	0.25	74 [III.], 11 [VI.]	9 [a.]	2.5 [a.]	0.77 [a.]	52 [a.]	5 [a.]	0.12	40	120 [a.]

Please refer to notes at end of table.

TABLE 19B
GROUNDWATER CHEMISTRY RESULTS: METALS - OU2

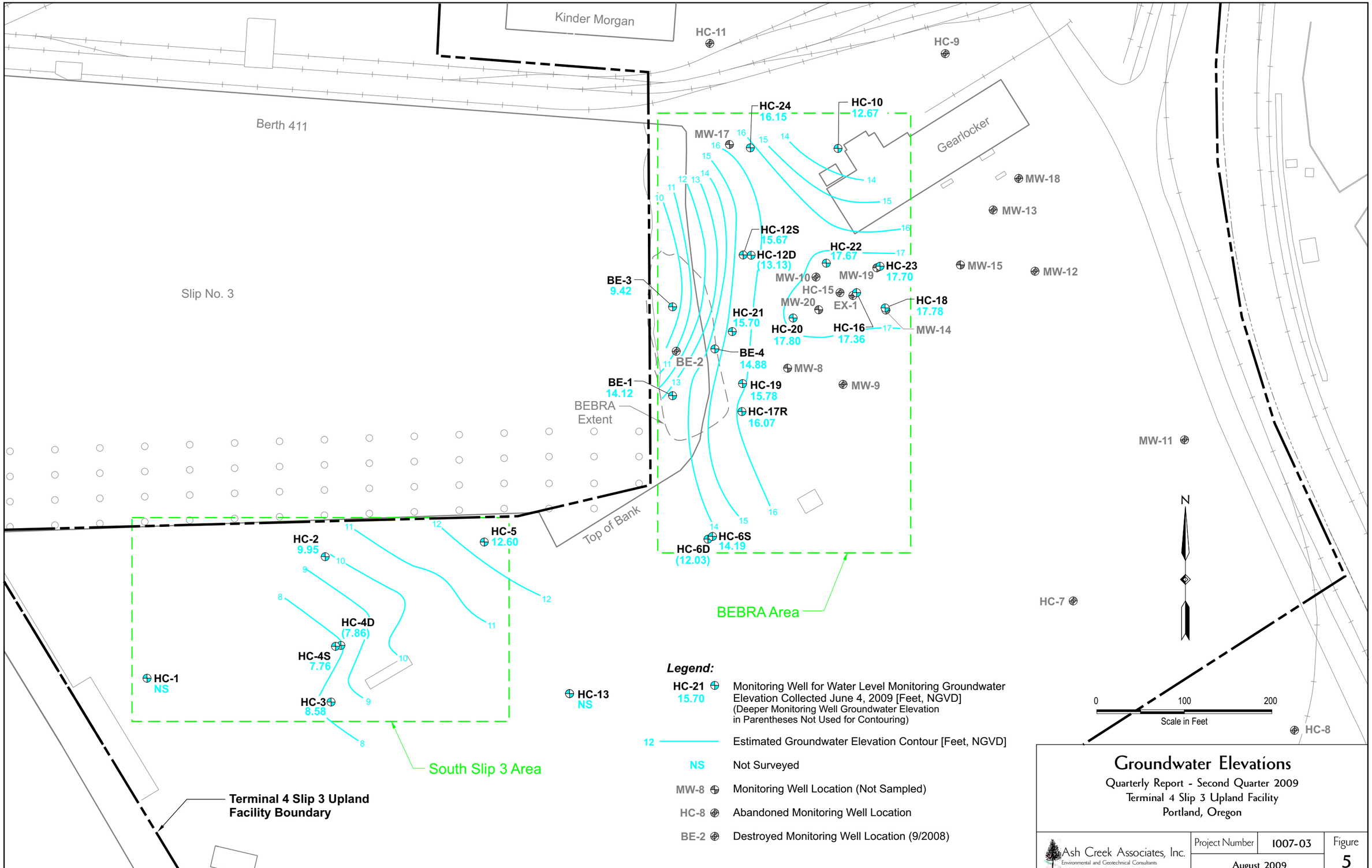
REMEDIAL INVESTIGATION
PORT OF PORTLAND - TERMINAL 4 SLIP 1

			Dissolved Metals (µg/L)												
Sample Location:	**Sample ID:**	**Date Sampled:**	Antimony	Arsenic	Beryllium	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Thallium	Zinc
T4S1MW09	T4S1MW09-GW-1	9/1/2004	0.05 U	8.6	0.02 U	0.02 U	0.57	0.52	0.02 U	0.2 U	3.39	1 U	0.02 U	0.007 B	1
T4S1MW09	T4S1MW09-GW-1	2/9/2005	0.05 U	9.7	0.020 U	0.053	0.91	0.41	0.063	0.20 U	5.45	1.0 U	0.020 U	0.020 U	1.1
T4S1MW09	T4S1MW09-GW-1	5/9/2005	0.05 U	11.5	0.020 U	0.06	1.82	0.55	0.01 B	0.2 U	5.98	1 U	0.020 U	0.007 B	2.01
T4S1MW10	T4S1MW10-GW-1	9/1/2004	0.05 U	0.3 B	0.02 U	0.02 U	0.51	1.37	0.042	0.05 B	6.07	0.4 B	0.02 U	0.02 U	1
T4S1MW10	T4S1MW10-GW-1	2/4/2005	0.05 U	0.4 B	0.020 U	0.04	0.16 B	0.50	0.020 U	0.06 B	3.5	0.3 B	0.020 U	0.020 U	5.5
T4S1MW10	T4S1MW10-GW-1	5/9/2005	0.05 U	0.38 B	0.020 U	0.06	1.17	0.84	0.01 B	0.2 U	5.21	1 U	0.020 U	0.020 U	1.76
T4S1MW11	T4S1MW11-GW-1	04/19/2004	0.13	7.4	0.02 U	0.02	0.09 B	0.69	0.01 U	0.10 U	4.44	0.2 U	0.01 U	0.01 B	2.17
T4S1MW11	T4S1MW11-GW-1	9/1/2004	0.05 U	7.2	0.02 U	0.02 U	0.68	0.52	0.02 U	0.05 B	4.55	1 U	0.02 U	0.02 U	0.9
T4S1MW11	T4S1MW11-GW-1	2/8/2005	0.06	8.0	0.020 U	0.03	0.46	0.33	0.078	0.08 B	3.1	0.4 B	0.020 U	0.020 U	0.8
T4S1MW11	T4S1MW11-GW-1	5/10/2005	0.05 U	6.0 J	0.020 U	0.02 U	0.47	1 U	0.02 U	0.20 U	2.93 J	1.0 U	0.020 U	0.02 U	1.08 U
T4S1MW12	T4S1MW12-GW-1	04/19/2004	0.14	2	0.02 U	0.02 B	0.22	0.82	0.01 B	0.10 U	3.82	1.3	0.01 U	0.015 B	2.65
T4S1MW12	T4S1MW12-GW-1	8/31/2004	0.05 U	10 U	0.02 U	0.02 U	0.93	0.24	0.02 U	0.2 U	2.75	5 U	0.02 U	0.02 U	0.5
T4S1MW12	T4S1MW12-GW-1	2/7/2005	0.05 U	0.6	0.020 U	0.02 U	0.52	0.12	0.020 U	0.09 B	2.6	1.0 U	0.020 U	0.020 U	4.2
T4S1MW12	T4S1MW12-GW-1	5/9/2005	0.02 B	0.55	0.020 U	0.03 J	1.37	0.37	0.03	0.2 U	5.83	1 B	0.020 U	0.020 U	2.82
T4S1MW13	T4S1MW13-GW-1	04/16/2004	0.09	14.6	0.02 U	0.01 U	0.66	0.56	0.01 B	0.10 U	2.4	0.2 U	0.01 U	0.007 B	1.5
