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DRAFT Technical Memorandum

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Re: **Dredged Material Permeability Evaluation for Portland Harbor Sediments**
Terminal 4 Early Action Remedial Design

The long-term permeability of dredged material after it has been placed within the confined disposal facility (CDF) and allowed to consolidate is an input parameter of the long-term groundwater transport model. While permeability measurements have been conducted on Terminal 4 sediments, data are not currently available for other potential sediment remediation sites in Portland Harbor. This technical memorandum provides a summary of laboratory-measured dredged material permeabilities from available Region 10 CDF design projects and compares their sediments to Portland Harbor sediments.

Consolidation tests are typically performed on dredged materials intended for placement in a CDF to better understand the consolidation behavior of the sediments, as well as their permeability. *In situ* permeability measurements are not representative because the sediments are subjected to additional overburden pressures when placed in a CDF. For instance, surface and near-surface sediments on the river bottom may end up beneath 40 feet of material—this added weight consolidates the sample into a more tightly packed condition. In the Terminal 4 CDF, these overburden pressures are caused by the self-weight of the 45-foot thick layer of dredged sediments, as well as the 23-foot thick layer of imported fill material used to bring the CDF up to final grade. The load induced by placing 23 feet of imported fill material over the dredged sediments is called a surcharge.

This memorandum summarizes permeability data for sediments evaluated for placement in the Port of Portland's proposed Terminal 4 CDF, and in the St. Paul and Blair Slip One CDFs in Commencement Bay. The physical properties of these sediments are compared to those of Portland Harbor sediments, and by analogy, the bulk permeabilities of Portland Harbor sediments are estimated based on these existing Region 10 data. The permeabilities estimated for Portland Harbor sediments will then be used in the long-term groundwater transport model for the Terminal 4 CDF.

Methods

Two different tests have been used to determine permeability. The Commencement Bay sites had consolidation tests completed in accordance with Appendix D of EM 1110-2-5027and ASTM D2435, Method B, as appropriate. The test is run on a disturbed sample that has had water added to create a slurry and then allowed to settle. Different loads are applied to the sample and the change in void ratio is measured. Permeability is calculated from measured test parameters.

The second test, the seepage induced consolidation test (SICT), was used for the sediments to be dredged as part of the Terminal 4 sediment remediation. This test was completed in general accordance with Znidarcic, et al (1992). The test is also run on a disturbed sample that has had water added to create a slurry. Loads are then applied by using a constant flow rate. The change in void ratio and permeability is measured as the loads are applied. The data is used to develop a constitutive model of void ratio versus stress and permeability versus stress.

Data Sources

Consolidation test data were reviewed from the following projects:

- **Port of Portland Terminal 4.** Seepage induced consolidation tests were performed on Slip 3 sediments proposed for dredging. These results were presented in Appendix H of the Design Analysis Report (DAR).
- **Thea Foss Waterway, Tacoma.** Dredged sediments in Thea Foss Waterway were subjected to consolidation tests to evaluate placement in the St. Paul CDF (City of Tacoma 1999; Table 4-15).

- **Hylebos Waterway, Tacoma.** Dredged sediments in Segment 5 of the Hylebos Waterway were subjected to consolidation tests to evaluate placement in the Blair Slip One CDF (Hart Crowser and others, 2003).

Physical Properties

The physical properties of Portland Harbor sediments were compared to the physical properties of other sediments that underwent consolidation testing to confirm the representativeness of these tests for application in Portland Harbor. Grain size, moisture content, and total organic carbon are compared in Table 1.

The physical properties of the sediments from the various sites are relatively comparable. The bulk sediment descriptions are typically slightly clayey to clayey, very sandy silt, or slightly clayey, silty sand. Except for sample T4-COMP-01 from Terminal 4 (at 30 percent), the remaining samples have fines contents (silt plus clay) between 53 and 66 percent. Most sites have relatively similar total organic carbon contents, between 1.5 and 1.9 percent, except Thea Foss which is somewhat more enriched in organics (at 3.0 percent).

Table 1. Physical Properties of Dredged Material Evaluated for CDF Placement

		Terminal 4 Early Action			
Parameter	**Portland Harbor[2]**	**T4-COMP-01[1]**	**T4-COMP-02[1]**	**Hylebos Segment 5[3]**	**Thea Foss SSMAs 3/5/6[4]**
Grain Size					
Gravel	6%	2%	0%	0%	4%
Sand	38%	67%	33%	47%	39%
Silt	46%	21%	47%	53%	44%
Clay	10%	9%	19%		15%
Physical Properties					
Moisture Content	--	61%	72%	54%	44%
Total Organic Carbon	1.7%	1.5%[5]	1.7%[6]	1.9%	3.0%

1. Terminal 4 60% DAR Appendix H: Pre-Construction Sampling Data Report
2. Parameters in table for Portland Harbor were obtained from the LWG Portland Harbor RI/FS database
3. Hart Crowser and others 2003, Hylebos Waterway Segment 5 100 Percent Design
4. City of Tacoma September 30, 1999. Thea Foss Waterway Round 3 Data Evaluation Report
5. Average of cores T4-S3-01, -02, and -04
6. Average of cores T4-S3-03, -05, and -07

Results

The permeabilities calculated or measured from consolidation test data are presented on Figure 1 and Table 2. A standard hydrogeologic relationship correlates permeability to the 10th percentile value of the grain size distribution (Freeze and Cherry, 1979), i.e. the smallest grains control the permeability of the sediment. As a result, the permeabilities appear to be most closely correlated with the clay content of the sediments—the higher the clay content, the lower the permeability.

The clay content of the Portland Harbor sediments most closely resembles T4-COMP-01 and the composite sample from Thea Foss Waterway. Both bulk sediment samples yielded similar permeability values. Therefore, the recommended permeability value for use in the long-term groundwater model for Portland Harbor sediments is 3.E-7 cm/sec.

Table 2. Calculated Permeabilities (cm/sec)

	Self-Weight		Surcharge
	Low	High	Average
Terminal 4			
T4-COMP-01	5.E-07	1.E-06	3.E-07*
T4-COMP-02	1.E-07	5.E-07	6.E-08
Commencement Bay			
Thea Foss	4.E-07	9.E-07	3.E-07*
Hylebos	3.E-06	5.E-06	2.E-06

*Recommended value for long-term groundwater model

References

City of Tacoma 1999. Round 3 Data Evaluation Report and Pre-Design Evaluation Report, Thea Foss and Wheeler-Osgood Waterways, Tacoma, Washington, September 30, 1999.

Hart Crowser, Berger/ABAM, and Anchor, 2003. 100 Percent Design Submittal: Hylebos Waterway Cleanup (Segment 5)/Slip 1 Nearshore Confined Disposal (NCD) Facility Project. Prepared for the Port of Tacoma and Occidental Chemical Corporation, June 20, 2003.

Znidarcic, D., Abu-Hejleh, A.N., Fairbanks, T. and Robertson A., 1992, Seepage-Induced Consolidation Test; Equipment Description and Users Manual, Prepared for Florida Institute of Phosphate Research, University of Colorado, Boulder, 52 pp.

T4 CDF Permeability after Settlement