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Memorandum

To: Sean Sheldrake - USEPA; John Malek and Ken Fellows - Parametrix

From: Ben Hung and Todd Thornburg - Anchor Environmental, L.L.C.

CC: Nicole LaFranchise, Marcel Hermans, and Krista Koehl - Port of Portland; Tom Schadt and John Verduin - Anchor Environmental, L.L.C.

Date: March 21, 2007

Re: Supplemental Analysis and Rationale for the Proposed Turbidity Point of Compliance (100 Meters from the Mouth of Slip 3)
Port of Portland—Terminal 4 Phase I Removal Action

As a follow-up to a March 17, 2007 teleconference with Ken Fellows and John Malek on the draft Water Quality Monitoring and Compliance Conditions Plan (WQMCCP), this memorandum presents the supplemental analysis and rationale requested to support the proposed point of compliance for turbidity during the Terminal 4 Phase I Removal Action. Based on discussions during that call, this supplemental analysis is needed to provide the regulatory justification for the point of compliance for turbidity at 100 meters from the mouth of Slip 3, rather than 100 meters from construction activities as proposed for the other monitored parameters. This supplemental analysis includes:

- A review of the turbidity standard for the State of Oregon;
- Proposed turbidity criteria and compliance boundary;
- Interpretation of dredging elutriate testing (DRET) data, which indicate that meeting the criteria for turbidity will be more difficult than meeting the criteria for chemical parameters;
- Expected total suspended solids (TSS) concentrations at the point of dredging;
- The effect of residual discoloration of the water on turbidity results;
- The results of far-field modeling of the dispersion of the turbidity plume; and
- Concluding recommendations regarding the turbidity compliance boundary.

Turbidity Standard

The State of Oregon water quality standard for turbidity is: "*No more than a ten percent cumulative increase in natural stream turbidities may be allowed, as measured relative to a control point*

immediately upstream of the turbidity causing activity. However, limited duration activities necessary to address an emergency or ***to accommodate essential dredging, construction, or other legitimate activities*** *and which cause the standard to be exceeded may be authorized provided all practicable turbidity control techniques have been applied…"* (Oregon Administrative Rules [OAR] 340-041-0038)(emphasis added).

The annualized mean and 90th percentile turbidity values in the lower Willamette River are approximately 10 and 27 Nephelometric Turbidity Units (NTU), respectively (USGS Station #14211720, 1974-2000), and values below 5 NTU are typically observed during the low-flow season when the construction will occur. Explicit compliance with the unmodified turbidity standard would, therefore, require the Port of Portland's (Port's) activities to generate no more than a 0.5 to 2.7 NTU increase above background. Such a standard is unachievable (as discussed further below) and arguably not even accurately measurable at these very low increments. As a result, we believe a temporary modification of the turbidity criteria during low-turbidity conditions should be allowed in consideration of the Port's limited duration essential dredging and cleanup activities, as provided for in the State standard.

Port's Proposed Turbidity Criteria and Compliance Boundary

Consistent with State regulations, the following proposed turbidity criteria would apply at the compliance boundary:

- Turbidity should not exceed 5 NTU above background if background is less than 50 NTU; and,
- Turbidity should not exceed 10 percent above background if background is greater than 50 NTU.

The U.S. Environmental Protection Agency (USEPA) has proposed that turbidity should not exceed 3 NTU above background if background is less than 50 NTU. It should be noted that the USEPA's proposed criteria based on 3 NTU would in effect *reduce* the criteria *below the state standard* for background levels between 30 and 50 NTU.

Consistent with State regulations, the proposed point of compliance for turbidity is 100 meters from the mouth of Slip 3 for Phase I construction activities taking place within the slip. This compliance boundary is depicted in Figure 1 by the dashed green line. The other compliance

boundaries apply to the rest of the monitored parameters and specific Phase I Removal Action subareas, as described in the Water Quality Monitoring Plan (Anchor 2008, Appendix B).

Turbidity Compliance More Difficult than Meeting Chemical Parameter Criteria

Elevated turbidity is expected to be the monitoring parameter that is most difficult to control, whereas little or no water quality effects are predicted for chemical constituents, as shown in DRET test results (BBL 2005; Table 1). The DRET test simulates the release of contaminants into the water column caused by sediment resuspension at the point of dredging. Turbidity levels near the dredge will need to be diluted within the compliance zone in order to meet water quality standards at the compliance boundary. In contrast, dissolved chemical constituents in DRET samples were either undetected, below water quality criteria, or comparable to ambient background levels.

