DATA REPORT
SEDIMENT CHARACTERIZATION RESULTS
FOR
TERMINAL 4 PHASE I REMOVAL ACTION
POST-CONSTRUCTION SAMPLING
PORT OF PORTLAND, PORTLAND, OREGON

Prepared for

Port of Portland

Portland, Oregon

Prepared by

Anchor QEA, LLC

6650 SW Redwood Lane, Suite 333

Portland, Oregon 97224

August 2009

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1 INTRODUCTION

In 2000, the U.S. Environmental Protection Agency (USEPA) added the Portland Harbor Superfund Site to the National Priorities List. In fall 2001, the USEPA and 10 of the Superfund Site's potentially responsible parties entered into an Administrative Order on Consent (AOC) for a Remedial Investigation/Feasibility Study (RI/FS) of the Superfund Site. The AOC allows Early Actions to be conducted to address known contamination at specific locations within the Superfund Site. Contaminants found in Terminal 4 (T4) sediment samples during a remedial investigation directed by the Oregon Department of Environmental Quality (DEQ) led to a determination that a Removal Action at T4 is warranted. Accordingly, the Port of Portland (Port) is conducting a Non-Time-Critical Removal Action (NTCRA) under an AOC for Removal Action executed by the Port and USEPA in October 2003.

The Port is a port district of the State of Oregon, which owns the T4 uplands between River Miles 4.1 and 4.5 on the Lower Willamette River. The Port also owns a portion of the submersible and submerged lands in Slip 1 and Slip 3 located within the Removal Action Area (RAA; as defined in the AOC). The remainder of the submersible or submerged land is owned by the State of Oregon and managed by the State of Oregon Department of State Lands (DSL). Figure 1 is a vicinity map and site plan locating T4 and the RAA.

The Port completed an engineering evaluation and cost analysis (EE/CA; BBL 2005) in which various Removal Action alternatives were identified, compared, and ranked for their relative performance at meeting specific objectives associated with the evaluation criteria of effectiveness, implementability, and cost. Based on the alternatives evaluated in the EE/CA, the USEPA issued an Action Memorandum (Action Memo) on May 11, 2006 (USEPA 2006) that documented the selection of the Removal Action. The selected Removal Action includes construction of a confined disposal facility (CDF) in Slip 1 and combination of dredging, capping, and monitored natural recovery (MNR) in Slip 3, Wheeler Bay, Berth 401, and North of Berth 414. Dredged material from Slip 3 will be placed in the CDF in Slip 1. The AOC requires the Port to complete a design of the selected Removal Action.

The Port proceeded down a path to implement the Removal Action, which included several steps (30, 60, and 100 percent design deliverables). The Port submitted the T4 Early Action 60 Percent Design Submittal in December 2006, and from January 2007 through November 2007, the Port and USEPA (including the Tribes, DEQ, and National Oceanic and Atmospheric Administration [NOAA]) entered into an informal dispute resolution (IDR) process to resolve technical questions and issues associated with the design.

As part of the IDR process, it was determined that many of the design issues are linked to the overall harbor-wide RI/FS process. For this reason, the Parties agreed to revise the schedule for implementation of the T4 Removal Action to realign the project with the harbor-wide RI/FS schedule. As a condition of the approval of the schedule realignment, USEPA required the Port to implement an abatement action during the 2008 in-water work window to reduce risks present at the T4 site. Essentially, this action resulted in the division of the Removal Action project into two phases. Phase I (the abatement action) was planned for the 2008 in-water work window and encompassed abatement measures that could be initiated in the near term to reduce risk and address any imminent and substantial endangerment at T4 that may exist. Phase II (including construction of the CDF) will commence once the project is realigned with the harbor-wide RI/FS process. The Port submitted an Abatement Measures Proposal (Phase I remedy) in October 2007 (Anchor 2007). USEPA provided comments on the proposal in November 2007, and based on those comments and their resolution, Phase I of the Removal Action was identified.

Phase I of the Removal Action was completed in October 2008 and included the following components:

- Dredging and off-site disposal of sediment exhibiting the highest chemical concentrations, providing a permanent solution of contaminant mass removal
- Construction of a nearshore cap at the head of Slip 3 to isolate petroleum-contaminated sediments from aquatic receptors and control a potential ongoing source to nearby areas
- Stabilization and capping of the Wheeler Bay bank to minimize contaminant migration to the river

- Dredging and off-site disposal of contaminated sediments in Slip 3 at Berth 410 to support water-dependent maritime use in a manner consistent with the Action Memo (USEPA 2006) and in support of overall risk reduction in the RAA

The performance standard of the Phase I dredging action was to remove the highest risk sediments, defined as those with surface sediments having exceedance ratios greater than 20 times the Probable Effects Concentration (PEC), down to an elevation coinciding with exceedance ratios of 10 times the PEC or less, as predetermined by the sediment core data. Since full removal was not technically feasible, partial removal was completed, and a 6-inch sand layer was placed in predetermined areas.

The Removal Action's Phase II objective will be to remove impacted sediments as defined by remediation goals as they are developed through the harbor-wide RI/FS process. It is anticipated that the extent of the Phase II sediment removal may encompass portions of the Phase I removal area. This data report presents the post-construction sediment surface results from sediment collected in the RAA for Phase I of the Removal Action.

2 POST-CONSTRUCTION SEDIMENT SAMPLING

Appendix I to the Removal Action Work Plan (RAWP; Anchor 2008a) presented the post-construction sediment sampling plan. Surface samples were collected after dredging of the Phase I dredge area was completed. Dredging was completed in September 2008 and sampling was conducted in December 2008. Sampling stations were located on a 50-foot grid (10 samples from the Berth 411 area, two samples from the center square dredge area, and two samples from the Berth 414 dredge area). As discussed above, a sand layer was placed in a portion of the Berth 411 area. Two samples were collected from the Berth 411 area where sand was placed, and eight samples were collected from the rest of the Berth 411 area. Actual sediment sampling locations are depicted on Figure 2. Sampling location coordinates, depths, elevations, and related information are provided in Table 1. Surface sediment field records are provided in Appendix A.

2.1 Sample Collection, Processing, and Handling Procedures

The field operations, equipment, sampling, sample handling, and analysis were performed using the previously approved procedures specified in the T4 Phase I Removal Action *Sampling and Analysis Plan* (SAP) and *Quality Assurance Project Plan* (QAPP) (Appendices I and J, respectively, to the RAWP, Anchor 2008a). These procedures were developed in accordance with USEPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (USEPA 1988) and USEPA's *Methods for Collection, Storage, and Maintenance of Sediments for Chemical and Toxicological Analyses* (USEPA 2001). This work was also performed in accordance with the T4 Archaeological Monitoring Protocol (Appendix G to the RAWP, Anchor 2008a).

2.2 Chemical and Conventional Analyses

Samples were analyzed for the Slip 3 contaminants of concern (COCs), including:

- Metals (cadmium, lead, zinc)
- Polycyclic aromatic hydrocarbons (PAHs)
- Total petroleum hydrocarbons (TPH; diesel and motor oil range)

Four composite samples were analyzed for polychlorinated biphenyls (PCBs) and dichloro-diphenyl-trichloroethanes (DDTs). The four composites were prepared using aliquots from the surface samples that were collected, including:

- One composite prepared with aliquots from the two samples from Berth 414
- One composite prepared with aliquots from the two samples from the center square
- One composite prepared with aliquots from the two samples located within the Berth 411 sand layer
- One composite prepared with aliquots from the remaining eight samples located in the Berth 411 area

Discrete samples used to create the composite samples were archived at the laboratory to ensure availability for later analysis as directed by USEPA (e.g., should elevated levels be detected in the composites).