T4S1MW13	T4S1MW13-GW-1	8/31/2004	0.05 U	6.4 B	0.02 U	0.02 U	0.75	0.35	0.02 U	0.2 U	3.1	5 U	0.02 U	0.02 U	0.6
T4S1MW13	T4S1MW13-GW-1	2/8/2005	0.05 U	14.4	0.020 U	0.02	0.52	0.18	0.026	0.07 B	2.4	0.2 B	0.020 U	0.020 U	1.3
T4S1MW13	T4S1MW13-GW-1	5/10/2005	0.05 U	12.4 J	0.02 U	0.02 U	0.38 U	1 U	0.022 U	0.20 U	1.05 J	1.0 U	0.02 U	0.020 U	1.01 U
T4S1MW15	T4S1MW15-GW-1	04/16/2004	0.06	0.2 U	0.02 U	0.02	0.47	1.28	0.01 U	0.10 U	0.4	0.2 U	0.01 U	0.006 B	0.5
T4S1MW15	T4S1MW15-GW-1	8/27/2004	0.05 U	10 U	0.02 U	0.02 U	6.8	1.07	0.02	0.2 U	9.45	5 U	0.02 U	0.02 U	0.6
T4S1MW15	T4S1MW15-GW-1	2/9/2005	0.05 U	0.3 B	0.020 U	0.090	1.18	1.00	0.068	0.20 U, J	10.1	1.0 U	0.020 U	0.020 U	1.6
T4S1MW15	T4S1MW15-GW-1	5/10/2005	0.05 U	0.2 J	0.020 U	0.02 U	1.96	1 U	0.023 U	0.20 U	3.36 J	1.0 U	0.02 U	0.020 U	1.60 U
T4S1MW16	T4S1MW16-GW-1	04/19/2004	0.18	0.5	0.02 U	0.14	0.06 U	4.02	0.02	0.10 U	7.19	1.1	0.02 U	0.039	9.18
T4S1MW16	T4S1MW16-GW-1	8/27/2004	0.02 B	0.3 B	0.007 B	0.03	0.46	2.93	0.036	0.05 B	4.18	0.4 B	0.02 U	0.006 B	4.2
T4S1MW16	T4S1MW16-GW-1	2/10/2005	0.05	0.3 B	0.020 U	0.202	0.93	2.16	0.600	0.20 U, J	2.91	0.4 B	0.020 U	0.020 U	4.3
T4S1MW20	T4S1MW20-GW-1	9/2/2004	0.05 U	1.8	0.014 B	0.02	0.25	0.61	0.01 B	0.2 U	10.2	0.6 B	0.02 U	0.005 B	3.2
T4S1MW20	T4S1MW20-GW-1	2/10/2005	0.05 U	1.3	0.011 B	0.075	0.31	0.57	0.070	0.20 U, J	10.2	0.7 B	0.020 U	0.020 U	1.5
T4S1MW20	T4S1MW20-GW-1	5/11/2005	0.05 U	1.4 J	0.02 U	0.027 U	0.80	1 U	0.020 U	0.20 U	7.51 J	1.0 U	0.020 U	0.02 U	2.35 U
T4S1MW21	T4S1MW21-GW-1	9/2/2004	0.05 U	0.3 B	0.013 B	0.04	0.29	0.55	0.035	0.2 U	19.9	0.2 B	0.02 U	0.005 B	3.2
T4S1MW21	T4S1MW21-GW-1	2/10/2005	0.02 B	0.5 U	0.012 B	0.110	0.33	0.65	0.091	0.20 U, J	18.4	1.0 U	0.020 U	0.007 B	4.4
T4S1MW21	T4S1MW21-GW-1	5/11/2005	0.05 U	0.1 J	0.02 U	0.086	0.75	1 U	0.022 U	0.20 U	10.4 J	1.0 U	0.020 U	0.02 U	3.26 U
	Preliminary	**Fish Consumption SLV**	640	0.14	--	--	--	--	--	--	4,600	4,200	--	6.3	26,000
	Screening Levels	**Aquatic SLV**	1,600	150 [a.]	5.3	0.25 [a.]	74 [III.], 11 [VI.]	9 [a.]	2.5 [a.]	0.77 [a.]	52 [a.]	5 [a.]	0.12	40	120 [a.]

