CENPS-OP-DMMO

MEMORANDUM FOR RECORD 13 February 1994

SUBJECT: DETERMINATION ON THE SUITABILITY OF DREDGED MATERIAL RETESTED FOR THE U.S. NAVY'S PIER D DREDGING PROJECT , BREMERTON, WASHINGTON (OYB-2-012791) FOR DISPOSAL AT A PSDDA UNCONFINED OPEN-WATER DISPOSAL SITE.

1. The following summary reflects the consensus determination of the PSDDA Agencies' (U.S. Army Corps of Engineers, Department of Ecology, Department of Natural Resources, and the Environmental Protection Agency) with jurisdiction on dredging and disposal on the suitability of the estimated 105,100 cubic yards of dredged material proposed for dredging from the U.S. Navy's Pier D dredging project, at Bremerton, Washington, in Sinclair Inlet for disposal at a PSDDA unconfined open-water disposal site (Elliott Bay nondispersive site). The determination of suitability is based on the acceptability of the sampling conducted between August 9-16, 1993 and all relevant test data contained in December 30, 1993 Data Summary Report submitted by GeoEngineers to the Dredged Material Management Office (DMMO) on December 31, 1993 for distribution to and review by the PSDDA agencies. This SDM also reviews additional data relevant to the PSDDA suitability determination, which are contained in the GeoEngineer's December 30, 1993 Supplemental Sampling Report, which addresses Sediment Management Standards (SMS) characterization of the material immediately outside the dredging prism for the Pier D project.

2. The proposed dredging project, exhibiting a larger dredging footprint (171,400 cubic yards) underwent initial full PSDDA characterization in April 1991, with twenty-eight dredged material management units (DMMU) characterizing the high ranked sediments. A suitability determination memorandum (SDM) for this testing was finalized on 3 April 1992 (enclosure 1). The initial characterization results found 69,400 cubic yards suitable and 102,000 cubic yards unsuitable for unconfined open-water disposal.

3. PSDDA recency guidelines indicate that testing data for high concern areas are generally valid for up to two years from the collection date. Due to unanticipated delays in the Navy's construction schedule, the two year PSDDA recency guideline was exceeded, and the Navy asked the PSDDA agencies in letter dated November 17, 1992 for clarification on the recency issue relative to their project. The Navy was notified in a DMMO letter dated January 28, 1993 of the PSDDA agency decision on the recency issue, and that retesting would be necessary to reassess the sediment quality for unconfined open-water disposal. The testing data reviewed herein is germane to this reassessment of a smaller dredging footprint of 105,100 cubic yards.

4. The Sampling and Analysis plan (SAP) was submitted to and approved by the PSDDA agencies on July 15, 1993, and the sampling generally followed the specifications proposed in the SAP. The data collected from these analyses were sufficient and acceptable for decision making by the Agencies based on best professional judgement.

5. The conceptual sampling and analysis plan for the 105,100 cubic yard dredging footprint has 63,100 cubic yards in the surface (0-4 ft.) and 42,000 cubic yards in the subsurface (> 4 ft.) layer of the proposed dredged material. Minimum PSDDA sampling and analysis requirements call for sixteen uncomposited surface analyses and four composited subsurface analyses. The approved SAP had two additional analyses resulting in seventeen uncomposited surface analyses (Figure 1) and five composited subsurface analyses (Figure 2), for a total of twenty-two dredged material management

units (DMMU). A summary of sediment conventional characteristics for each of the twenty-two DMMU characterized is provided in Table 1.

6. The results of these chemical analyses showed that all seventeen surface DMMU had quantitated or detection limit exceedances of PSDDA screening levels (SL) for chemicals of concern as depicted in Table 2. Sample S3 also exceeded the maximum level (ML) and bioaccumulation trigger (BT) for total PCB's. DMMU S8 exceeded the mercury BT. The five subsurface composited samples analyzed indicated that two DMMU (C2 and C3) had no quantitated SL exceedances, whereas the remaining three DMMU (C1, C4, and C5) each had a single chemical exceedances of SL. No exceedances of Tributyltin SLs were noted in any of the twenty-two DMMU analyses conducted. A summary of all chemicals exceeding PSDDA guidelines within each DMMU is provided in Table 2. The Navy elected to conduct concurrent bioassay testing on all twenty-two DMMU because of timing considerations and concerns about exceeding bioassay holding times. Therefore, PSDDA agency determinations on the suitability of these dredged material for unconfined open-water disposal rest on the outcome of the biological testing results.