A rinsate blank sample obtained from the sediment sampling apparatus was analyzed for a subset of the COCs.

2.2.1 Laboratory Quality Assurance/Quality Control Summary

Analytical laboratory case narratives, chain-of-custody forms, and validation reports are provided in Appendix B. Laboratory quality assurance/quality control (QA/QC) was performed by Apex Labs located in Tigard, Oregon. Laboratory Data Consultants (LDC) in Carlsbad, California, performed additional QA/QC and prepared a validation report for the analytical data. A supplementary validation was performed by Anchor QEA on four semivolatile analytes in the rinse blank that were not included in the original report. All of the analytical laboratory test measurements were found acceptable for use with two minor exceptions. The data validation was performed using method or technical criteria and the USEPA national functional guidelines for data review (USEPA 1999, 2004). The data validation reports verified the analytical accuracy and precision of the chemical analyses performed during this sampling event. Validation of the data may have resulted in the qualification of some results as estimated. Data qualified with a “J” indicates that the associated numerical value is the approximate concentration of the analyte. Data qualified with a “UJ” indicates the approximate reporting limit below which the analyte was not

detected. Diethylphthalate and dimethylphthalate results in the rinse blank were rejected due to low or no recoveries in the laboratory control sample (LCS) and matrix spike/matrix spike duplicate (MS/MSD) analyses. Consequently, these data qualifications are not expected to alter the data quality objectives defined in the QAPP (Appendix J to the RAWP, Anchor 2008a).

Most reporting limit goals were met, as specified in the QAPP, and all reporting limits were below PEC values, with one exception. The 2,4'-DDD reporting limit for sample T4-IM-S3AD-SS-081230 (43.7 micrograms per kilogram [µg/kg]) was above the total DDD PEC value (28 µg/kg). The laboratory indicated that the reporting limit goal exceedance in this case was due to matrix interference. In the future, sample cleanup methods that may help minimize matrix interferences will be discussed with the laboratory prior to analysis. In addition, extra sample material may be collected and archived, where feasible, in case re-extraction and re-analysis is required.

2.2.2 Chemical and Conventional Analytical Results

Per the Final Phase I Design Analysis Report (DAR; Anchor 2008b), Section 2.3, Item 1, first bullet, the performance standard used to guide the design of the Phase I Removal Action construction and verification/monitoring activities with respect to sediment was to:

> "Remove contaminated sediments defined as those with surface sediments having a greater than 20 PEC exceedance ratio down to a specified elevation coinciding with PEC exceedance ratios of 10 or less as predetermined by sediment core data."

The sediment chemistry and conventional analytical results for the sediment quality characterization samples are provided in Table 2. Although the performance standard is based on pre-construction data, the post-construction chemical results were screened against PECs developed by MacDonald et al. (2000). Chemical analytical results from the rinsate blank sample are provided in Table 3. The metals results were below 10 times the PEC at all locations except location T4-IM-09 (15 times the PEC for lead, which was the only exceedance of 10 times the PEC for metals). The PAH results were below 10 times the PEC at all locations except for T4-IM-06 and T4-IM-09 (29 and 30 times the PEC, respectively, for

benzo(a)anthracene, which was the highest exceedance of the six PAHs that exceeded 10 times the PEC). The total PAH results were below 10 times the PEC at all locations except T4-IM-06 and T4-IM-09 where exceedances of approximately 13 times the PEC were reported.

2.2.3 Interpretation of Results

While the performance standard specified in the Final Phase I DAR (Anchor 2008b) is based on pre-construction sediment core data at discrete locations, it is illustrative to average the chemical analytical results over the entire dredged area as well as the individual sub-areas. The average of the chemical analytical results for metals and PAHs for the entire Phase I removal area, as well as individual sub-areas, are provided in Table 4. The average results for the entire area, as well as the individual sub-areas, were below 20 times the PEC with no exceptions, and below 10 times the PEC with only one exception. The average result for benzo(a)anthracene exceeded 10 times the PEC in the Berth 411 sub-area by approximately 4 percent. These results confirm that the sediment exhibiting the highest chemical concentrations was removed.

The chemical analytical results were used to update the surface sediment exceedance ratio map provided in the Final Phase I DAR (Anchor 2008b, Figure 4). The pre-construction and post-construction surface sediment exceedance ratio maps utilized the exact same interpolation methods. For comparison, both maps are depicted on Figure 3. Note that the post-construction interpolation contours located outside of the Phase I dredge "daylight" boundary where dredging did not occur are the same as the pre-construction interpolation contours.

Based on sediment characterization data used to design the Phase I dredge prism, the approximate amount of COC mass removed during Phase I included:

- 15 kilograms (kg; 33 pounds) of cadmium
- 2,300 kg (5,071 pounds) of lead
- 2,900 kg (6,393 pounds) of zinc
- 1,200 kg (2,645 pounds) of total PAHs

It is estimated that the mass of sediment removed during Phase I amounted to approximately 11 percent of the total sediment mass for the total project (i.e., combined Phase I and Phase II actions). Average site-wide contaminant concentrations are derived from Anchor 2007[1]. The percentage of total contaminant mass removed during Phase I is approximately:

- 13 percent of the total mass of cadmium
- 18 percent of the total mass of lead
- 16 percent of the total mass of zinc
- 33 percent of the total mass of total PAHs

Information documenting the basis for the estimated COC mass removed and percentage of total early action area COC mass removed during Phase I is provided in Table 5.

2.2.4 Deviations from the QAPP and SAP

Analytical methodologies set forth in the referenced QAPP were followed. Based on the data validation, all of the data were determined to be acceptable for use as reported or as qualified with the exception of results for two semivolatile analytes in the rinse blank. Field activities related to sample collection and handling were generally completed in accordance with the SAP, with the following exceptions:

- Complete penetration was not possible at stations 02, 07, 08, and 10 due to hard sediment, debris, and/or the presence of cobble. However, penetration was still sufficient to collect samples from sediment not in contact with walls of the Van Veen grab sampler.
- Due to the soft nature of the sediment, grabs at stations 06, 13, and 14 were slightly overfilled and in contact with the lid of the Van Veen. Samples were collected only from sediment not in contact with the lid.
- The location of station 01 was relocated 15 feet shoreward (east) due to large amounts of cobble preventing full closure of the Van Veen. Five sampling attempts were conducted at the relocated station. A very small amount of fine-grained material was

[1] The sediment characterization results for the bulk sediment sample used in the modified elutriate testing were used for this analysis. The results were provided to USEPA during the IDR process, and they will be summarized and formally submitted in the upcoming CDF Groundwater Model Input Parameter Memorandum.

collected during the five sampling attempts. Hence, chemical analytical testing was limited to metals analysis and PAH analysis was not performed.

- Comparison of the corrected sample elevations to post-construction bathymetry at the sample locations showed a uniform difference of approximately 4.5 feet, with the corrected sample elevations deeper than the post-construction bathymetry. The most likely reason for this discrepancy is that the fathometer calibration was incorrect, and/or the fathometer malfunctioned or was knocked out of calibration during the sampling event. As a result, the mudline elevations (top elevations) reported in Table 1 are based on post-construction bathymetry. In the future, it is recommended that fathometer readings be checked more frequently using lead line measurements to better determine if and when the fathometer drifts out of calibration.