Notes:
1. All analytes are reported in the table.
2. Total/Dissolved Metals using EPA 6000-7000 Series Methods.
3. µg/L = Micrograms per liter.
4. Fish Consumption SLV = EPA National Recommended Water Quality Criteria: 2002 Human Health for Consumption of Fish.
5. Aquatic SLV = EPA National Recommended Water Quality Criteria: 2002 for CCC Freshwater Biota (noted with [a.]). Where CCC values are not available, Oregon Department of Environmental Quality Level II Screening Level Values (SLVs) for Surface Water Aquatic are listed.
6. -- = No screening level available or not analyzed.
7. B = The result is an estimated concentration that is less than the MRL but greater than or equal to the method detection limit (MDL).
8. U = The compound was analyzed for but was not detected at or above the MRL/MDL.
9. N = The matrix spike sample recovery is not within control limits. The case narrative suggests that this sample may be biased low.
10. [III.] = SLV for Chromium III.
11. [VI.] = SLV for Chromium VI.
12. Boxed values indicate that the detected concentration exceeds the Ecological Screening Criteria (for chromium, Chromium III used).
13. Shaded values indicate that the detected concentration exceeds the EPA AWQC criteria.

APPENDIX C

Groundwater Analytical Results

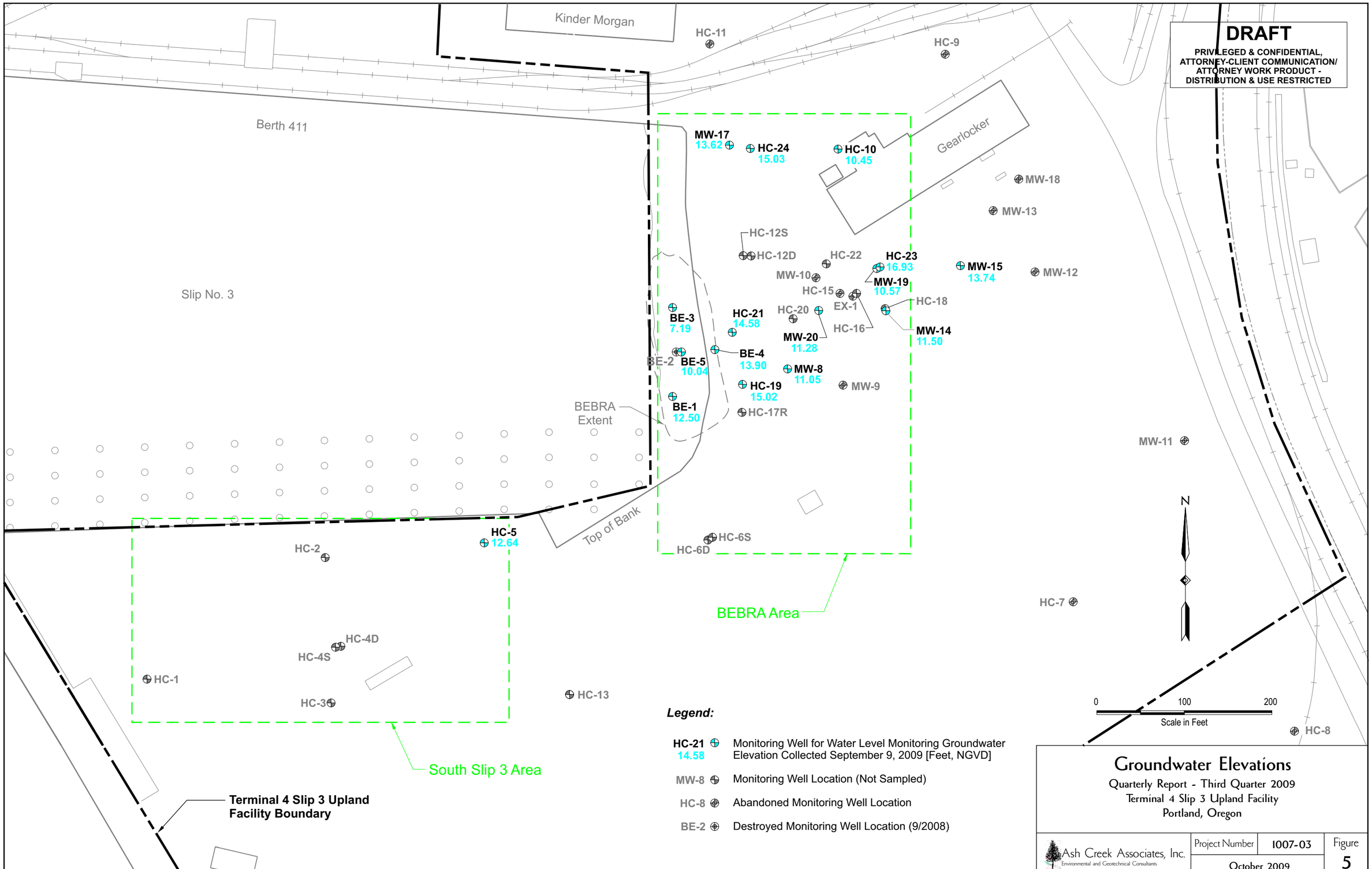


Groundwater Elevations

Quarterly Report - Second Quarter 2009
Terminal 4 Slip 3 Upland Facility
Portland, Oregon

Ash Creek Associates, Inc.
Environmental and Geotechnical Consultants

Project Number	1007-03	Figure
August 2009		5



Groundwater Elevations

Quarterly Report - Third Quarter 2009
Terminal 4 Slip 3 Upland Facility
Portland, Oregon