7. Standard bioassay testing was conducted on all twenty-two DMMU within the 56 day biological holding time. Table 3a summarizes the solid phase bioassay Quality Control (QC) performance guidelines and Table 3b summarizes solid phase bioassay interpretative guidelines for nondispersive sites, which were used to evaluate the bioassay data discussed below. The results for the 28-day bioaccumulation test are discussed separately in paragraph 8. Table 4 provides summaries of standard bioassay testing results and suitability outcomes relative to the PSDDA disposal guidelines for the 22 DMMU characterized.

a. Amphipod. Amphipod testing was conducted using both amphipod species as approved by the PSDDA agencies. *Rhepoxynius abronius* was used when percent fines in test sediment was less than 60 percent. Six DMMU were tested with *Rhepoxynius* in two testing rounds. Correspondingly, the remaining sixteen DMMU were assessed in two rounds of testing with *Ampelisca abdita*. The test sediments utilizing this species contained percentages of fines higher than 60 percent (PSDDA 1993 ARM Clarification). A single DMMU (S12) was tested with both amphipod species, and had a fines content of 41.5 percent. Amphipod control and reference sediments for both species met performance standards and the results were considered acceptable for decision making. As depicted in Table 4 there were no hits for DMMU tested with *Rhepoxynius*, whereas there were four double hit (S4, S6, S7, and C2) and one single hit (S8) failures for DMMU tested with *Ampelisca*.

b. Sediment Larval. Sediment larval testing was conducted over three testing rounds utilizing the sandollar (*Dendraster excentricus*). Additional blind QA/QC analyses were conducted concurrently by an independent bioassay lab (Northwest Aquatic Sciences, Inc.) on six DMMU tested by Beak during round 3. A number of problems were encountered in conducting the sediment larval test. The normal spawning cycle for this species extends from April to December each year. Animals induced to spawn towards the end of the spawning cycle (October to December) produce fewer gametes and exhibit lower viability and are subject to increased performance failures in this test. The seawater controls generally met the PSDDA performance requirements (i.e., mortality < 50 % and abnormality < 10 %), except initial round 2 testing, where the abnormality standard of 10% was exceeded at 13.7%. A retest was authorized for those samples, where the abnormality performance standard was exceeded (enclosure 2). During the third testing round, the seawater control abnormality standard was slightly exceeded at 11%. This performance exceedance of abnormality was not surfaced to the PSDDA agencies until after testing had been completed, and it was not deemed a significant QC issue

given the other problems experienced with the larval test during the running of these tests (BPJ). Carr reference R5 (57% fines) exceeded PSDDA performance guidelines (see Table 4) with 23.7% mortality during round 1 testing, and therefore was not used in decision making. Because of the round 1 reference performance failure a second within batch Carr reference R6 (81% fines) was used for test sediment statistical comparisons and decision making. No reference problems were encountered during round 2 testing. One of the two references (R6) slightly exceeded PSDDA performance guidelines at 20.3% during round 3. This exceedance was not deemed significant using BPJ and both references were deemed suitable for decision making.

Of serious concern however, was the wide range in positive control (EC50) responses ($CdCl_2$) observed among the three rounds of testing conducted, which were 17.9 mg/l, 0.1 mg/l, and 224 mg/l for rounds 1 - 3, respectively. This demonstrated a wide range in apparent larval sensitivity between testing rounds. The positive control (EC50) response ($CdCl_2$) for the QA/QC analyses conducted by Northwest Aquatic Sciences was 8.62 mg/l in comparison.

The testing summaries for the sediment larval test results are shown in Tables 4 and 5, where 7 DMMU passed bioassay interpretative guidelines, 8 had single hit failures, and 7 DMMU had double hit failures (note that a DMMU double hit response must be confirmed by another hit to be judged unsuitable) relative to nondispersive site interpretive guidelines (see Tables 3a-b). Initial round 1 testing for DMMU S3 had high mortalities that appeared to be associated with high water quality sulfides measured during the test (6.2 mg/l). This was brought to the attention of the PSDDA agencies and a retest was authorized in DMMO letter dated October 14, 1993 to GeoEngineers, Inc. (enclosure 2). DMMU S3 passed the nondispersive site suitability guidelines on retest, as did a blind sample analyzed by Northwest Aquatic Sciences, Inc. as a QA/QC check (see Tables 4 and 5).

The comparative results from Beak Consultants, Inc. and Northwest Aquatic Science's QA/QC analyses results for DMMU's S3, S7, S11, S17, C4, and C5 are summarized in Table 5.
In general, five of the six QC analyses passed nondispersive site interpretative guidelines, while S17 showed a double hit failure. The between laboratory comparisons indicated analyses results were similar for S3, S11, S17, and C4, but differed for S7 and C5. Both S7 and C5 had single hit failures for the initial testing results from Beak Consultants. Supplemental analyses conducted on these samples by Northwest Aquatic Sciences (NWAS) failed to confirm the toxic responses observed by Beak, and both showed relatively low mortalities in comparison (14.4 and 7.7 % respectively). The double hit observed in S17 by NWAS was consistent with Beak's results. A review of the QA/QC data from Beak and NWAS failed to provide a sufficient reason for the equivocal test outcomes for S7 and C5, to set aside the initial Beak results, although high variability in Beak Consultants positive control responses may have contributed to the observed larval test responses. The uncertainties in the positive control data, however, are not sufficient to set aside these results, and the results for Beak were used in regulatory decision making for this SDM.