3 CONCLUSIONS

Per the Final Phase I DAR (Anchor 2008b), Section 2.3, Item 1, first bullet, the performance standard used to guide the design of the Phase I Removal Action construction and verification/monitoring activities with respect to sediment was to:

> "Remove contaminated sediments defined as those with surface sediments having a greater than 20 PEC exceedance ratio down to a specified elevation coinciding with PEC exceedance ratios of 10 or less as predetermined by sediment core data."

Phase I dredging and off-site disposal was a success given that sediment exhibiting the highest chemical concentration was effectively targeted and removed, providing a permanent solution of contaminant mass removal. However, given the exceedances noted in Section 2.2.2, the Phase I design process was assessed to determine whether these residual concentrations could have been improved if different design processes or decisions had been followed. In retrospect, the design process was appropriate for meeting the objectives of the abatement action. This conclusion is based on the following:

- There is always some degree of uncertainty in our understanding of contaminant distributions based on inherent physical/chemical variability in the environment. Dredge prism design must manage this uncertainty in a cost-effective manner.
- Additional overdredging beyond the specified 1-foot overdredge allowance could have been specified; however, this would have resulted in more unnecessary dredging of lower concentration materials that would not otherwise require action during Phase I.
- It was recognized during the design process that this was an interim action, and that there was going to be a follow-up phase of remediation (Phase II) to address remaining contamination at T4.
- Post-dredge bathymetric survey data show target dredge elevations were effectively achieved by the contractor.
- Dredging is an imperfect technology, and some amount of residual contamination is expected and nearly always observed (Bridges et al. 2008).

- Nevertheless, sediment verification goals were met 80 percent of the time on an individual sample basis, and nearly 100 percent of the time on an average concentration basis.

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TABLES

Table 1
Sampling Station Locations and Related Information

Station	Northing	Easting	Depth (ft)	Date	Time	Top Elevation (ft)[1]	Sample Depth (ft)	Bottom Elevation (ft)[1]
	NAD 83 OSP N Int. ft.					NGVD		NGVD
01	713382.13	7620440.4	38.7	12/30/2008	14:25	-38.0	0.3	-38.3
02	713335.6	7620428.1	44.0	12/30/2008	14:40	-40.0	0.2	-40.2
03	713389.3	7620367.1	56.2	12/30/2008	13:00	-47.0	0.5	-47.5
04	713345.7	7620357.9	57.4	12/30/2008	13:30	-47.5	0.6	-48.1
05	713397.4	7620303.1	57.2	12/30/2008	11:30	-49.0	0.5	-49.5
06	713349.6	7620297.7	56.2	12/30/2008	12:15	-47.0	0.6	-47.6
07	713407.4	7620235.9	57.0	12/30/2008	10:15	-47.0	0.2	-47.2
08	713363.5	7620232.6	58.5	12/30/2008	10:45	-49.0	0.1	-49.1
09	713421.2	7620179.2	58.2	12/30/2008	8:45	-47.0	0.3	-47.3
10	713375.9	7620165.7	59.9	12/30/2008	9:15	-50.0	0.3	-50.3
11	713175.5	7620016.3	51.5	12/29/2008	14:45	-42.0	0.5	-42.5
12	713180.6	7619979.2	51.5	12/29/2008	14:25	-42.0	0.5	-42.5
13	712883.8	7619670.9	24.5	12/29/2008	12:20	-19.0	0.5	-19.5
14	712874.3	7619641.6	30.5	12/29/2008	11:40	-24.0	0.5	-24.5
414	Composite of 13, 14							
S3C	Composite of 11, 12							
S3AC	Composite of 01, 02							
S3AD	Composite of 03, 04, 05, 06, 07, 08, 09, 10							

Notes:

1. Elevation data taken from post-construction bathymetry.

Table 2
Summary of Sediment Chemistry Results Compared to PEC Criteria

Station Location:		Composite	Composite	Composite	Composite	Composite	T4-IM-01
Top of Interval Elevation:		--	--	--	--	--	34.5
Bottom of Interval Elevation:		--	--	--	--	--	-34.9
Sample Matrix:		SE	SE	SE	SE	SE	SE
Sample Date:		12/29/08	12/29/08	12/30/08	12/30/08	12/30/08	12/30/08
Sample Name:		T4-IM-414-SS-081229	T4-IM-S3C-SS-081229	T4-IM-S3AD-SS-081230	T4-IM-S3AD-SS-081230-DUP	T4-IM-S3AC-SS-081230	T4-IM-01-SS-081230
	PEC						
Conventional Parameters (pct)							
Total solids	--	**53.8**	**67.9**	**65.3**	**65.8**	**85.7**	**98.8**
Metals (mg/kg)							
Cadmium	4.98	--	--	--	--	--	0.0705 U
Lead	128	--	--	--	--	--	**1.1 J**
Zinc	459	--	--	--	--	--	**3.68 J**
Aromatic Hydrocarbons (µg/kg)							
1-Methylnaphthalene	--	--	--	--	--	--	--
2,3,5-Trimethylnaphthalene	--	--	--	--	--	--	--
2,6-Dimethylnaphthalene	--	--	--	--	--	--	--
2-Methylnaphthalene	--	--	--	--	--	--	--
Acenaphthene	--	--	--	--	--	--	--
Acenaphthylene	--	--	--	--	--	--	--
Anthracene	845	--	--	--	--	--	--
Benzo(a)anthracene	1050	--	--	--	--	--	--
Benzo(a)pyrene	1450	--	--	--	--	--	--
Benzo(b,k)fluoranthene	--	--	--	--	--	--	--
Benzo(e)pyrene	--	--	--	--	--	--	--
Benzo(g,h,i)perylene	--	--	--	--	--	--	--
Chrysene	1290	--	--	--	--	--	--
Dibenzo(a,h)anthracene	--	--	--	--	--	--	--
Fluoranthene	2230	--	--	--	--	--	--
Fluorene	536	--	--	--	--	--	--
Indeno(1,2,3-c,d)pyrene	--	--	--	--	--	--	--
Naphthalene	561	--	--	--	--	--	--
Perylene	--	--	--	--	--	--	--
Phenanthrene	1170	--	--	--	--	--	--
Pyrene	1520	--	--	--	--	--	--
Total PAH	22800	--	--	--	--	--	--
PCB Aroclors (µg/kg)							
Aroclor 1016	--	6.35 U	4.86 U	5.24 U	4.95 U	3.78 U	--
Aroclor 1221	--	6.35 U	4.86 U	5.24 U	4.95 U	3.78 U	--
Aroclor 1232	--	6.35 U	4.86 U	5.24 U	4.95 U	3.78 U	--
Aroclor 1242	--	6.35 U	4.86 U	5.24 U	4.95 U	3.78 U	--
Aroclor 1248	--	**11.7**	**4.08 J**	**11.9**	**7.19**	3.78 U	--
Aroclor 1254	--	**14.2**	**6.92**	**14.4**	**12.4**	3.78 U	--
Aroclor 1260	--	6.35 U	4.86 U	**13.4**	**13.2**	3.78 U	--
Aroclor 1262	--	6.35 U	4.86 U	5.24 U	4.95 U	3.78 U	--
Aroclor 1268	--	6.35 U	4.86 U	5.24 U	4.95 U	3.78 U	--
Total PCB	676	**25.9**	**11**	**39.7**	**32.79**	3.78 U	--
Pesticides (µg/kg)							
2,4'-DDD (o,p'-DDD)	--	**0.588 J**	**1.97 J**	43.7 U	**1.47 J**	0.897 U	--
2,4'-DDE (o,p'-DDE)	--	1.48 UJ	2.2 UJ	2.47 UJ	**0.935 J**	0.897 UJ	--
2,4'-DDT (o,p'-DDT)	--	1.48 U	**2.82**	46.6 U	**0.751 J**	0.897 U	--
4,4'-DDD (p,p'-DDD)	--	**2.17**	**8.62**	2.47 U	**2.58 J**	0.897 U	--
4,4'-DDE (p,p'-DDE)	--	**2.94 J**	**2.38 J**	2.47 UJ	**1.78 J**	0.897 UJ	--
4,4'-DDT (p,p'-DDT)	--	**1.14 J**	**8.41**	29.1 U	**1.51 J**	0.897 U	--
Sum DDD	28	**2.758**	**10.59**	43.7 U	**4.05 J**	0.897 U	--
Sum DDE	31.3	**2.94**	**2.38**	2.47 UJ	**2.715 J**	0.897 UJ	--
Sum DDT	62.9	**1.14**	**11.23**	46.6 U	**2.261 J**	0.897 U	--
Total DDT	572	**6.838**	**24.2**	46.6 U	**9.026 J**	0.897 U	--
Semi-Volatile Organics (µg/kg)							
Biphenyl (1,1'-Biphenyl)	--	--	--	--	--	--	--
Phthalates (µg/kg)							
Bis(2-ethylhexyl) phthalate	--	--	--	--	--	--	--
Butylbenzyl phthalate	--	--	--	--	--	--	--
Diethyl phthalate	--	--	--	--	--	--	--
Dimethyl phthalate	--	--	--	--	--	--	--
Di-n-butyl phthalate	--	--	--	--	--	--	--
Di-n-octyl phthalate	--	--	--	--	--	--	--
Total Petroleum Hydrocarbons (mg/kg)							
Diesel Range	--	--	--	--	--	--	2 U
Residual Range	--	--	--	--	--	--	3.99 U