Ash Creek Associates, Inc.
Environmental and Geotechnical Consultants

Project Number	1007-03	Figure
October 2009		5

TABLE 4
SUMMARY OF GROUNDWATER ANALYTICAL RESULTS
TERMINAL 4 SLIP 3 UPLAND FACILITY
PORT OF PORTLAND

Sample Point	Sample Date	Analyte Concentration in µg/L (ppb)																	
		Total Petroleum Hydrocarbons		Polynuclear Aromatic Hydrocarbons (PAHs)															
		Diesel-Range	Residual-Range	Acenaphthene	Acenaphthylene	Anthracene	BAA	BAP	BBF	BGP	BKF	Chrysene	DAA	Fluoranthene	Fluorene	ICP	Naphthalene	Phenanthrene	Pyrene
South Slip 3 Area																			
HC-2	11/5/1998	--	--	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
	5/10/2004	<250	< 500	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
	2/11/2005	120 J	310 J	< 0.021	--	--	0.0053	< 0.021	--	--	--	--	--	0.0084	< 0.021	--	0.14	0.0069	--
	6/2/2005	20 J	< 500	0.0058 J	0.0055 J	0.027	0.0043 J	0.0044 J	0.0056 J	0.0046 J	0.0042 J	0.0049 J	< 0.020	0.0086 J	0.0094 J	0.0052 J	0.026	0.017 J	0.0075 J
	9/15/2005	<238	< 476	< 0.098	< 0.098	< 0.098	< 0.098	< 0.098	< 0.098	< 0.098	< 0.098	< 0.098	< 0.196	< 0.098	< 0.098	< 0.098	< 0.098	< 0.098	< 0.098
	12/9/2005	<236	< 472	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.190	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952
	6/28/2006	<240	< 481	< 0.0943	< 0.0943	< 0.0943	< 0.0943	< 0.0943	< 0.0943	< 0.0943	< 0.0943	< 0.0943	< 0.189	< 0.0943	< 0.0943	< 0.0943	< 0.0943	< 0.0943	< 0.0943
	6/27/2007	<238	< 476	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.190	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952
	6/12/2008	<236	<472	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.190	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952
	6/4/2009	<238	<476	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.190	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952
HC-5	11/12/1998	--	--	< 2.5	< 2.5	< 0.5	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 2.5	< 0.1	< 0.1	< 0.5	< 0.1
	5/10/2004	**990,000**	< 50,000	< 25	< 25	27.6	**0.742**	< 0.5	< 0.5	< 0.5	< 0.5	1.65	< 1.0	< 25	**86.1**	< 0.5	< 37.5	**43.0**	14.9
	6/10/2004	**102,000**	< 5,000	11.4	< 10	< 10	**0.422**	< 0.25	< 0.25	< 0.5	< 0.25	0.815	< 0.25	< 10	**35.3**	< 0.25	16.8	**17.4**	4.68
	2/11/2005	**26,000 J**	**4,800 J**	0.65	--	--	< 0.02	< 0.02	--	--	--	--	--	0.07	2.9	--	< 0.19	0.28	--
	6/2/2005	**3,200 Y**	< 500	0.26	< 0.064	< 0.37	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.096	2.7	< 0.020	< 0.17	< 0.21	< 0.020
	9/15/2005	**1,510 J**	< 476	0.973	< 0.476	< 0.476	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.190	< 0.0952	**4.21**	< 0.0952	< 0.952	< 0.476	< 0.143
	12/7/2005	**1,940**	< 485	< 0.143	< 0.0952	< 0.238	< 0.0952	< 0.476	< 0.476	< 0.476	< 0.476	< 0.0952	< 0.952	< 0.0952	1.15	< 0.476	< 0.143	< 0.143	< 0.238
	6/28/2006	**2,990**	< 476	< 0.190	< 0.190	< 0.190	< 0.190	< 0.190	< 0.190	< 0.190	< 0.190	< 0.190	< 0.381	< 0.190	1.10	< 0.190	< 0.190	< 0.190	< 0.190
	6/27/2007	856	< 476	0.835	< 0.288	< 0.192	< 0.192	< 0.192	< 0.192	< 0.192	< 0.192	< 0.192	< 0.385	< 0.192	3.08	< 0.192	0.421	< 0.288	< 0.192
	6/12/2008	**1,050 Q11**	<472	0.495	0.476	0.190	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.190	<0.0952	1.55	<0.0952	0.266	<0.190	<0.0952
	6/4/2009	999 Q11	<476	0.279	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.190	<0.0952	1.41	<0.0952	< 0.143	< 0.143	<0.0952
BEBRA Area																			
HC-19	5/10/2004	**10,800**	**1,420**	< 1.5	< 0.5	< 1.25	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 1.0	< 0.5	**4.3**	< 0.5	< 1.75	< 1.0	< 0.5
	2/11/2005	**9,700 J**	**1,800 J**	1.0	--	--	0.014	**0.016**	--	--	--	--	--	0.041	3.1	--	< 0.26	0.054	--
	6/3/2005	510 Y	< 500	0.72	< 0.086	0.21	0.023	**0.034**	0.028	0.025	0.025	0.041	< 0.020	0.076	2.8	0.028	< 0.19	0.17	0.12
	9/15/2005	< 236	< 472	0.961	< 0.476	< 0.476	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.190	< 0.0952	3.48	< 0.0952	< 0.714	< 0.476	< 0.0952
	12/7/2005	< 240	< 481	0.619	< 0.0962	< 0.144	< 0.0962	< 0.0962	< 0.0962	< 0.0962	< 0.0962	< 0.0962	< 0.192	< 0.0962	2.10	< 0.0962	< 0.385	< 0.0962	0.0908 J
	3/14/2006	211	< 481	0.402	< 0.102	< 0.102	< 0.102	< 0.102	< 0.102	< 0.102	< 0.102	< 0.102	< 0.204	< 0.102	1.02	< 0.102	< 0.102	< 0.102	< 0.102
	6/28/2006	**3,940**	598	0.939	< 0.190	< 0.190	< 0.190	< 0.190	< 0.190	< 0.190	< 0.190	< 0.190	< 0.381	< 0.190	2.95	< 0.190	< 0.190	< 0.190	< 0.190
	9/19/2006	< 238	< 476	0.583	< 0.0952	< 0.143	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.190	< 0.0952	1.89	< 0.0952	< 0.143	< 0.0952	< 0.0952
	12/13/2006	610	< 481	0.283	< 0.0962	< 0.0962	< 0.0962	< 0.0962	< 0.0962	< 0.0962	< 0.0962	< 0.0962	< 0.192	< 0.0962	0.698	< 0.0962	< 0.0962	< 0.0962	< 0.0962
	3/29/2007	324	< 476	< 0.143	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.190	< 0.0952	0.660	< 0.0952	< 0.0952	< 0.0952	< 0.0952
	6/27/2007	190 J	< 476	0.660	< 0.0962	< 0.192	< 0.0962	< 0.0962	< 0.0962	< 0.0962	< 0.0962	< 0.0962	< 0.192	< 0.0962	1.87	< 0.0962	< 0.144	< 0.0962	< 0.0962
	9/18/2007	< 236	< 472	0.775	< 0.0952	< 0.190	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.190	< 0.0952	1.95	< 0.0952	< 0.381	< 0.0952	< 0.0952
	12/6/2007	407	< 476	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.190	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952
	3/10/2008	<238	<476	0.472	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.190	<0.0952	0.913	<0.0952	0.120	<0.0952	<0.0952
	6/12/2008	<236	<472	<0.476	<0.476	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.190	<0.0952	1.77	<0.0952	<0.143	<0.0952	<0.0952
	9/8/2008	939 Q11	<481	0.868	<0.192	<0.192	<0.192	<0.192	<0.192	<0.192	<0.192	<0.192	<0.385	<0.192	2.63	<0.192	<0.192	<0.192	<0.192
	12/29/2008	**3,410 Q11**	<500	0.930	<0.0952	<0.143	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.190	<0.0952	2.33	<0.0952	<0.286	<0.0952	<0.0952