c. Neanthes Biomass. The Neanthes test was conducted in one testing round. The West Beach negative control sediment met the performance standard (i.e., <10% mortality) at 8 % mortality. Both reference sediments from Carr Inlet (R5 and R4) out performed the control sediment with average individual biomasses of 113% and 135% of the West Beach control, respectively. There were some test innoculation irregularities noted among 5 of the 22 test sediments (S1, S2, S5, S12, S17) and one reference sediment, where one of the five replicate beakers was over innoculated (6 or 7 individuals instead of 5 as called for in the protocol). This deviation from the protocol is a concern, but most likely did not have a demonstrable effect on the test outcomes. Observed mean mortalities in test

sediments and reference sediments were generally 20 percent or less. Test sediments exhibiting individual mean biomass greater than 80% of the negative control biomass or less than 120% of the negative control biomass (i.e., test sediment biomass greater than 5.63 mg/individual and less than 8.45 mg/individual) are considered suitable for UCOWD, regardless of the reference sediment comparisons results. The following sediments were deemed suitable based on test sediment comparisons to negative control sediments: S6, S7, S8, S12, C2, C3, C4, and C5. The reference sediment performance standard specifies that the reference sediment must be at least eighty percent of the control sediment biomass to be acceptable, but does not set a limit for reference sediments that outperform the negative control. The West Beach Control (5.2% fines) was utilized as the appropriate reference sediment comparisons for tested DMMU with total fines < 30% (S1, S13, C1,). Carr Inlet reference R4 (48.8% fines) was the appropriate reference comparison for three DMMU (S2, S12, C3), whereas R5 (57% fines) was utilized to compare the remaining DMMU with higher concentrations of fined grained sediments. Comparing the relative differences of test sediments with appropriate reference sediments of similar grain size indicated that three DMMU exceeded the interpretative guidelines with test sediment biomass less than 70 percent of reference, and these were S12 (69 %), S16 (55 %) and C3 (69.8 %). However, as indicated above, both S12 and C3 were deemed suitable based on relative test biomass comparisons with negative control sediments. Statistical comparison of S16 with its appropriate reference R5 was problematic given the high within replicate variability exhibited by R5 (i.e.standard deviation = 3.92 mg/individual). It should be noted that reference R4 also had high variability (standard deviation = 4.5 mg/individual). The high variability within the references precluded establishing statistical significance. Currently, there is no performance standard for within replicate variability for reference sediments for this bioassay, although the PSDDA agencies recognize this as an issue needing future clarification. Power analyses conducted on S16 and R6 showed low Power and corresponding high Beta for the test sediment compared to reference (Power = 0.2 and Beta = 0.8)[1]. Because of the low Power and high Beta exhibited by S16 and R6 exceeding interpretive guidelines, the PSDDA agencies elected to exercise BPJ and consider this DMMU a hit under the double hit guidelines (see Table 3b).

d. Saline Microtox. The saline microtox test was conducted in three testing rounds by Laucks Laboratory. The two Carr Inlet reference sediments (R5, R6) both demonstrated light enhancement as did all twenty-two test sediments. The reference sediments were all run in a single batch, which is a departure from PSDDA testing guidelines requiring comparative reference and test sediments be analyzed within a batch. Given the positive light enhancement exhibited in all tested sediments, this deviation from testing protocol would not have changed the test interpretation outcome. The results from all 22 saline microtox tests showed light enhancement and were not interpretable.

e. Standard Bioassay Testing Summary. Table 4 summarizes the overall DMMU suitability determination relative to these test results. It indicates that 11 of 22 DMMU were deemed unsuitable for UCOWD relative to these test results, and are considered the suitability endpoint for all DMMU except DMMU S3. DMMU S3 passed standard bioassay tests, but underwent bioaccumulation testing

---

[1] In the statistical hypothesis testing of two means, low power of a test indicates that there is a high probability of accepting the null hypothesis that the two sample means (test and reference) are equal, when in fact they are different (Type I error), or alternatively when Beta is high of rejecting the alternative hypothesis that the two sample means are not equal, when in fact the alternative hypothesis is true (Type II error).

due to exceedance of the PCB trigger level. Therefore, the bioaccumulation test results are required to reach a regulatory suitability decision on this DMMU.

8. Bioaccumulation Testing Summary. The 56 day holding time was slightly exceeded by 2 days for the bioaccumulation test. The two day exceedance was necessary in order to allow the test animals (*Macoma nasuta*) to acclimate to laboratory conditions (4 to 7 days) as called for by the EPA protocol (Lee et. al., 1989). This issue was brought to the attention of the PSDDA agencies and allowance for the holding time exceedance was documented in DMMO letter to Ms. Sally Fisher (GeoEngineers) dated October 14, 1993 (enclosure 2). The bioaccumulation test was conducted on DMMU S3 over the 28 day exposure period to assess PCB bioaccumulation potential. The results of this test demonstrated a significant uptake of arochlor 1254 in *Macoma nasuta* tissue from S3 compared to reference sediment. No other arochlors were quantitated in the tissue samples. Tissue analyses from Carr Inlet reference sediment exposures failed to detect any arochlors. The results are summarized in Table 6.