Table 2
Summary of Sediment Chemistry Results Compared to PEC Criteria

Station Location:		T4-IM-02	T4-IM-03	T4-IM-04	T4-IM-05	T4-IM-05	T4-IM-06	T4-IM-07
Top of Interval Elevation:		39.8	51.7	53.0	52.4	52.4	51.6	52.0
Bottom of Interval Elevation:		-40.1	-52.2	-53.5	-52.9	-52.9	-52.1	-52.1
Sample Matrix:		SE	SE	SE	SE	SE	SE	SE
Sample Date:		12/30/08	12/30/08	12/30/08	12/30/08	12/30/08	12/30/08	12/30/08
Sample Name:		T4-IM-02-SS-081230	T4-IM-03-SS-081230	T4-IM-04-SS-081230	T4-IM-05-SS-081230	T4-IM-05-SS-081230-DUP	T4-IM-06-SS-081230	T4-IM-07-SS-081230
	PEC							
Conventional Parameters (pct)								
Total solids	--	**80.2**	**70**	**68.8**	**62.9**	**64.5**	**64.9**	**76.6**
Metals (mg/kg)								
Cadmium	4.98	**0.3**	**1.53**	**1.41**	**4.19**	**6.04**	**1.61**	**2.55**
Lead	128	**58.2 J**	**191 J**	**209 J**	**743 J**	**700 J**	**144 J**	**474 J**
Zinc	459	**60 J**	**279 J**	**265 J**	**731 J**	**842 J**	**314 J**	**481 J**
Aromatic Hydrocarbons (µg/kg)								
1-Methylnaphthalene	--	20.1 U	85.3 U	92.2 UJ	**64 J**	**62.9 J**	**124 J**	205 UJ
2,3,5-Trimethylnaphthalene	--	20.1 U	85.3 U	92.2 UJ	103 U	96 U	238 U	205 UJ
2,6-Dimethylnaphthalene	--	20.1 U	**50.4 J**	**65.4 J**	**80.2 J**	**73.1 J**	**158 J**	**205 UJ**
2-Methylnaphthalene	--	20.1 U	85.3 U	**76 J**	**117**	**128 J**	**256**	**107 J**
Acenaphthene	--	20.1 U	**214**	**961 J**	**1150**	**1340 J**	**5350**	**603 J**
Acenaphthylene	--	20.1 U	85.3 U	92.2 UJ	103 U	96 U	238 U	205 UJ
Anthracene	845	**11.4 J**	**333**	**1470 J**	**1390**	**1420 J**	**6230**	**669 J**
Benzo(a)anthracene	1050	**55.8**	**1760**	**9160 J**	**6840**	**7150 J**	**30700**	**6050 J**
Benzo(a)pyrene	1450	**74.1**	**2520**	**11900 J**	**9160**	**9590 J**	**41100**	**7930 J**
Benzo(b,k)fluoranthene	--	**114**	**4180**	**21100 J**	**16200**	**16900 J**	**70900**	**15700 J**
Benzo(e)pyrene	--	**46.1**	**1560**	**7700 J**	**5930**	**6190**	**25500**	**5720 J**
Benzo(g,h,i)perylene	--	**43.4**	**1320**	**6470 J**	**4540**	**5020 J**	**19300**	**4030 J**
Chrysene	1290	**59.8 J**	**1960**	**9960 J**	**7560**	**7800 J**	**30800**	**7970 J**
Dibenzo(a,h)anthracene	--	**23.5**	**389**	**1880 J**	**1400**	**1480 J**	**5940**	**1430 J**
Fluoranthene	2230	**104**	**2770**	**12600 J**	**10900**	**11000 J**	**43200**	**11800 J**
Fluorene	536	20.1 U	**95.4**	**426 J**	**483**	**575 J**	**1580**	**314 J**
Indeno(1,2,3-c,d)pyrene	--	**49.3**	**2120**	**10400 J**	**7910**	**8190 J**	**33900**	**6700 J**
Naphthalene	561	20.1 U	**73.1 J**	**166 J**	**277**	**237 J**	**537**	**216 J**
Perylene	--	**19.7 J**	**677**	**3530 J**	**2610**	**2750**	**11900**	**2190 J**
Phenanthrene	1170	56.1 U	**1090**	**4850 J**	**4860**	**5020 J**	**18900**	**3660 J**
Pyrene	1520	**108**	**2740**	**11300 J**	**9770**	**9700 J**	**38900**	**9470 J**
Total PAH	22800	**527.1**	**17735.5**	**83893**	**68590**	**70732**	**288197**	**64382**
PCB Aroclors (µg/kg)								
Aroclor 1016	--	--	--	--	--	--	--	--
Aroclor 1221	--	--	--	--	--	--	--	--
Aroclor 1232	--	--	--	--	--	--	--	--
Aroclor 1242	--	--	--	--	--	--	--	--
Aroclor 1248	--	--	--	--	--	--	--	--
Aroclor 1254	--	--	--	--	--	--	--	--
Aroclor 1260	--	--	--	--	--	--	--	--
Aroclor 1262	--	--	--	--	--	--	--	--
Aroclor 1268	--	--	--	--	--	--	--	--
Total PCB	676	--	--	--	--	--	--	--
Pesticides (µg/kg)								
2,4'-DDD (o,p'-DDD)	--	--	--	--	--	--	--	--
2,4'-DDE (o,p'-DDE)	--	--	--	--	--	--	--	--
2,4'-DDT (o,p'-DDT)	--	--	--	--	--	--	--	--
4,4'-DDD (p,p'-DDD)	--	--	--	--	--	--	--	--
4,4'-DDE (p,p'-DDE)	--	--	--	--	--	--	--	--
4,4'-DDT (p,p'-DDT)	--	--	--	--	--	--	--	--
Sum DDD	28	--	--	--	--	--	--	--
Sum DDE	31.3	--	--	--	--	--	--	--
Sum DDT	62.9	--	--	--	--	--	--	--
Total DDT	572	--	--	--	--	--	--	--
Semi-Volatile Organics (µg/kg)								
Biphenyl (1,1'-Biphenyl)	--	20.1 U	**54.3 J**	**60.5 J**	**68.3 J**	**65.2 J**	**160 J**	205 UJ
Phthalates (µg/kg)								
Bis(2-ethylhexyl) phthalate	--	66.5 U	255 U	275 UJ	307 U	287 UJ	710 U	612 UJ
Butylbenzyl phthalate	--	60 U	255 U	275 UJ	307 U	287 U	710 U	612 UJ
Diethyl phthalate	--	60 U	255 U	275 UJ	307 U	287 U	710 U	612 UJ
Dimethyl phthalate	--	60 U	255 U	275 UJ	307 U	287 U	710 U	612 UJ
Di-n-butyl phthalate	--	60 U	255 U	275 UJ	307 U	287 U	710 U	612 UJ
Di-n-octyl phthalate	--	**34.7 J**	255 U	275 UJ	307 U	287 U	710 U	**385 J**
Total Petroleum Hydrocarbons (mg/kg)								
Diesel Range	--	**2.82**	**37.8**	**68.8**	**87.7**	**100**	**77.1**	**68**
Residual Range	--	**8.39**	**133**	**233**	**320**	**365**	**272**	**195**