	3/10/2009	326 Q11	<476	0.490	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.190	<0.0952	1.06	<0.0952	<0.0952	<0.0952	<0.0952
	6/4/2009	<236	<472	0.155	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.190	<0.0952	0.378	<0.0952	<0.0952	<0.0952	<0.0952
	9/9/2009	<236	<472	0.909	<0.143	<0.143	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.190	<0.0952	3.460	<0.0952	<0.286	<0.0952	<0.0952
HC-21	5/10/2004	**1,210**	< 625	1.95	< 0.5	0.966	**1.43**	**1.63**	1.5	1.44	1.5	1.66	< 1.0	3.4	1.28	1.21	< 0.5	4.38	3.6
	2/11/2005	**13,000 J**	**3,200 J**	0.58	--	--	**3.8**	**5.7**	--	--	--	--	--	4.7	0.94	--	0.18	2.3	--
	6/3/2005	430 Y	< 500	0.30	< 0.059	0.24	**0.62**	**0.95**	0.79	0.82	0.56	0.77	0.22	1.2	0.82	1.1	0.13	0.62	1.3
	9/15/2005	179 J	< 476	< 0.485	< 0.485	< 0.485	**0.410**	**0.515**	0.577	0.283	0.470	0.521	< 0.194	0.679	1.87	0.262	< 0.485	< 0.485	0.925
	12/7/2005	652	< 481	0.495	< 0.0962	< 0.240	**0.259**	**0.397**	0.405	0.252	0.375	0.342	< 0.385	0.403	0.808	0.224	0.172	0.334	0.667
	3/14/2006	221	< 481	< 0.102	< 0.102	< 0.153	**0.242**	**0.244**	0.188	0.156 J	0.184	0.208	< 0.204	0.318	< 0.102	0.156	< 0.102	< 0.204	0.298
	6/28/2006	**2,460**	< 476	1.07	< 0.400	0.840	**4.62**	**5.37**	5.67	4.43	4.02	4.61	1.73	**7.33**	0.996	3.97	0.457	3.21	8.31
	9/19/2006	600	< 476	3.74	< 0.476	3.33	**19.6**	**21.5**	20.6	15.2	17.6	19.8	4.64	**25.1**	3.08	14.4	0.759	**14**	25.8
	12/13/2006	**1,210**	< 481	< 0.0952	< 0.0952	< 0.143	**0.135**	**0.174**	0.167	0.133	0.141	0.122	< 0.190	0.184	< 0.0952	0.125	< 0.0952	< 0.190	0.125
	3/29/2007	< 238	< 476	< 0.0952	< 0.0952	< 0.190	**0.145**	**0.202**	0.186	0.166	0.152	0.175	< 0.190	0.315	< 0.0952	0.153	< 0.0952	< 0.0952	0.192
	6/27/2007	390	< 476	0.745	< 0.476	< 0.476	< 0.476	< 0.476	< 0.476	< 0.476	< 0.476	< 0.476	< 0.952	< 0.476	2.06	< 0.476	< 0.476	< 0.476	< 0.476
	9/18/2007	261	< 472	0.247	< 0.0952	< 0.190	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.190	< 0.190	0.622	< 0.0952	< 0.190	< 0.190	< 0.190
	12/6/2007	582	< 476	< 0.0952	< 0.0952	< 0.0952	**0.0978**	**0.128**	0.116	0.0994	0.106	0.114	< 0.190	0.149	< 0.0952	< 0.0952	< 0.0952	< 0.0952	0.144
	3/10/2008	<238	<476	<0.0952	<0.0952	<0.143	**0.156**	**0.194**	0.220	0.109	0.139	0.169	<0.190	0.218	<0.0952	0.117	<0.0952	<0.143	0.212
	6/12/2008	<236	<472	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.190	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952
	9/8/2008	<240	<481	<0.0962	<0.0962	<0.144	<0.0962	<0.0962	<0.0962	<0.0962	<0.0962	<0.0962	<0.192	<0.144	0.258	<0.0962	<0.0962	<0.144	<0.144
	12/29/2008	**16,100 Q9**	<5,000	<0.190	<0.190	<0.381	<0.190	**0.269**	0.208	<0.190	<0.190	0.276	<0.381	0.279	<0.190	<0.190	1.28	<0.190	0.463
	3/10/2009	569 Q11	< 476	0.336	<0.0952	<0.0952	<0.0952	**0.0619 J**	0.0566 J	<0.0952	0.054 J	<0.0952	<0.190	<0.0952	1.18	<0.0952	<0.0952	<0.0952	0.0939 J
	6/4/2009	**5,070 Q11**	802	0.309	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.190	<0.0952	0.77	<0.0952	<0.0952	0.099	0.144
	9/9/2009	**559 Q11**	<476	0.284	<0.0952	<0.143	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.190	0.121	1.19	<0.0952	<0.429	<0.143	0.171
HC-24	5/10/2004	736	< 500	1.21	< 0.25	< 0.3	< 0.1	**0.118**	0.101	0.101	< 0.1	0.109	< 0.2	0.144	3.51	< 0.1	< 1.5	4.09	0.163
	2/11/2005	**4,500 J**	970 J	1.2	--	--	**0.11**	**0.15**	--	--	--	--	--	0.18	**5.4**	--	< 0.55	1.8	--
	6/6/2005	450 Y	30 J	1.1	< 0.25	0.13	0.021	**0.019 J**	0.019 J	0.015 J	0.018 J	0.022	< 0.020	0.053	**5.0**	0.019 J	< 0.63	2.8	0.071
	9/15/2005	**4,480 J**	536	0.594	< 0.146	< 0.243	**0.288**	**0.370**	0.342	0.247	0.363	0.353	< 0.194	0.427	3.79	0.224	< 0.874	0.698	0.462
	12/7/2005	837	< 481	0.861	< 0.144	< 0.192	< 0.0962	< 0.0962	< 0.0962	< 0.0962	< 0.0962	< 0.0962	< 0.192	< 0.0962	2.83	< 0.0962	< 1.06	1.91	< 0.0962
	3/13/2006	706	< 481	0.441	< 0.153	< 0.102	< 0.102	< 0.102	< 0.102	< 0.102	< 0.102	< 0.102	< 0.204	< 0.102	1.60	< 0.102	< 0.255	1.06	< 0.102
	6/28/2006	**1,020**	< 476	1.99	< 0.377	0.363	**0.996**	**1.10**	1.97 J	0.834	< 0.189 J	0.989	< 0.377	1.49	**6.00**	0.754	< 0.943	4.24	1.34
	9/20/2006	705	< 481	1.49	< 0.481	< 0.481	0.753	0.948	0.935	0.668	0.823	0.82	< 0.962	1.02	**4.35**	0.62	< 0.481	1.00	1.04
	12/13/2006	**1,810**	< 481	2.10	< 0.962	< 0.962	< 0.962	< 0.962	< 0.962	< 0.962	< 0.962	< 0.962	< 1.92	< 0.962	**6.99**	< 0.962	< 1.44	5.73	< 0.962
	3/29/2007	787	< 481	1.01	< 0.190	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.190	< 0.0952	3.43	< 0.0952	< 0.524	1.10	< 0.0952
	6/27/2007 **	**--**	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	9/18/2007	436	< 472	1.05	< 0.286	< 0.190	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.190	< 0.0952	3.53	< 0.0952	< 1.14	1.92	0.12
	12/6/2007	676	< 476	1.32	< 0.476	< 0.190	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.190	< 0.0952	**4.71**	< 0.0952	< 0.476	3.72	< 0.0952
	3/10/2008	**2,270**	<476	2.3	<0.952	<0.952 Q10	<0.952	<0.952	<0.952	<0.952	<0.952	<0.952	<1.90	<0.952	**7.08**	<0.952	<1.43	**6.64**	<0.952
	6/12/2008	**1,150**	<472	1.51	<0.286	<0.143	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.190	<0.0952	**4.99**	<0.0952	<0.429	3.42	<0.0952
	9/9/2008	459 Q9	<481	1.22	<0.192	0.117	<0.0962	<0.0962	<0.0962	<0.0962	<0.0962	<0.0962	<0.192	<0.0962	**4.74**	<0.0962	<0.481	0.759	<0.0962
	12/29/2008	**2,780 Q9**	<500	1.29	<0.238	0.121	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.190	<0.0952	**4.42**	<0.0952	<0.476	3.04	<0.0952
	3/10/2009	Sample Lost During Lab Extraction		1.54	<0.238	<0.143	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.190	<0.0952	**5.06**	<0.0952	<1.33	1.05	<0.0952
	6/4/2009	**1,100**	<476	1.13	<0.190	<0.190	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.190	<0.0952	3.64	<0.0952	<0.524	1.69	<0.0952
	9/9/2009	**2,840 Q9**	<472	0.991	<0.143	<0.333	**1.220**	**1.630**	1.610	1.230	1.340	1.340	0.365	1.960	**4.23**	1.07	<0.571	1.64	1.66