Expected TSS Concentrations at the Point of Dredging

A number of factors will control the water quality around the dredging operations. These factors include dredging equipment and methods, sediment characteristics, hydrodynamic conditions, water depth, and others. The U.S. Army Corps of Engineers (USACE) model DREDGE was used to predict suspended sediment concentrations around the Terminal 4 Phase I dredging operation (Kuo and Hayes 1991; Anchor 2008). The model predicted initial TSS concentrations of 180 milligrams per liter (mg/L) in the immediate vicinity of the mechanical dredge.

DRET testing provides another line of evidence for estimating turbidity at the point of dredging. Whereas TSS was not measured in the DRET test conducted as part of the Engineering Evaluation/Cost Analysis (EE/CA; BBL 2005), TSS results of 850 mg/L were reported in DRET testing from a previous maintenance dredging project at Terminal 4, Berth 410 (Hart Crowser 1997). These two lines of evidence (a model result and a laboratory bench-scale simulation) were used to estimate a range of expected TSS concentrations at the point of dredging (approximately 200 to 800 mg/L).

Turbidity Associated with Residual Discoloration of Water - Not Dissolved Contaminants

When subjected to a column settling test (CST), Terminal 4 sediments showed high levels of residual turbidity even after much of the suspended solids had settled out (Figure 2).

Terminal 4 sediments appear to color the water, even though elutriate test results indicate the turbidity generated by these sediments is not associated with elevated levels of dissolved contaminants. The nature of this correlation indicates that TSS drop out more quickly over time, whereas residual discoloration of the water (expressed as turbidity) may persist even at relatively low TSS concentrations.

Far-Field Modeling Results Indicate Limited Dispersion of "Dissolved Turbidity"

A "far-field" dilution model (USEPA PLUMES model; USEPA/600/R-94/086; Baumgartner et al. 1994) was used to estimate turbidity concentrations at distances away from the point of dredging. Far-field dilution models are utilized to model dispersion and dilution of nonpoint-source contaminant plumes such as those associated with dredging.

Inputs to the model included a range of TSS values based on the DREDGE model and DRET testing results. The TSS-turbidity correlation developed from the CST results was used to calculate the turbidity at the point of dredging based on estimated TSS at the point of dredging. The far-field model was used to determine far-field dispersion factors at 100 and 200 meters, which were 5.8 and 8.2, respectively. The expected turbidity decrease at 100 and 200 meters, based on the range of source concentrations, is provided in Table 2. These results are based on a background turbidity of 0 NTU; therefore, these results represent the ***incremental*** increase above background that may be caused by the dredging activity, not the total measured turbidity including background.

Supplemental Turbidity Analysis Supports Proposed Turbidity Compliance Boundary

Based on the above analysis, it follows that the turbidity criteria will likely be exceeded based on a point of compliance of 100 meters. Since the weight of evidence indicates that turbidity in this particular case is indicative of coloration and not representative of toxicity to aquatic life, and in order to enable the implementation of this project, the proposed compliance boundary for turbidity is proposed to be set at 100 meters from the mouth of Slip 3. No purpose would be served by subjecting the project to operational response procedures (up to and including project shut down) triggered by a color-driven turbidity exceedance, because elutriate test results indicate that the turbidity generated by these sediments is actually not associated with elevated levels of dissolved contaminants, nor is it associated with suspended solids.

The turbidity standard allows for exceedances to be authorized within the vicinity of the construction site provided all practicable turbidity control techniques will be applied. The turbidity control techniques specified for the project include all of the best management practices that have been shown to be effective in controlling turbidity for similar projects. In addition, as an added measure of protectiveness, a fish diversion technique will be utilized to divert fish from entering the slip. Given these protective measures, and since Slip 3 is substantially bounded on three sides and dredging is occurring throughout the Slip, monitoring at the mouth of the Slip, as proposed, is consistent with both the language and intent of the standard.

References

Anchor Environmental, L.L.C. (Anchor). 2008. Draft Design Analysis Report, Terminal 4 Phase I Removal Action, Port of Portland, Portland, Oregon. Prepared by Anchor Environmental for Port of Portland. January 2008.