Table 2
Summary of Sediment Chemistry Results Compared to PEC Criteria

Station Location:		**T4-IM-08**	**T4-IM-09**	**T4-IM-10**	**T4-IM-11**	**T4-IM-12**	**T4-IM-13**	**T4-IM-14**
Top of Interval Elevation:		**53.6**	**52.9**	**54.7**	**47.4**	**47.5**	**20.6**	**26.3**
Bottom of Interval Elevation:		**-53.7**	**-53.2**	**-54.9**	**-47.8**	**-48.0**	**-21.1**	**-26.8**
Sample Matrix:		**SE**	**SE**	**SE**	**SE**	**SE**	**SE**	**SE**
Sample Date:		**12/30/08**	**12/30/08**	**12/30/08**	**12/29/08**	**12/29/08**	**12/29/08**	**12/29/08**
Sample Name:		**T4-IM-08-SS-081230**	**T4-IM-09-SS-081230**	**T4-IM-10-SS-081230**	**T4-IM-11-SS-081229**	**T4-IM-12-SS-081229**	**T4-IM-13-SS-081229**	**T4-IM-14-SS-081229**
	PEC							
Conventional Parameters (pct)								
Total solids	--	**63.1**	**58.6**	**64.6**	**73.7**	**65.1**	**53.8**	**52.4**
Metals (mg/kg)								
Cadmium	4.98	**0.56**	**8.36**	**1.69**	**1.13**	**0.812**	**0.544**	**0.495**
Lead	128	**36.6 J**	**1850 J**	**213 J**	**55.2 J**	**35.8 J**	**15.1 J**	**19.4 J**
Zinc	459	**118 J**	**1300 J**	**308 J**	**190 J**	**143 J**	**106 J**	**112 J**
Aromatic Hydrocarbons (µg/kg)								
1-Methylnaphthalene	--	25.7 U	**184 J**	94.6 U	**11.3 J**	95.1 U	28.8 U	30.5 U
2,3,5-Trimethylnaphthalene	--	25.7 U	276 UJ	94.6 U	**16.2 J**	95.1 U	28.8 U	30.5 U
2,6-Dimethylnaphthalene	--	25.7 U	**210 J**	**55.9 J**	21.9 U	**75.1 J**	28.8 U	30.5 U
2-Methylnaphthalene	--	25.7 U	**370 J**	94.6 U	**27.8**	**105**	28.8 U	30.5 U
Acenaphthene	--	**17.6 J**	**4360 J**	**135**	**40.3**	**121**	28.8 U	30.5 U
Acenaphthylene	--	25.7 U	276 UJ	94.6 U	**58.8**	**322**	28.8 U	30.5 U
Anthracene	845	**20.4 J**	**6400 J**	**175**	**142**	**914**	28.8 U	30.5 U
Benzo(a)anthracene	1050	**137**	**31600 J**	**1220**	**567**	**3530**	**23.8 J**	**86.4**
Benzo(a)pyrene	1450	**173**	**39700 J**	**1690**	**797**	**4700**	**40.8**	**103**
Benzo(b,k)fluoranthene	--	**298**	**73100 J**	**2990**	**1120**	**6290**	**46.2 J**	**203**
Benzo(e)pyrene	--	**109**	**26700 J**	**1110**	**498**	**2880**	**19.5 J**	**74.6**
Benzo(g,h,i)perylene	--	**108**	**22200 J**	**1070**	**669**	**3720**	**34**	**59.6**
Chrysene	1290	**166**	**34100 J**	**1570**	**704**	**3890**	**20.7 J**	**122**
Dibenzo(a,h)anthracene	--	**36.5**	**6470 J**	**282**	**81.2**	**471**	28.8 U	**35.4**
Fluoranthene	2230	**230**	**48200 J**	**2120**	**1350**	**7980**	**38.5**	**163**
Fluorene	536	**14.6 J**	**2070 J**	**65.3 J**	**48.9**	**186**	28.8 U	30.5 U
Indeno(1,2,3-c,d)pyrene	--	**133**	**34500 J**	**1380**	**686**	**3850**	**24.8 J**	**79.5**
Naphthalene	561	25.7 U	**518 J**	**82.1 J**	**130**	**527**	28.8 U	30.5 U
Perylene	--	**87.2**	**11900 J**	**460**	**207**	**1210**	**16.5 J**	**31.4**
Phenanthrene	1170	**113**	**22500 J**	**721**	**419**	**2580**	31.5 U	**79.4**
Pyrene	1520	**224**	**40500 J**	**2000**	**1600**	**9680**	**33.9**	**135**
Total PAH	22800	**1393.6**	**303048**	**12768.4**	**6977**	**40720**	**203.9**	**891.8**
PCB Aroclors (µg/kg)								
Aroclor 1016	--	--	--	--	--	--	--	--
Aroclor 1221	--	--	--	--	--	--	--	--
Aroclor 1232	--	--	--	--	--	--	--	--
Aroclor 1242	--	--	--	--	--	--	--	--
Aroclor 1248	--	--	--	--	--	--	--	--
Aroclor 1254	--	--	--	--	--	--	--	--
Aroclor 1260	--	--	--	--	--	--	--	--
Aroclor 1262	--	--	--	--	--	--	--	--
Aroclor 1268	--	--	--	--	--	--	--	--
Total PCB	676	--	--	--	--	--	--	--
Pesticides (µg/kg)								
2,4'-DDD (o,p'-DDD)	--	--	--	--	--	--	--	--
2,4'-DDE (o,p'-DDE)	--	--	--	--	--	--	--	--
2,4'-DDT (o,p'-DDT)	--	--	--	--	--	--	--	--
4,4'-DDD (p,p'-DDD)	--	--	--	--	--	--	--	--
4,4'-DDE (p,p'-DDE)	--	--	--	--	--	--	--	--
4,4'-DDT (p,p'-DDT)	--	--	--	--	--	--	--	--
Sum DDD	28	--	--	--	--	--	--	--
Sum DDE	31.3	--	--	--	--	--	--	--
Sum DDT	62.9	--	--	--	--	--	--	--
Total DDT	572	--	--	--	--	--	--	--
Semi-Volatile Organics (µg/kg)								
Biphenyl (1,1'-Biphenyl)	--	25.7 U	**173 J**	**57.1 J**	**27.1**	**100**	28.8 U	30.5 U
Phthalates (µg/kg)								
Bis(2-ethylhexyl) phthalate	--	131 U	825 UJ	282 U	74.8 U	284 U	86 U	96 U
Butylbenzyl phthalate	--	76.6 U	825 UJ	282 U	65.2 U	284 U	86 U	91.2 U
Diethyl phthalate	--	76.6 U	825 UJ	282 U	65.2 U	284 U	86 U	91.2 U
Dimethyl phthalate	--	76.6 U	825 UJ	282 U	65.2 U	284 U	86 U	91.2 U
Di-n-butyl phthalate	--	76.6 U	825 UJ	282 U	65.2 U	284 U	86 U	91.2 U
Di-n-octyl phthalate	--	76.6 U	825 UJ	282 U	**37.3 J**	284 U	86 U	91.2 U
Total Petroleum Hydrocarbons (mg/kg)								
Diesel Range	--	**2.66 J**	**565**	**68.6**	**22.8**	**72.3**	**3.08 J**	**1.96 J**
Residual Range	--	**9.5**	**2260**	**290**	**69.8**	**233**	**12.1**	**8.34**