Please refer to notes on last page of table.

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TABLE 4
SUMMARY OF GROUNDWATER ANALYTICAL RESULTS
TERMINAL 4 SLIP 3 UPLAND FACILITY
PORT OF PORTLAND

Sample Point	Sample Date	Analyte Concentration in µg/L (ppb)																	
		Total Petroleum Hydrocarbons		Polynuclear Aromatic Hydrocarbons (PAHs)															
		Diesel-Range	Residual-Range	Acenaphthene	Acenaphthylene	Anthracene	BAA	BAP	BBF	BGP	BKF	Chrysene	DAA	Fluoranthene	Fluorene	ICP	Naphthalene	Phenanthrene	Pyrene
BEBRA Area - Continued																			
BE-1	6/6/2005	**3,500 Y***	**2,300 O***	0.31	0.11	0.28	**1.7**	**2.1**	2.0	1.8	1.6	2.2	0.36	3.4	0.16	2.0	0.49	1.4	3.4
	9/15/2005	172 J*	< 515*	0.0575 J	< 0.103	0.0516 J	**0.322**	**0.385**	0.368	0.296	0.370	0.424	< 0.206	0.646	< 0.103	0.251	< 0.103	0.286	0.674
	12/7/2005	430*	< 400*	< 0.200	< 0.200	< 0.200	**0.397**	**0.449**	0.540	0.214	0.459	0.501	< 0.400	0.866	< 0.200	0.169 J	< 0.200	0.461	1.12
	3/13/2006	< 102 J	< 191 J	< 0.333	< 0.333	< 0.333	< 0.333	**0.350**	0.334	< 0.333	< 0.333	< 0.333	< 0.667	0.448	< 0.333	< 0.333	< 0.333	< 0.333	0.431
	6/28/2006	< 312	< 625	< 0.0962	< 0.0962	< 0.0962	**0.112**	**0.133**	0.137	0.105	< 0.0962	0.124	< 0.192	0.181	< 0.0962	< 0.0962	< 0.0962	< 0.0962	0.244
	9/20/2006 1	< 357	< 714	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	12/14/2006	801	< 476	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.190	< 0.0952	0.298	< 0.0952	< 0.0952	0.503	< 0.0952
	3/30/2007	210	< 250	< 0.0267	< 0.0267	< 0.0267	< 0.0267	< 0.0267	< 0.0267	< 0.0267	< 0.0267	< 0.0267	< 0.0267	< 0.0267	< 0.0267	< 0.0267	< 0.0533	0.0431	0.0423
	6/27/2007	518	< 476	< 0.476	< 0.476	< 0.476	**2.19**	**2.78**	2.61	2.20	2.31	2.49	< 0.952	3.14	< 0.476	1.98	< 0.476	1.34	3.09
	9/18/2007	598	< 1,000	< 0.0333	< 0.0333	< 0.0333	< 0.0333	< 0.0333	< 0.0333	< 0.0333	< 0.0333	< 0.0333	< 0.0333	< 0.050	0.0791	< 0.0333	0.498	0.145	0.0598
	12/6/2007	< 238	< 476	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.190	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952
	3/12/2008	449	<500	<0.0943	<0.0943	<0.0943	<0.0943	<0.0943	<0.0943	<0.0943	<0.0943	<0.0943	<0.189	0.101	<0.0943	<0.0943	<0.0943	<0.0943	0.145
	6/12/2008	<236	<472	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.190	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952
	9/9/2008	190 Q11	<588	<0.357	<0.357	<0.357	<0.357	<0.357	<0.357	<0.357	<0.357	<0.357	<0.714	<0.357	<0.357	<0.357	<0.357	<0.357	<0.357
	12/29/2008	377 Q9	<500	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.190	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952
	3/9/2009	<236	<472	<0.0971	<0.0971	<0.0971	<0.0971	<0.0971	<0.0971	<0.0971	<0.0971	<0.0971	<0.194	<0.0971	<0.0971	<0.0971	<0.0971	<0.0971	<0.0971
	6/5/2009	<238	<476	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.190	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952	<0.0952
	9/9/2009	<250	<500	<0.0971	<0.0971	<0.0971	<0.0971	<0.0971	<0.0971	<0.0971	<0.0971	<0.0971	<0.194	<0.0971	<0.0971	<0.0971	0.141	<0.0971	<0.0971
BE-2	6/6/2005	660 Y*	290 J*	0.13	0.12	0.25	**1.5**	**2.3**	2.0	2.2	1.6	2.0	0.38	2.8	0.13	2.4	0.077	0.79	3.3
	9/15/2005	**1,150 J***	457*	< 0.500	< 0.500	< 0.500	**0.679**	**0.898**	0.763	0.753	0.839	0.898	< 1.00	1.47	< 0.500	0.592	< 0.500	0.571	1.69
	12/7/2005	**2,610***	**1,120***	< 0.200	< 0.200	0.182 J	**0.720**	**0.987**	1.08	0.478	0.952	0.980	< 0.400	1.65	< 0.200	0.373	0.211	0.634	2.31
	3/13/2006	341 J	167 J	< 0.200	< 0.200	< 0.200	**0.849**	**0.995**	0.873	0.709	0.558	0.825	< 0.400	1.60	< 0.200	0.627	< 0.200	0.500	1.66
	6/28/2006	366	< 476	< 0.0943	< 0.0943	< 0.0943	**0.482**	**0.503**	0.527	0.413	0.296	0.506	< 0.189	0.884	< 0.0943	0.342	< 0.0943	0.290	1.12
	9/20/2006	341	< 481	< 0.0962	< 0.0962	< 0.0962	**0.158**	**0.207**	0.190	0.159	0.162	0.187	< 0.192	0.293	< 0.0962	0.132	< 0.0962	0.113	0.36
	12/13/2006	367	< 481	< 0.0952	< 0.0952	< 0.0952	**0.116**	**0.141**	0.126	0.130	0.105	0.127	< 0.190	0.215	< 0.0952	0.106	< 0.0952	< 0.0952	0.215
	3/29/2007	624	< 194	< 0.0392	< 0.0392	< 0.0392	**0.150**	**0.207**	0.183	0.183	0.124	0.194	0.0410	0.276	< 0.0392	0.140	< 0.0588	0.119	0.355
	6/27/2007	**1,440**	555	< 0.190	< 0.190	< 0.190	**0.420**	**0.486**	0.416	0.424	0.404	0.500	< 0.381	0.790	< 0.190	0.352	0.119 J	0.339	0.958
	9/18/2007	< 236	< 472	< 0.0952	< 0.0952	< 0.0952	**0.292**	**0.354**	0.332	0.554	0.322	0.376	< 0.190	0.525	< 0.0952	0.427	0.105	0.246	0.815