Baumgartner, D.J., W.E. Frick, and P.J.W. Roberts. 1994. Dilution Models for Effluent Discharges (Third Edition). Pacific Ecosystems Branch, ERL-N, Newport, OR. EPA/600/R-94/086, June 1994, 189pp. (DPS PLUMES).

Blasland, Bouck & Lee, Inc. (BBL). 2005. Terminal 4 Early Action Engineering Evaluation/Cost Analysis, Public Review Draft. Report prepared for Port of Portland, Portland, Oregon.

Hart Crowser, Inc. (Hart Crowser). 1997. TCLP and Dredging Elutriate Test Results, Terminal 4, Berth 410. Prepared by Hart Crowser for Port of Portland. December 23, 1997.

Kuo, A. Y. and D.F. Hayes. 1991. Model for Turbidity Plume Induced by Bucket Dredge. Journal of Waterway, Port, Coastal, and Ocean Engineering. 117(6):610-624.

ATTACHMENTS

Table 1
DRET Elutriate Chemistry Results

Sample ID Lab ID Date Sampled	Acute Water Quality Value	Chronic Water Quality Value	Regional Background Concentrations[1]	T4-CM1-Dret K2402978-004 04/20/2004		T4-CM2-Dret K2403382-001 05/05/2004	
Metals (µg/L)							
Arsenic	340	150	2	0.9		0.8	
Cadmium	0.5	0.09	<1	0.02	U	0.04	U
Chromium	183	24	1	1.11		1.77	
Copper	3.6	2.7	9	5.08		4.25	
Lead	14	0.54	13.3	1.63		1.86	
Mercury	1.4	0.77	<0.1	0.2	U	0.2	U
Nickel	145	16	5.5	1.3		1.65	
Selenium			0.2	0.7	U	0.4	B
Silver	0.3		<1	0.03	U	0.03	
Zinc	36	36	38	5.62		6.7	
Semivolatile Organics (µg/L)							
Naphthalene	807	194		0.40	U	0.39	U
2-Methylnaphthalene	300			0.40	U	0.39	U
1-Methylnaphthalene	312			0.40	U	0.39	U
Biphenyl				0.40	U	0.39	U
2,6-Dimethylnaphthalene	108			0.40	U	0.39	U
Acenaphthylene	1,277	307		0.40	U	0.099	J
Acenaphthene	233	56		0.40	U	0.19	J
2,3,5-Trimethylnaphthalene	41			0.40	U	0.027	J
Fluorene	162	39		0.40	U	0.096	J
Phenanthrene	79	19		0.40	U	0.13	J
Anthracene	87	21		0.40	U	0.39	U
1-Methylphenanthrene	31			0.40	U	0.39	U
Fluoranthene	30	7.1		0.40	U	0.092	J
Pyrene	42	10		0.075	J	0.13	J
Benz(a)anthracene	9.2	2.2		0.40	U	0.39	U
Chrysene	8.3	2.0		0.40	U	0.39	U
Benzo(b)fluoranthene	2.8	0.68		0.40	U	0.39	U
Benzo(k)fluoranthene	2.7	0.64		0.40	U	0.39	U
Benzo(e)pyrene	3.7			0.40	U	0.39	U
Benzo(a)pyrene	4.0	0.96		0.40	U	0.39	U
Perylene	3.7			0.40	U	0.39	U
Indeno(1,2,3-cd)pyrene	1.2	0.28		0.40	U	0.39	U
Dibenz(a,h)anthracene	1.2	0.28		0.40	U	0.39	U
Benzo(g,h,i)perylene	1.8	0.44		0.40	U	0.39	U
Dimethyl phthalate				9.9	U	9.6	UJ
Diethyl phthalate				9.9	U	9.6	U
Di-n-butyl phthalate				9.9	U	9.6	U
Butylbenzyl phthalate				9.9	U	9.6	U
Bis(2-ethylhexyl) phthalate				9.9	U	9.6	U
Di-n-octyl phthalate				9.9	U	9.6	U
Total PAHs				0.075	J	0.737	J
Pesticides (µg/L)							
4,4'-DDE				0.099	U	0.097	U
4,4'-DDD				0.099	U	0.097	U
4,4'-DDT	1.1	0.001		0.099	U	0.097	U
2,4'-DDE				0.099	U	0.097	U
2,4'-DDD				0.099	U	0.097	U
2,4'-DDT				0.099	U	0.097	U