Interpretation guidelines for evaluating bioaccumulation data involve a comparison of test results with Food and Drug Administration (FDA) guidelines. The results indicate that the wet weight tissue concentrations (0.506 mg/kg wet-weight) were below (0.504/2.0 = 0.25) the established 2.0 mg/kg (wet weight) FDA guideline for PCB's. An approximate *t*-test comparison (nonparametric approximate *t*-test utilized due to nonhomogeneous variances) of the DMMU S3 exposures with reference exposures demonstrated a significant difference, and test/reference tissue ratios were 72 when expressed at the Arochlor 1254 detection limit for the undetected reference, and the ratio was 145 if the undetected reference values (Arochlor 1254) are expressed at 1/2 the detection limit. The corresponding dry weight tissue/sediment ratio for DMMU S3 was 0.92 (i.e., *Macoma* tissue: 4486 µg/kg / Sediment: 4900 µg/kg = 0.92). The calculated Accumulation Factor (AF) for *Macoma* can be empirically derived from the formula:

$$AF = \frac{\dfrac{C_i(organism)}{LipidContent}}{\dfrac{C_i(sediment)}{TOC}}$$

where: Ci(organism) = *Macoma* tissue concentration (4486 ppb Arochlor 1254 = Total PCBs)
Lipid Content = *Macoma* lipid content (0.053 %)
Ci(sediment) = Sediment concentration DMMU S3 (4900 ppb Total PCBs)
TOC = Total Organic Carbon DMMU S3 (1.0 %)

The calculated AF = 1.9, is 2.3 times the AF derived for *Macoma* in an experimental evaluation of PCB uptake in three marine organisms (*Macoma*, *Palaemonetes*, and *Nereis*) by Pruell et.al. (1990)[2]. An AF of 1.9 indicates a pronounced bioaccumulation potential from material represented by DMMU S3. Given the high tissue uptake of PCBs observed, there is a significant concern for the ecological health of marine communities exposed to these sediments.The sediments represented by DMMU S3 are therefore determined to be unsuitable for UCOWD.

---

[2]R.J. Pruell, N.I.Rubenstein, B.K. Taplin, J.A. LiVolsi, and C.B. Norwood. 1990. 2, 3, 7, 8-TCDD, 2, 3, 7, 8-TCDF and PCBs in Marine Sediments and Biota: Laboratory and Field Studies. Prepared for U.S. Environmental Protection Agency for New York District, U.S. Army Corps of Engineers.

9. The following discussion addresses the need to analyze archived samples (Z samples) underlying failed subsurface DMMU C2 and C5. The requirement to characterize samples representing the post dredging surface material is deemed necessary when subsurface sediment quality and expressed surface quality is a concern (Phase II MPR, page 5-34, paragraph 5.7). Comparative surface DMMU sediment chemistry overlying these two DMMU is notably higher than the subsurface sediment quality as depicted in Table 7. Two of the surface DMMU (S15 and S17) overlying C5 passed PSDDA disposal guidelines, but exhibited chemical concentrations either equal to (S15) or higher (S17) than C5 (Table 7). All four surface DMMU overlying C2 failed PSDDA disposal guidelines and exhibited markedly higher chemical values than C2, which had no SL exceedances. In the case of DMMU C5, the sediment failed PSDDA disposal guidelines based on a single hit from the sediment larval bioassay. However, a separate QA/QC sediment larval analysis of this DMMU by an independent testing lab (Northwest Aquatic Sciences) failed to confirm the toxicity for this bioassay. Therefore, the PSDDA agencies have determined based on the aforementioned facts, that analysis of archived Z samples would not be required based on the exhibited overall pattern of contamination and chemical levels using best professional judgement.

10. The Agencies concluded based on the above discussion and summary of sediment chemical and biological retesting results for the Navy's Pier D dredging project in Sinclair Inlet, that 51,700 cubic yards is suitable (DMMU S1, S10, S11, S12, S13, S15, S17, C1, C3, C4) and 53,400 cubic yards is unsuitable (S2, S3, S4, S5, S6, S7, S8, S9, S14, S16, C2, C5) for unconfined open-water disposal. Table 8 summarizes the suitable and unsuitable volumes for the surface and subsurface. Figures 1 and 2 also depict the plan view of suitable and unsuitable DMMU characterized.