	12/6/2007	709	< 476	< 0.0952	< 0.0952	< 0.0952	**0.389**	**0.485**	0.411	0.458	0.355	0.491	< 0.190	0.802	< 0.0952	0.371	0.125	0.282	0.769
	3/12/2008	<238	<476	<0.189	<0.189	<0.189	**0.915**	**1.10**	1.10	0.974	0.765	0.982	<0.377	1.62	<0.189	0.801	<0.189	0.54	1.73
	6/12/2008	674 Q11	<472	<0.0952	<0.0952	<0.0952	**0.211**	**0.261**	0.233	0.212	0.200	0.250	<0.190	0.370	<0.0952	0.180	<0.0952	0.135	0.542
	9/9/2008	495 Q11	<100	<0.05	<0.05	<0.05	**0.097**	**0.111**	0.101	0.114	0.0846	0.124	<0.050	0.132	<0.050	0.0884	<0.050	<0.050	0.198
BE-3	6/6/2005	640 Y*	**1,000 O***	0.33	0.16	0.43	**2.8**	**4.2**	3.7	3.8	2.8	3.6	0.79	4.9	0.22	4.1	0.14	1.6	4.9
	9/15/2005	159 J*	< 500*	< 0.100	< 0.100	< 0.100	**0.142**	**0.188**	0.179	0.161	0.175	0.190	< 0.200	0.239	< 0.100	0.128	< 0.100	0.0966 J	0.292
	12/7/2005	< 500*	< 1,000*	< 0.200	< 0.200	< 0.200	**0.302**	**0.342**	0.371	0.170 J	0.350	0.395	< 0.400	0.612	< 0.200	0.130 J	< 0.200	0.288	0.851
	3/13/2006	91.2 J	< 250 J	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.500	0.349	< 0.250	< 0.250	< 0.250	< 0.250	0.393
	6/28/2006	< 258	< 515	< 0.515	< 0.515	< 0.515	< 0.515	< 0.515	< 0.515	< 0.515	< 0.515	< 0.515	< 1.03	< 0.515	< 0.515	< 0.515	< 0.515	< 0.515	< 0.515
	9/20/2006	< 240	< 481	< 0.130	< 0.130	< 0.130	< 0.130	< 0.130	< 0.130	< 0.130	< 0.130	< 0.130	< 0.260	< 0.130	< 0.130	< 0.130	< 0.130	< 0.130	< 0.130
	12/14/2006	522	< 476	< 0.0952	< 0.0952	< 0.0952	**0.147**	**0.193**	0.182	0.173	0.152	0.170	< 0.190	0.223	< 0.0952	0.149	< 0.0952	0.155	0.203
	3/30/2007	417	< 267	< 0.0308	< 0.0308	< 0.0308	**0.0986**	**0.131**	0.122	0.119	0.0868	0.117	0.0316	0.129	< 0.0308	0.0988	< 0.0615	0.0730	0.173
	6/27/2007	**2,270**	310 J	< 0.364	< 0.364	< 0.364	**0.391**	**0.424**	0.370	0.342 J	0.338 J	0.458	< 0.727	0.702	< 0.364	0.290 J	0.364	0.338 J	1.05
	9/18/2007	210	< 1,000	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	12/6/2007	371	< 806	0.0460	< 0.0333	0.0680	**0.434**	**0.604**	0.655	0.503	0.439	0.540	< 0.167	1.10	< 0.0667	0.407	0.199	0.316	0.538
	3/12/2008	634 QP, Q11	<714	<0.50	<0.50	<0.10	**0.212**	**0.269**	0.281	0.285	0.186	0.232	<0.20	0.364	<0.50	0.22	0.228	0.14	0.253
	6/12/2008	787 Q9	<472	<0.118	<0.118	<0.118	**0.302**	**0.358**	0.360	0.272	0.291	0.340	<0.235	0.476	<0.118	0.242	<0.118	0.235	0.578
	9/9/2008	264 Q11	<833	<0.100	<0.100	<0.100	<0.100	<0.100	0.104	<0.100	<0.100	0.175	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
	12/29/2008	563 Q11	<746	<0.111	<0.111	<0.111	<0.111	<0.111	<0.111	<0.111	<0.111	<0.111	<0.222	<0.111	<0.111	<0.111	<0.111	<0.111	<0.111
	3/9/2009	<133	<833	<0.182	<0.182	<0.182	<0.182	<0.182	<0.182	<0.182	<0.182	<0.182	<0.364	0.120 J	<0.182	<0.182	<0.182	<0.182	0.0915 J
	6/5/2009	<248	<495	<0.0990	<0.0990	<0.0990	<0.0990	<0.0990	<0.0990	<0.0990	<0.0990	<0.0990	<0.198	<0.0990	<0.0990	<0.0990	<0.0990	<0.0990	<0.0990
	9/9/2009	--	--	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.200	<0.100	<0.100	<0.100	0.100	<0.100	<0.100
BE-4	6/3/2005	590 Y	< 500	1.9	< 0.25	< 0.22	0.012 J	< 0.020	< 0.020	< 0.020	< 0.020	0.034	< 0.020	0.036	3.8	< 0.020	< 0.31	< 0.088	0.084
	9/15/2005	**1,560 J**	< 476	< 0.714	< 0.476	< 0.190	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.0952	< 0.19	< 0.0952	0.844	< 0.0952	< 0.476	< 0.190	< 0.0952
	12/7/2005 **	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	3/13/2006 **	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	6/28/2006 **	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	9/20/2006 **	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	12/13/2006 **	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	3/30/2007 **	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	6/27/2007 **	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	9/18/2007 **	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	12/6/2007 **	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	9/8/2008**	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	12/29/2008**	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	03/9/2009**	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	06/5/2009**	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	09/9/2009**	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
BE-5	9/9/2009	<263	<526	<0.0952	<0.0952	<0.0952	**0.184**	**0.217**	0.194	0.166	0.174	0.216	<0.190	0.388	<0.0952	0.135	<0.238	<0.238	0.422
ROD Compliance Criteria		1,000	1,000	520	--	--	0.027	0.014	--	--	--	--	--	6.16	3.9	--	620	6.3	--