Table 1
DRET Elutriate Chemistry Results

Sample ID Lab ID Date Sampled	Acute Water Quality Value	Chronic Water Quality Value	Regional Background Concentrations[1]	T4-CM1-Dret K2402978-004 04/20/2004		T4-CM2-Dret K2403382-001 05/05/2004	
Total DDD				0.099	U	0.097	U
Total DDE				0.099	U	0.097	U
Total DDT				0.099	U	0.097	U
ΣDDTs	1.1	0.001		0.099	U	0.097	U
PCBs (µg/L)							
Aroclor 1016				0.099	U	0.097	U
Aroclor 1221				0.099	U	0.097	U
Aroclor 1232				0.099	U	0.097	U
Aroclor 1242				0.099	U	0.097	U
Aroclor 1248				0.099	U	0.097	U
Aroclor 1254				0.099	U	0.097	U
Aroclor 1260				0.099	U	0.097	U
Aroclor 1262				0.099	U	0.097	U
Aroclor 1268				0.099	U	0.097	U
Total PCBs	2	0.014		0.099	U	0.097	U
Petroleum Hydrocarbons (µg/L)							
Diesel Range Organics (DRO)				250	U	250	U
Residual Range Organics (RRO)				57	J	500	U
Conventionals (mg/L)							
Total suspended solids				5	U	5	U
Ammonia as Nitrogen				0.57		0.68	
Total Sulfide				0.05	U	0.05	U

Notes:

1. Orgeon DEQ Memorandum "Default Background Concentrations for Metals" dated October 28, 2002, Table 1.

B = Analyte was also detected in method blank.

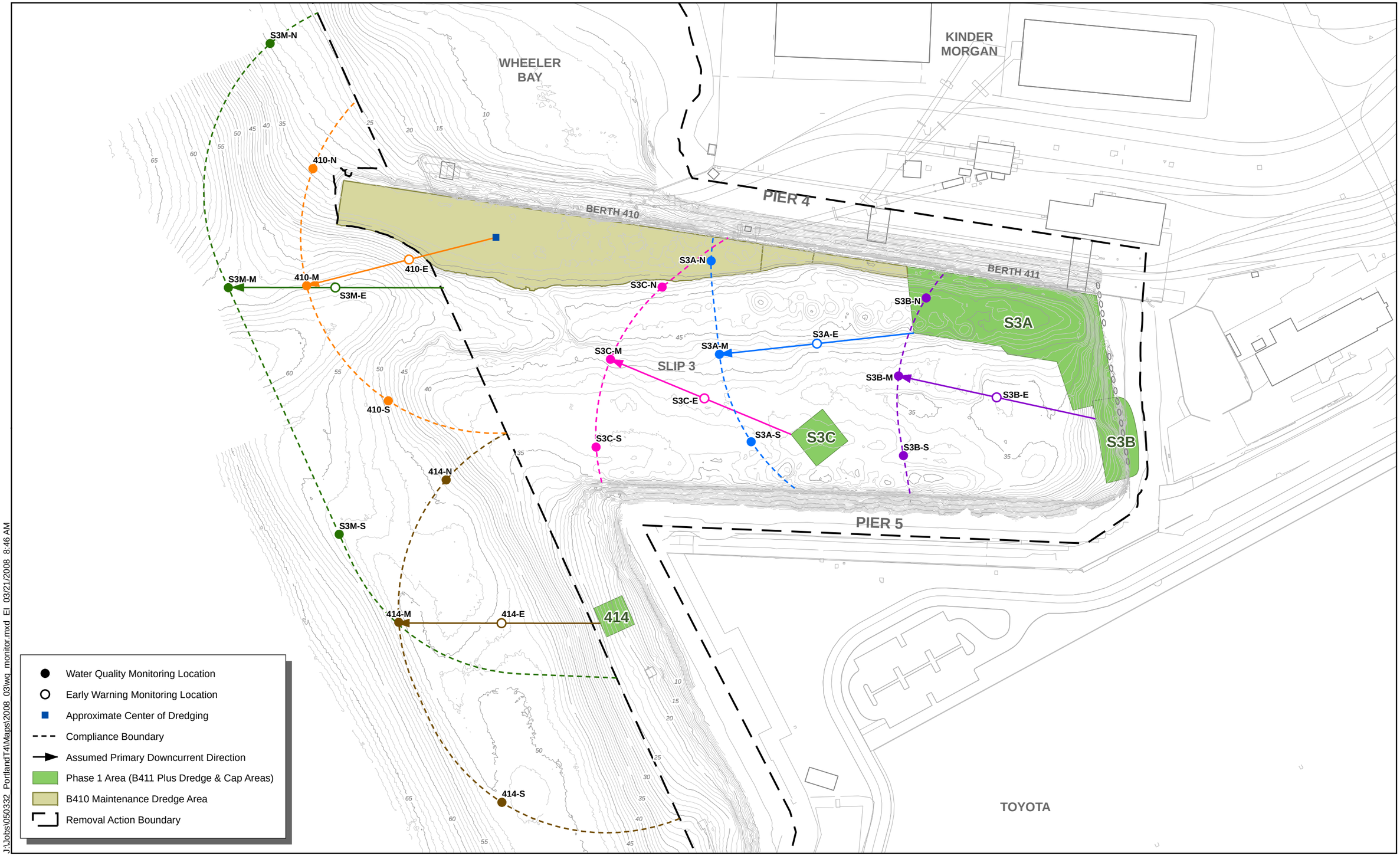
J = Analyte was positively identified; associated concentration is an estimated value.