Table 2
Summary of Sediment Chemistry Results Compared to PEC Criteria

Notes:

Result 10-20 times PEC

Result ≥ 20 times PEC

ND value exceeds PEC

Bold = Detected result

J = Estimated value

U = Compound analyzed, but not detected above detection limit

µg/kg = micrograms per kilogram

mg/kg = milligrams per kilogram

pct = percent

Total PCB is the sum of aroclors 1016, 1221, 1232, 1242, 1248, 1254, 1260, 1262, and 1268

Total PAH is the sum of Acenaphthene, Acenaphthylene, Anthracene, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b,k)fluoranthene, Chrysene, Fluoranthene, Fluorene, Naphthalene, Phenanthrene, and Pyrene

Sum DDD is the sum of 2,4'-DDD (o,p'-DDD) and 4,4'-DDD (p,p'-DDD)

Sum DDE is the sum of 2,4'-DDE (o,p'-DDE) and 4,4'-DDE (p,p'-DDE)

Sum DDT is the sum of 2,4'-DDT (o,p'-DDT) and 4,4'-DDT (p,p'-DDT)

Total DDT is the sum of all 6 analytes

Nondetects are treated as zero in summations unless all results are not detected; then the maximum reporting limit is reported

Table 3
Summary of Equipment Blank Results

Station Location:	Rinsate Blank
Sample Matrix:	WQ
Sample Date:	12/30/08
Sample Name:	T4-IM-RB-081230
Metals (mg/L)	
Cadmium	0.0002 U
Lead	**0.000267 J**
Zinc	**0.00141 J**
Aromatic Hydrocarbons (µg/L)	
1-Methylnaphthalene	0.0381 UJ
2-Methylnaphthalene	0.0381 UJ
Naphthalene	0.0381 UJ
Acenaphthylene	0.0381 UJ
Acenaphthene	0.0381 UJ
Fluorene	0.0381 UJ
Phenanthrene	0.0381 UJ
Anthracene	0.0381 UJ
Fluoranthene	0.0381 UJ
Pyrene	0.0381 UJ
Benzo(a)anthracene	0.0381 UJ
Chrysene	0.0381 UJ
Benzo(b)fluoranthene	0.0381 UJ
Benzo(k)fluoranthene	0.0381 UJ
Benzo(a)pyrene	0.0381 UJ
Indeno(1,2,3-c,d)pyrene	0.0381 UJ
Dibenzo(a,h)anthracene	0.0381 UJ
Benzo(g,h,i)perylene	0.0381 UJ
Phthalates (µg/L)	
Bis(2-ethylhexyl) phthalate	0.952 UJ
Butylbenzyl phthalate	0.952 UJ
Diethyl phthalate	R
Dimethyl phthalate	R
Di-n-butyl phthalate	0.952 UJ
Di-n-octyl phthalate	0.952 UJ
Semi-Volatile Organics (µg/L)	
Dibenzofuran	0.0381 UJ
Total Petroleum Hydrocarbons (mg/L)	
Diesel Range	0.236 U
Residual Range	0.472 U

Notes:

Bold = Detected result

J = Estimated value

U = Compound analyzed, but not detected above detection limit

R = Rejected result

mg/L = milligrams per liter

µg/L = micrograms per liter

Table 4

PEC Exceedance Ratio of Average Sediment Chemistry Results by Dredging Sub-Area[1]

Station Location:		T4-IM-01 thru T4-IM-14	T4-IM-03 thru T4-IM-10	T4-IM-01 and T4-IM-02	T4-IM-11 and T4-IM-12	T4-IM-13 and T4-IM-14
Area:		All Areas	B411	B411 Sand Layer	Center Square	B414
Number of Samples:		14	8	2	2	2
	PEC					
Metals (mg/kg)						
Cadmium	4.98	0.4	0.5	0.0	0.2	0.1
Lead	128	2.3	3.8	0.2	0.4	0.1
Zinc	459	0.7	1.0	0.1	0.4	0.2
Aromatic Hydrocarbons (µg/kg)[2]						
1-Methylnaphthalene	--	--	--	--	--	--
2,3,5-Trimethylnaphthalene	--	--	--	--	--	--
2,6-Dimethylnaphthalene	--	--	--	--	--	--
2-Methylnaphthalene	--	--	--	--	--	--
Acenaphthene	--	--	--	--	--	--
Acenaphthylene	--	--	--	--	--	--
Anthracene	845	1.5	2.5	0.0	0.6	0.0
Benzo(a)anthracene	1050	6.2	**10.4**	0.1	2.0	0.1
Benzo(a)pyrene	1450	5.9	9.8	0.1	1.9	0.0
Benzo(b,k)fluoranthene	--	--	--	--	--	--
Benzo(e)pyrene	--	--	--	--	--	--
Benzo(g,h,i)perylene	--	--	--	--	--	--
Chrysene	1290	5.5	9.1	0.0	1.8	0.1
Dibenzo(a,h)anthracene	--	--	--	--	--	--
Fluoranthene	2230	4.5	7.4	0.0	2.1	0.0
Fluorene	536	0.7	1.2	0.0	0.2	0.1
Indeno(1,2,3-c,d)pyrene	--	--	--	--	--	--
Naphthalene	561	0.3	0.4	0.0	0.6	0.1
Perylene	--	--	--	--	--	--
Phenanthrene	1170	3.7	6.1	0.0	1.3	0.0
Pyrene	1520	5.9	9.4	0.1	3.7	0.1
Total PAH	22800	2.8	4.6	0.0	1.0	0.0
PCB Aroclors (µg/kg)[4]						
Aroclor 1016	--	--	--	--	--	--
Aroclor 1221	--	--	--	--	--	--
Aroclor 1232	--	--	--	--	--	--
Aroclor 1242	--	--	--	--	--	--
Aroclor 1248	--	--	--	--	--	--
Aroclor 1254	--	--	--	--	--	--
Aroclor 1260	--	--	--	--	--	--
Aroclor 1262	--	--	--	--	--	--
Aroclor 1268	--	--	--	--	--	--
Total PCB	676	0.03	0.1	0.01	0.02	0.04
Pesticides (µg/kg)[4]						
2,4'-DDD (o,p'-DDD)	--	--	--	--	--	--
2,4'-DDE (o,p'-DDE)	--	--	--	--	--	--
2,4'-DDT (o,p'-DDT)	--	--	--	--	--	--
4,4'-DDD (p,p'-DDD)	--	--	--	--	--	--
4,4'-DDE (p,p'-DDE)	--	--	--	--	--	--
4,4'-DDT (p,p'-DDT)	--	--	--	--	--	--
Sum DDD	28	0.4	1.6	0.03	0.4	0.1
Sum DDE	31.3	0.1	0.1	0.03	0.1	0.1
Sum DDT	62.9	0.2	0.7	0.01	0.2	0.02
Total DDT	572	0.03	0.1	0.002	0.04	0.01

Notes:

1. For results below the limits of detection, the detection limit was used to calculate the average.
2. PAH results for Location 01 were assumed to be the same as PAH results for Location 02 when calculating the average for the All Areas and the B411 Sand Layer.
3. **Bold** values indicate that the PEC exceedance ratio was exceeded by 10 times.
4. PCB and Pesticide ratios were calculated using composite sample results.