11. The following discussion compares these retest results with the initial test results conducted in 1991. Initial 1991 test results indicated qualitatively that chemicals exceeding guidelines in 1991 were also quantitated during the 1993 retest. However, the magnitude of the concentrations measured between sampling events is widely different, for chemicals such as DDT as an example. The initial 1991 characterization noted total DDT exceedances in 16 of 28 DMMU, with 5 exceeding BT, 5 exceeding ML, and a high concentration of 829 ppb. Corresponding 1993 chemical retesting results only showed a single detected and undetected exceedance of DDT SL at 12 ppb and 7 ppb (undetected), respectively. An analysis of the distribution of suitable/unsuitable DMMU between 1991 and 1993 sampling events is disturbing. As noted previously, the 1993 proposed dredging footprint is smaller at 105,100 cubic yards compared with the 171,400 cubic yard footprint initially characterized. As such the DMMU sampling locations are not exactly comparable between sampling events, but DMMU boundaries are roughly comparable for DMMU lining up on the west side of the Pier. Comparative surface DMMU for the west side of the pier and suitability determination outcomes from the two sampling events are depicted in Table 9 to illustrate the differences. High DDT levels noted in many of the 1991 DMMU at these locations were not found in 1993, and the general sediment quality appeared to be substantially improved by comparison. It is not known whether the differences noted were due to any real improvement in sediment quality, or sampling location variability likely reflecting localized hot spots occuring within the dredging prism. Similar discrepancies in 1991 and 1993 retest suitability outcomes were noted for the east side of Pier D as well. The 1993 retest generally resulted in a patchwork of suitable and unsuitable DMMU consistent with the 1991 initial characterization, although the corresponding suitable and unsuitable DMMU do not match up well between sampling events.

12. The following discussion compares the PSDDA retest results with Sediment Management Standards (SMS) characterization results for surface (top 10 cm) stations surrounding the dredging

prism at 20 locations, to assess the potential recontamination of the dredging prism area from surrounding sediments. Ecology/Sediment Management Unit's review of these data is still ongoing and results discussed herein are only preliminary, and may change when Ecology issues its final determination regarding this issue. Figure 1 (plan view) depicts the sampling locations of the SMS samples relative to the PSDDA characterization sample locations. This figure highlights DMMU suitability outcomes as well as SMS stations likely to exceed minimum cleanup levels (MCL) based on chemical and biological testing results presented in the December 30, 1993 GeoEngineers Report to the Department of Ecology prepared on behalf of the U.S. Navy. The chemical testing results generally agreed with results from the PSDDA retest, depicting an assortment of metals (mercury, copper, and zinc exceeded either SQS or MCL criteria) and organic contamination (bis(2-ethylhexyl)phthalate and total PCBs exceeded either SQS or MCL criteria) dispersed throughout and extending immediately outside the dredging area. The SMS chemical characterization did not evaluate total DDT as a chemical of concern, so the distribution of this chemical outside the immediate dredging prism remains unknown (see discussion on DDT above). All 20 SMS samples underwent concurrent bioassay testing with the amphipod (*Rhepoxynius* or *Ampelisca*), sediment larval *(Dendraster excentricus*), and 20-day *Neanthes* biomass tests. The results from these biological tests indicated that 8 of the 20 SMS samples (X3, X4, X6, X7, X8, X11, X12, X16) likely exceeded the biological effects criteria of the SMS, and confirm that the Pier D area lies within a larger area of sediments at the shipyard that, based on site investigation data, will be designated as a contaminated sediments site. Two additional stations (X20, X15) exceeded MCL for bis(2-ethylhexyl)phthalate and copper, respectively, and likely would also be included within the listed areas of sediment contamination in accordance with WAC 173-204-510. The PSDDA agencies recognize that this dredging area lies within a larger MTCA/CERCLA cleanup area. The PSDDA agencies recommend that all dredging and any future post dredging testing be coordinated with these ongoing cleanup efforts. As noted in plan view figure 1, the distribution of 7 of the 10 stations likely exceeding SMS concern criteria surrounds unsuitable DMMU on the east side of the pier at SMS stations X3, X4, X6, X7, X8, X11, and X12. Of concern are stations X16 and X20 which are adjacent to DMMU S13 and S17, respectively, both of which were found suitable for UCOWD based on 1993 retest. These two DMMU were previously found to be unsuitable in 1991 SDM. Therefore, it is likely that some recontamination of the post-dredging footprint area will occur based on the surrounding SMS sediment quality data reviewed.

13. If a Section 404 permit is issued for this project, a dredging plan must be developed and submitted prior to dredging to the Enforcement Section of the Regulatory Branch of the Seattle District Corps of Engineers. This plan must include technology and methodology which is technically adequate to separate suitable from unsuitable material.

14. This memorandum documents the suitability of proposed dredged sediments for unconfined open-water disposal at a PSDDA site. It does not constitute final agency approval of the project, nor does it address the dredgability issue referred to in paragrah 13. A public notice will be issued for this project. During the public comment period, which follows a public notice, the resource agencies will provide input on the overall project. A final decision will be made after full consideration of agency input, and after an alternatives analysis is done under Section 404 (b)(1) of the Clean Water Act.

SUBJECT: DETERMINATION ON THE SUITABILITY OF DREDGED MATERIAL RETESTED FOR THE U.S. NAVY'S PIER D DREDGING PROJECT , BREMERTON, WASHINGTON (OYB-2-012791) FOR DISPOSAL AT A PSDDA UNCONFINED OPEN-WATER DISPOSAL SITE.