U = Analyte not detected above the reporting limit.

UJ = Analyte not detected above the reporting limit. Reporting limit is approximate.

Table 2
Estimated Turbidity with Distance from Point of Dredging

Source TSS (mg/L)	Source Turbidity (NTU)	Turbidity (100 Meters) (NTU)	Turbidity (200 Meters) (NTU)
200	18	3	2
400	60	10	7
600	121	21	15
800	200	34	24



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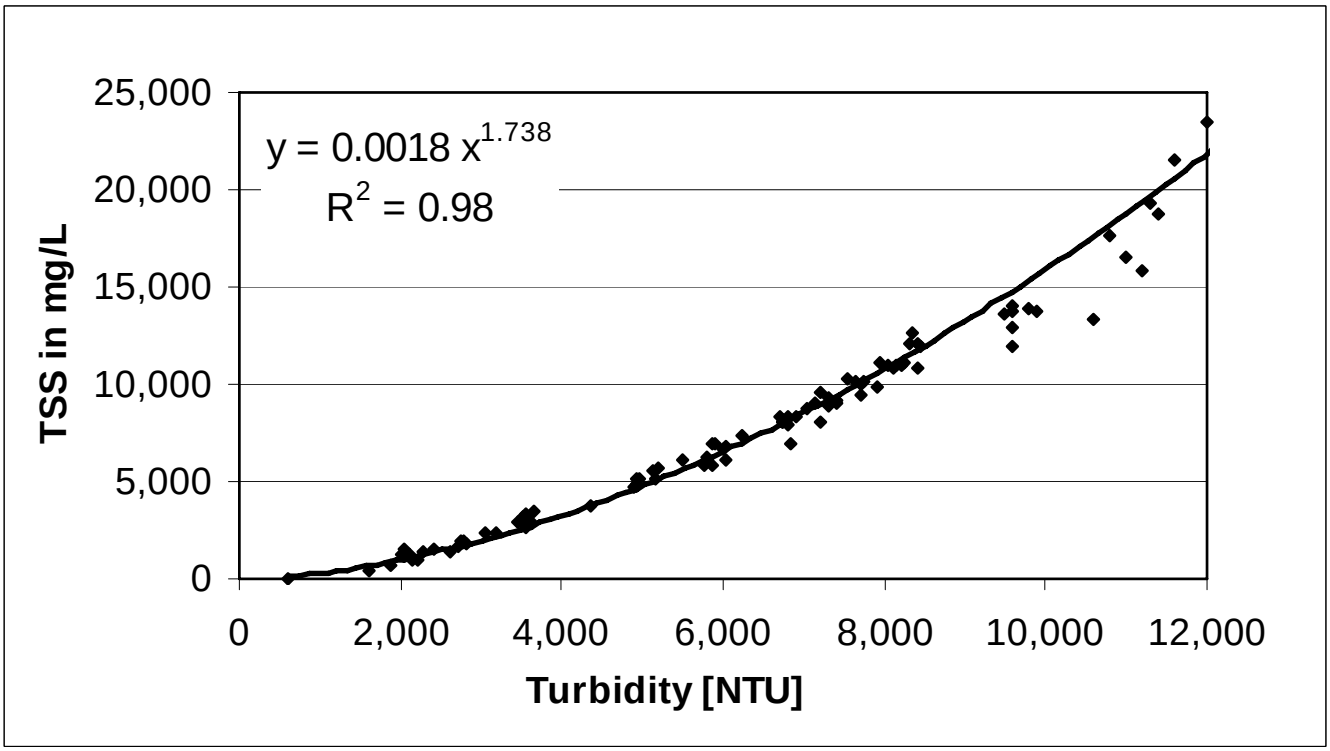
ANCHOR ENVIRONMENTAL, L.L.C.