Notes:

1. -- = Data not available or sample not analyzed for listed analyte.
2. **Boldface** data represents detected analyte concentrations exceeding compliance criteria; note, this is provided for information purposes only. Only sentinel wells have been installed to date and data is not collected at the point of compliance.
3. * = Sample did not include silica gel cleanup due to inadequate sample volume.
4. ** = Well not sampled due to presence of LNAPL in well at time of sampling.
5. ROD compliance criteria are included above; however, it is noted that the criteria is for groundwater discharge at the Slip or river and is not applicable to the wells monitored during this sampling event.
6. J = Analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
7. O = The chromatographic fingerprint of the sample resembles an oil, but does not match the calibration standard.
8. Y = The chromatographic fingerprint of the sample resembles a petroleum product eluting in approximately the correct carbon range, but the elution pattern does not match the calibration standard.
9. QP = Hydrocarbon result partly due to individual peak(s) in quantitation range.
10. Q11 = Detected hydrocarbons in the diesel range do not have a distinct diesel pattern and may be due to heavily weathered diesel.
11. Q9 = Hydrocarbon pattern most closely resembles weathered diesel.
12. Polynuclear Aromatic Hydrocarbons (PAHs):
    BAA = Benzo(a)anthracene; BKF = Benzo(k)fluroranthene; BGP = Benzo(g,h,i)perylene; ICP = Indeno(1,2,3-cd)pyrene
    BBF = Benzo(b)fluoranthene; BAP = Benzo(a)pyrene; DAA = Dibenzo(a,h)anthracene
13. Shading denotes data from the second quarter of 2009.

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