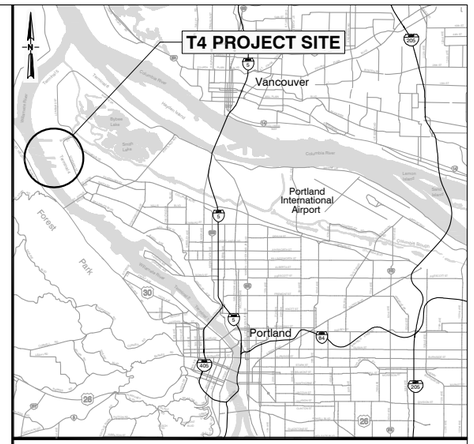
Table 5
Estimated Contaminant Mass Removed during Phase I

	COCs:	Cadmium	Lead	Zinc	Total PAH
Description	**Mass Removed (Tons)**	**Phase I Average Concentrations (mg/kg)**			
Phase I Berth 411	6,580	2.28	360	421	188
Phase I Berth 414	464	1.78	110	269	121
Phase I Center Square	1,504	0.6	95	169	3.9
Phase I Total	***8,548***				
Description	**Total Project Mass (Tons)**	**Total Project Average Concentrations (mg/kg)**			
T4 Project Dredge Prism[1]	78,000	1.6	184	250	51
Description		**Mass Removed (kg)**			
Berth 411		13.6	2146	2513	1119
Berth 414		0.75	46	113	51
Center Square		0.82	130	230	5.4
Estimated Phase I COC Mass[2]		**15**	**2300**	**2900**	**1200**
Estimated Total Project COC Mass[3]		113	13017	17686	3597
Estimated Percent Mass Removed	***11%***	***13%***	***18%***	***16%***	***33%***

Notes:

1. Total estimated tons and total volume-weighted average concentrations based on core interval lengths and Thiessen polygon areas unless otherwise noted from Proposed Sampling and Analysis Plan for Additional Modified Elutriate Testing Port of Portland - Terminal 4 Early Action, May 25, 2007.
2. Rounded to 2 significant figures.
3. Based on total project mass and total project average concentrations.

FIGURES



VICINITY MAP
SCALE: N.T.S.

0 150 300
SCALE IN FEET

K:\Jobs\050332-PORT_OF_PORTLAND\05033201 TERMINAL 4\ Phase 1\PH_1-GI-1_GI-2.dwg DAR FIG 1

Apr 13, 2009 6:37pm tgriga

ANCHOR QEA

Figure 1
Site Plan and Vicinity Map
Terminal 4 Phase I Removal Action
Portland, Oregon