0 150
Scale in Feet

Notes:
Compliance boundary for mouth of Slip 3 represents proposed turbidity monitoring locations.
Berth 410 water quality monitoring (except for turbidity) will occur 100 meters from the actual location of dredging activity. Compliance boundary shown may not be representative of the actual location.

Bathymetry and base map from Port of Portland, 2007.
Bathymetric elevations in feet NGVD.

Figure 1
Proposed Water Quality Monitoring Stations
Terminal 4 Phase I Removal Action
Portland, Oregon



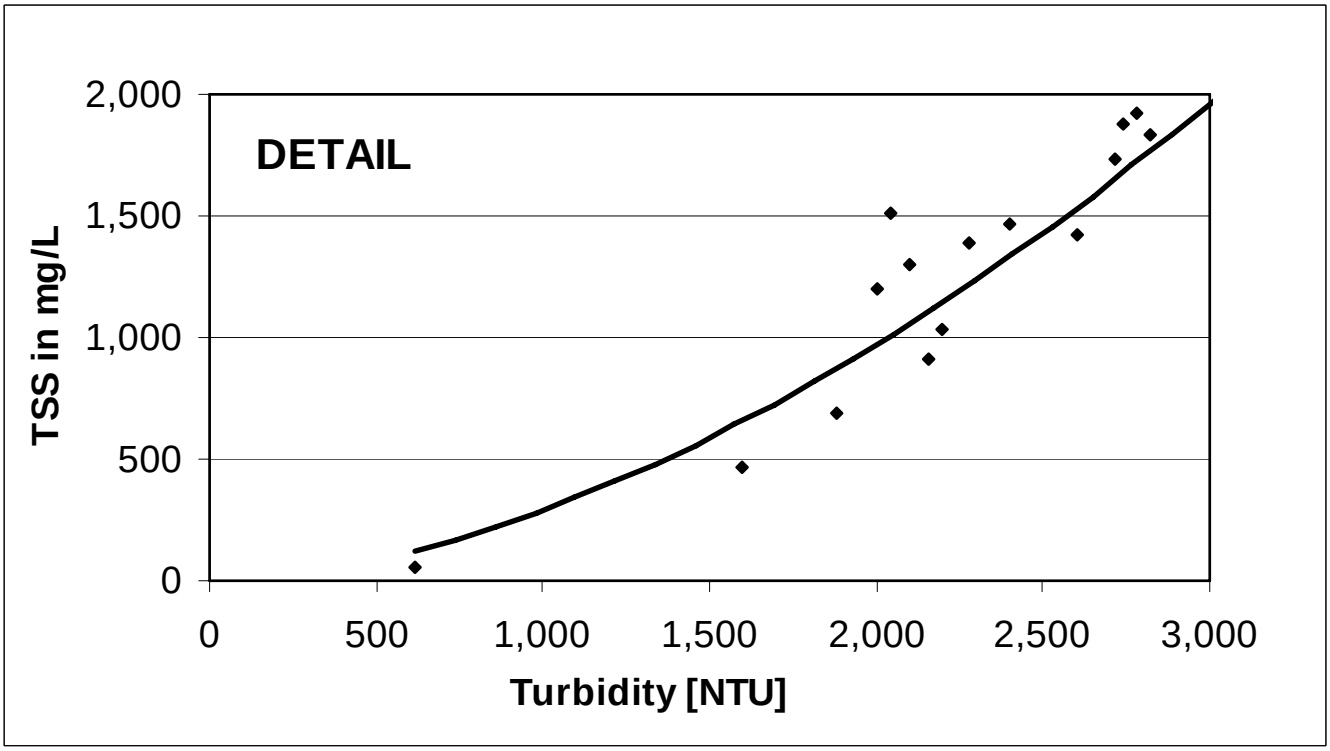


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Figure 2
Turbidity-TSS Correlation
Terminal 4 Phase I Removal Action
Portland, Oregon