Concur:

3/11/94
Date

David R. Kendall, Ph.D
Seattle District Corps of Engineers

3/23/94
Date

Justine Barton/John Malek
Environmental Protection Agency
Region X

3/15/94
Date

Tom Luster
Washington Department of Ecology

3/11/94
Date

Gene Revelas
Washington Department of Natural Resources

Copies Furnished:
Jack Kennedy, Corps
Tom Mueller, Corps
Tom Luster, Ecology
Justine Barton/John Malek, EPA
Gene Revelas, DNR
DMMO File

Table 1. Summary of DMMU Sediment Conventional Parameters and suitability for UCOWD[1].

Conventional Parameters	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11
DMMU Volume (cubic yards)	4000	3900	3800	4000	3800	3800	3200	4000	4000	3600	3600
Grain Size (%):											
Gravel	1.2	0.6	0.9	0.6	0.4	1.7	1.7	6.8	0.4	0.4	4.3
Sand	69.2	66.9	24.7	16.2	14.1	14.5	19.5	28.2	22.5	25.0	15.3
Silt	21.4	17.0	49.3	52.9	50.5	45.6	47.0	49.4	46.4	43.4	45.1
Clay	8.3	15.4	25.1	30.4	35.0	38.2	31.9	15.4	30.9	31.0	35.3
Total Solids (%)	73.1	56.3	54.7	53.0	48.1	46.8	40.8	64.5	53.0	52.7	46.8
Total Volatile Solids (%)	2.1	3.8	4.8	5.6	6.06	6.25	7.48	3.9	4.8	5.15	6.8
Total Organic Carbon (%)	0.38	0.94	1.0	1.7	1.6	1.6	1.7	1.3	1.6	1.8	2.5
Bulk Ammonia (mg/Kg)	2.9	4.6	75	68	110	47	120	5.4	13	21	34
Total Sulfides (mg/Kg)	890	590	350	180	770	260	640	260	2.3	18	580
Pass / Fail	Pass	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Pass	Pass

Conventional Parameters	S12	S13	S14	S15	S16	S17	C1	C2	C3	C4	C5
DMMU Volume (cubic yards)	3600	3000	3700	3700	3700	3700	8300	5200	9000	9200	10300
Grain Size (%):											
Gravel	1.9	57.9	0.2	0.2	0.4	1.3	8.5	0.2	28.7	1.8	0.4
Sand	56.6	19.0	21.4	18.9	8.1	9.6	64.7	14.0	33.5	26.6	26.1
Silt	21.9	13.6	55.1	58.1	60.1	57.2	14.7	51.2	30.3	41.1	50.8
Clay	19.6	9.3	23.2	26.8	31.4	32.0	12.1	34.6	7.4	30.6	22.5
Total Solids (%)	64.3	81.0	58.8	52.3	47.2	46.7	63.5	51.7	75.6	55.7	59.5
Total Volatile Solids (%)	3.42	1.38	5.0	6.0	8.0	6.5	3.4	5.74	2.6	4.82	4.6
Total Organic Carbon (%)	1.3	1.6	1.3	1.7	2.4	2.3	0.44	1.0	0.45	1.3	1.2
Bulk Ammonia (mg/Kg)	20	2.3	19	73	66	77	19	110	3.0	74	39
Total Sulfides (mg/Kg)	14	21	5.4	55	89	490	17	91	16	41	400
PASS / FAIL	Pass	Pass	Fail	Pass	Fail	Pass	Pass	Fail	Pass	Pass	Fail

1/ UCOWD = unconfined open-water disposal.

Table 2. DMMU summary of chemicals quantitated above the PSDDA Chemical Guidelines[1].

CHEMICALS	SL	BT	ML	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Metals (mg/kg)													
Antimony	20		200		21.0					240			
Cadmium	0.96		9.6		1.5		1.1	1.4 1.5		1.8	1.1 1.4	1.4 1.5	1.4
Copper	81		810	83.0	120			160 150	120	220	99.0 97.0		
Lead	66		660	74.0	360					160	130 130		
Mercury	0.21	1.5	2.1	0.32	0.8		0.41	0.28 0.22	0.23	0.27	1.83 1.75	0.23 0.23	0.33
Zinc	160		1600	190	320					360	260 260		
Organics (µg/kg)													
	800		8000	880									
Indeno(1,2,3,cd)pyrene	69		5200	160	120					150	88.0		
Pyrene	430		7300	1500	690					740	950		
Total HPAH's	1800		5100	3886	2180					2810			
Bis(2	3100									6600			
Hexachlorobutadiene	29		290						30.0	35.0			
Total DDT	6.9	50	69							7.0u		12.0	
Total PCB's	130	(38[1])	2500		200 (21.3)	4900 (490)				320 (18.8)			

CHEMICALS	SL	BT	ML	S11	S12	S13	S14	S15	S16	S17	C1	C4	C5
Metals (mg/kg)													
Cadmium	0.96		9.6	1.6	1.0		1.5	1.2	1.8	1.5		1.3	1.3
Copper	81		810	110	97.0				110	95			
Lead	66		660	85.0							94		
Mercury	0.21	1.5	2.1	0.55	0.33	0.26			0.45	0.54			
Zinc	160		1600	240	210				240	740			
Organics (µg/kg)													
Fluoranthene	630		6300		900								
Indeno(1,2,3,cd)pyrene	69		5200	160	130								
Pyrene	430		7300	550	840								
Total HPAH's	1800		5100	2329	3767								
Hexachlorobutadiene	29		290	31u					31u				
Total PCB's (TOC normalized, µg/g)	130	(38)	2500	160 (6.4)						250 (10.9)			

1/ DMMU C2 and C3 had no SL exceedances.