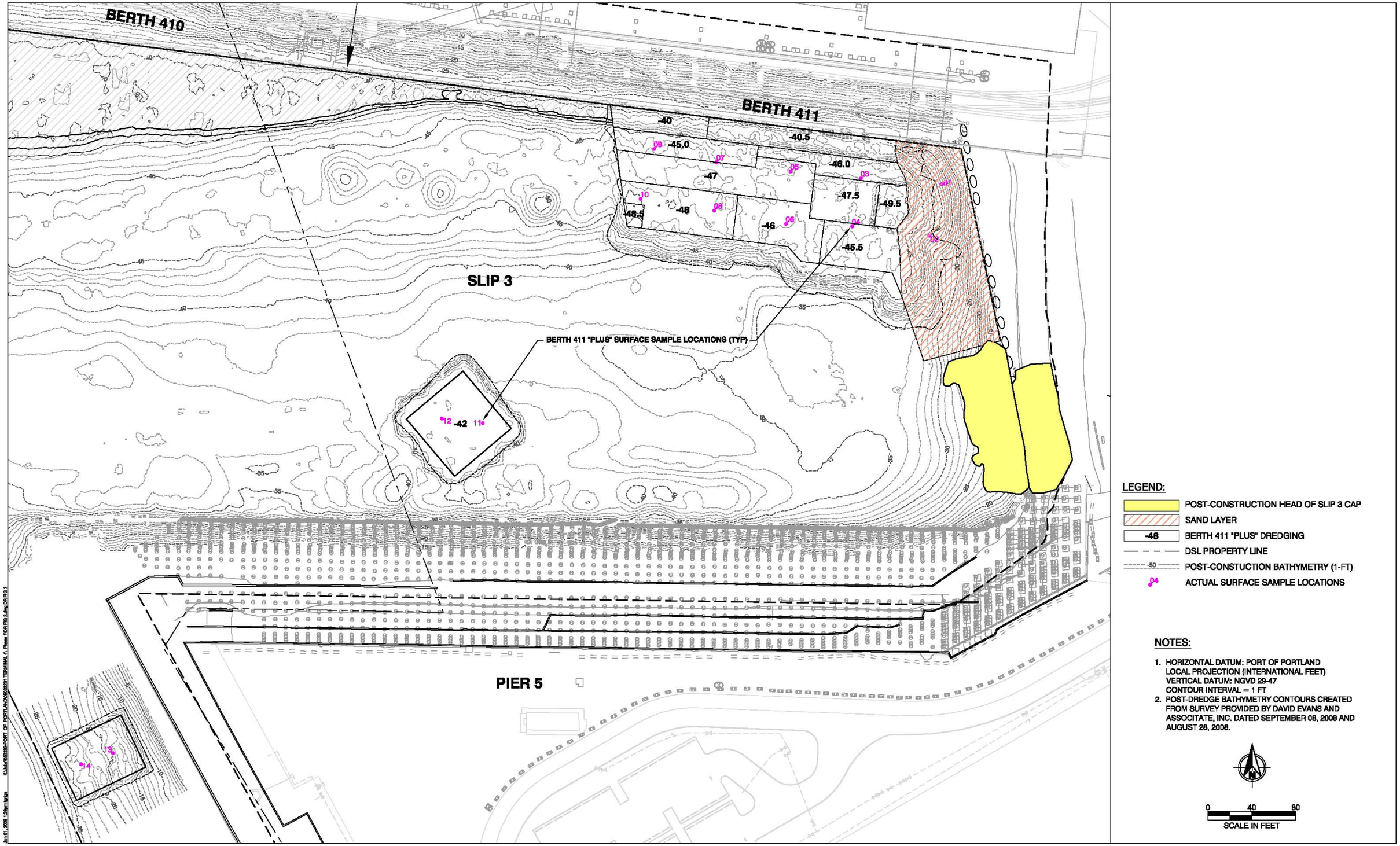


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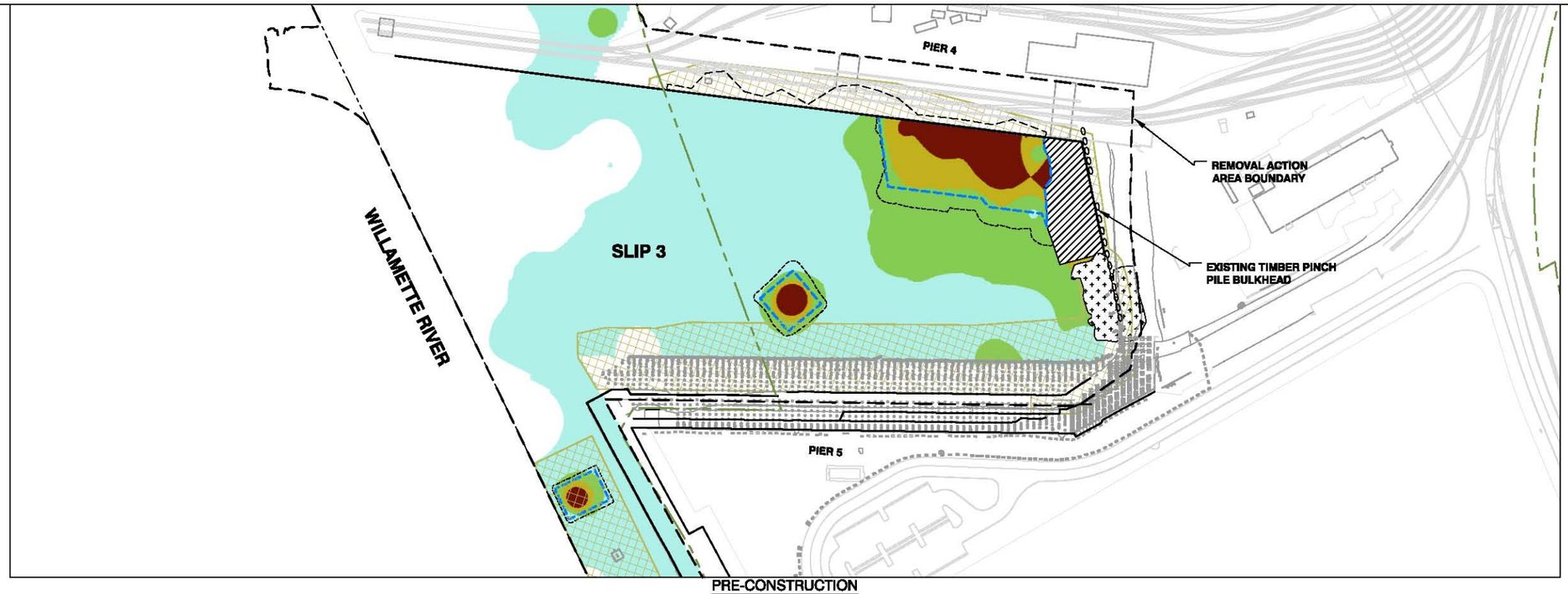
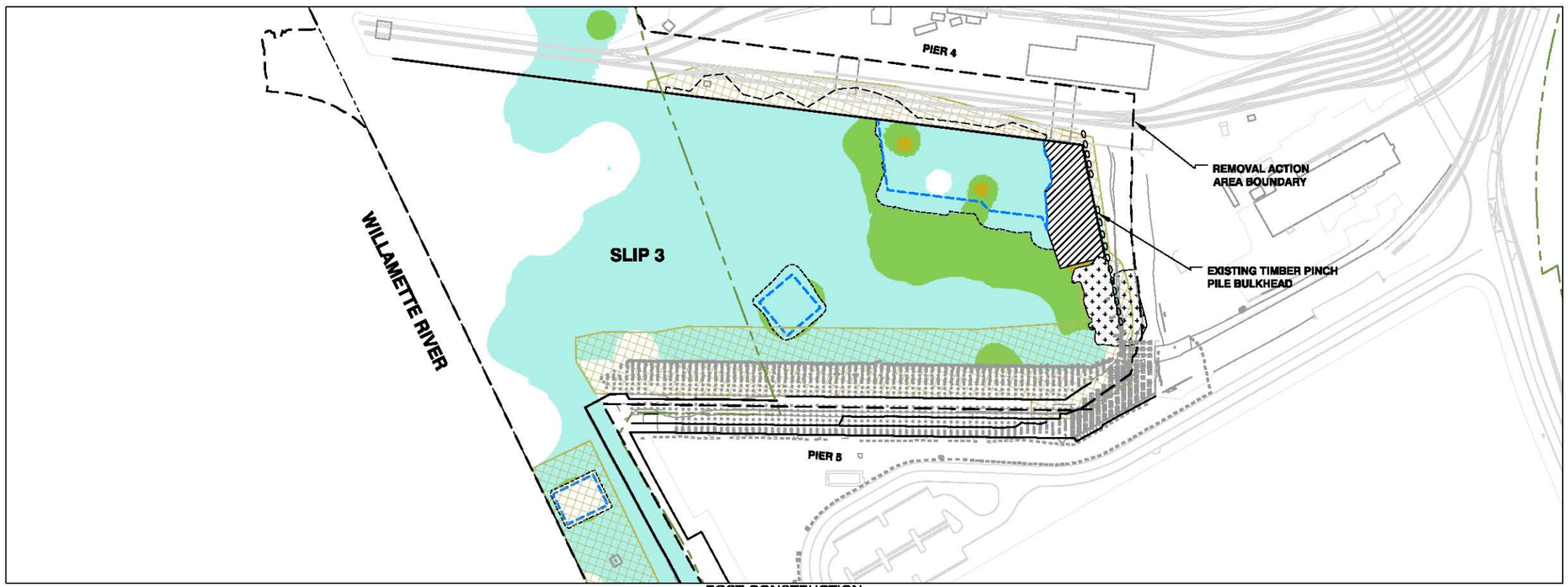
Figure 2
Post-Construction Actual Surface Sample Sediment Locations
Terminal 4 Phase I Removal Action
Portland, Oregon



PRE-CONSTRUCTION



POST-CONSTRUCTION

LEGEND:

- <1 PEC SURFACE EXCEEDANCE RATIO
- 1-10 PEC SURFACE EXCEEDANCE RATIO
- 10.1-20 PEC SURFACE EXCEEDANCE RATIO
- 20.1-30 PEC SURFACE EXCEEDANCE RATIO
- >30 PEC SURFACE EXCEEDANCE RATIO
- PHASE I DREDGE BOUNDARY
- PHASE I DAYLIGHT BOUNDARY
- PHASE I SAND LAYER
- PHASE I HEAD OF SLIP 3 CAP BOUNDARY
- REMOVAL ACTION AREA BOUNDARY
- DSL PROPERTY LINE
- HARBOR LINE
- TERMINAL 4 PHASE II CAP BOUNDARIES IN SLIP 3 AND BERTH 414

NOTES:

1. HORIZONTAL DATUM: PORT OF PORTLAND LOCAL PROJECTION (INTERNATIONAL FEET)
   VERTICAL DATUM: NGVD 29-47
   CONTOUR INTERVAL = 1FT

0 100 200
SCALE IN FEET

Aug 13, 2009 3:14pm dholmer K:\Jobs\0503332-PORT OF PORTLAND\05033201 TERMINAL 4\ Phase 1\DR FIG 3.dwg DR FIG 3

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Figure 3
Pre-Construction and Post-Construction Surface Sediment Concentrations and Phase I Boundaries
Terminal 4 Phase I Removal Action
Portland, Oregon

APPENDICES

(Previously Submitted)