Table 3a. Solid Phase Bioassay Performance Standards.

PARAMETER	AMPHIPOD BIOASSAY	SEDIMENT LARVAL BIOASSAY	*NEANTHES* 20-DAY BIOMASS TEST	SALINE MICROTOX TEST
Negative control performance	Mortality ≤ 10 %	CMA[1] ≤ 50 % <u>and</u> abnormality ≤ 10 %	Mortality ≤ 10 %	None
Reference sediment performance	Reference mortality minus control mortality ≤ 20 %	NCMA[2] ≤ 20 % Seawater Control	Mean individual biomass[3] ≥ 80 % of control	Blank-corrected light decrease ≤ 20%

[1] Combined mortality and abnormality.
[2] Normalized combined mortality and abnormality relative to Seawater control$_{(Final)}$
[3] Expressed as mg/individual (dry weight)

Table 3b. Solid Phase Bioassay Interpretive Guidelines for Nondispersive sites.

BIOASSAY	NONDISPERSIVE GUIDELINES[1]	
	2-HIT	1-HIT
Amphipod (% Mortality)	Test mortality > 20% over Control mortality; Test mortality < 30% over Reference mortality, and statistically significant[2]	Test mortality > 20% over Control mortality; Test mortality > 30% over Reference mortality, and statistically significant[2]
Sediment Larval (%Combined Mort+Abnor)	Test CMA > 20% over Control CMA; Test CMA < 30% over Reference CMA, and statistically significant[2]	Test CMA > 20% over Control CMA; Test CMA > 30% over Reference CMA, and statistically significant[2]
Neanthes-20-day Biomass (mg-individual)	Test biomass < 80% or > 120% of Control biomass; Test biomass < 70 of Reference biomass, and statistically significant[2]	Test biomass < 80% or >120% of Control biomass; Test biomass < 50% of Reference biomass, and statistically significant[2]
Saline Microtox (% light Δ)	Test light Δ > 20% over Control light Δ; Test light Δ <20% (absolute) over Reference light Δ, and statistically significant[2]	NA

1/ Test response ≤ 20% of Control response (test ≥ 80% or < 120% of control biomass endpoint for *Neanthes* Bioassay) = No Hit.

2/ Statistically significant (t-test, $p<0.05$).

Table 4. Solid Phase Bioassay Results Summary for all 22 DMMU.

Dredged Material Management Units (DMMU)	Amphipod Mortality, % (*Rhepoxynius*)	Amphipod Mortality, % (*Ampelisca*)	Sediment Larval (Echinoderm)		20-day *Neanthes* biomass, mg (% reference)	Saline Microtox (% light)	DMMU Testing Summary: Pass/Fail
			Mort+Abnorm, %	Abnorm.,%			
Control (K) Reference (R) West Beach K/R7 (5.2% fines)	1 (K/R7), 3 (K)	9 (K), 9 (K)	Seawater (t-Final) 9.0, 16.1, 47.8	3.4, 6.7, 11	7.04 (K/R7)		
R6 (81% fines)	NA	12, 14	17.2, 4.7, 20.3	4.4, 9.8, 17.9	NA	-17.7	
R5 (57% fines)	NA	16, 15	23.7, 2.5, 13.2	3.5, 11.5, 19.3	7.98 (113%)[1]	-7.0	
R4 (48.8% fines)	9	NA	NA		9.53 (135.4%)[1]	NA	
R2 (46.8% fines)	20	NA	NA		NA	NA	
R3 (25.1% fines)	14	NA	NA		NA	NA	
S1 (29.7% fines)	19 (R7)		19.2 (R6)	5.3	8.29 (118% R7)	-19.8	PASS
S2 (32.4% fines)	11 (R7)		51.2 (R6)[SS(SH)]	10.7	8.83 (93% R4)	-10.6	FAIL
S3 (74.45 fines)		17 (R6)	60.6 (R6)BPJ retest 12.7 (R6)	2.7 15.4	7.86 (98% R5)	-11.5	PASS
S4 (83.3% fines)		33 (R6)[SS(DH)]	49.5 (R6)[SS(SH)]	6.4	10.51 (131% R5)	-12.7	FAIL
S5 (85.5% fines)		24 (R6)	47.4 (R6)[SS(SH)]	12.8	9.15 (115% R5)	-15.3	FAIL
S6 (83.8% fines)		30 (R6)[SS(DH)]	62.2 (R6)[SS(SH)]	6.1	6.89 (86% R5)	-10.6	FAIL
S7 (78.9% fines)		42 (R6)[SS(DH)]	63.9 (R6)[SS(SH)]	4.6	5.63 (70.6% R5)	-25.7	FAIL
S8 (64.8% fines)		47 (R5)[SS(SH)]	15.2 (R6)	8.0	5.91 (74% R5)	-35.1	FAIL
S9 (77.3% fines)		16 (R6)	43 (R6)[SS(SH)]	9.0	9.0 (113% R5)	-34.5	FAIL
S10 (74.4% fines)		26 (R6)	34.2 (R6)	4.9	9.69 (121% R5)	-20.7	PASS
S11 (80.4% fines)		20 (R6)	12.3 (R6)	6.7	8.81 (110% R5)	-20.0	PASS
S12 (41.5% fines)	26 (R2)	24 (R5)	41.2 (R6)[SS(DH)]	4.0	6.6 (69% R4)	-19.8	PASS
S13 (22.9% fines)	11 (R7)		4.1 (R5)	11.4	9.25 (131% R7)	-17.9	PASS
S14 (78.3% fines)		20 (R6)	38.2 (R6)[SS(SH)]	12.8	6.1 (76% R5)	-35.1	FAIL
S15 (84.9% fines)		21 (R6)	29.5 (R6)[SS(DH)]	12.3	9.33 (117% R5)	-30.2	PASS
S16 (91.5% fines)		28 (R6)	32.8 (R6)[SS(DH)]	15.7	4.4 (55% R5)[BPJ(DH)]	-21.0	FAIL
S17 (89.2% fines)		28 (R6)	30.7 (R6)[SS(DH)]	12.2	11.45 (143% R5)	-4.8	PASS
C1 (26.8% fines)	7 (R7)		38.5 (R5)[SS(DH)]	10.7	5.54 (78.7% R7)	-24.2	PASS
C2 (85.8% fines)		31 (R6)[SS(DH)]	27.4 (R6)[SS(DH)]	10.8	7.35 (109% R5)	-13.0	FAIL
C3 (37.7% fines)	9 (R7)		18.5 (R5)	12.9	6.65 (69.8% R4)	-9.7	PASS
C4 (71.7% fines)		24 (R6)	21.7 (R6)[SS(DH)]	16.4	6.71 (84% R5)	-22.4	PASS
C5 (73.3% fines)		19 (R6)	37.1 (R6)[SS(SH)]	9.8	5.98 (74.9% R5)	-31.6	FAIL
Positive Control (LC50/EC50)	$CdCl^2$ 0.28/1.2 mg/L	$CdCl^2$ 0.14/0.12mg/L	$CdCl^2$ 17.9/0.1/224mg/L	--	$CdCl^2$ 10.2 mg/L	phenol 23.4/19.4/ 21.4 mg/L	

1/ Both R4 and R5 have high within replicate variability, which reduces power of T-test to discern real hits (significance); therefore BPJ was exercised in lieu of statistics for S16. Appropriate test comparisons with references used R4, R5 and R7 to assess whether biomass of test was less than 70% of reference.

Legend: NA = Not Analyzed; SS = statistically significant ($p<.05$); BPJ = best professional judgement. DH = double hit; SH = single hit.

Table 5. Comparative Sediment Larval Quality Control Test Results Summary.

Sample ID.	Beak Consultants, Inc.		Northwest Aquatic Sciences, Inc..	
	Mort.+Abnorm. % (mean ± stand.dev.)	Abnorm. %	Mort.+Abnorm. % (mean ± stand.dev.)	Abnorm. %
Seawater Control (T_{final})	R1: 9.0 R2: 16.1	3.4 6.7	20.2	5.9
Yaquina Bay Control	NA	NA	7.2 ± 10.7	6.0
R6 (81% fines)	R1: 17.2 ± 11.6 R2: 4.7 ± 6.9	4.4 9.8	1.2 ± 1.5	11.0
S3 (74.5% fines)	R1: 60.6 ± 12.7[BPJ] R2: 12.7 ± 13.4	2.7 15.4	4.9 ± 5.1	7.0
S7 (78.9% fines)	R1: 63.9 ± 18.6[SS(SH)]	4.6	14.4 ± 26.3	7.6
S11 (80.4% fines)	R2: 12.3 ± 11.9	6.7	16.5 ± 18.8	6.7
S17 (89.2% fines)	R2: 30.7 ± 18.7[SS(DH)]	12.2	23.8 ± 16.8[SS(DH)]	7.2
C4 (71.7% fines)	R2: 21.7 ± 11.7	16.4	10.3 ± 17.9	5.1
C5 (73.3% fines)	R2: 37.1 ± 18.1[SS(SH)]	9.8	7.7 ± 8.6	7.6

Legend: R1 = round 1; R2 = round 2; SS = statistically significant ($p<0.05$); DH = double hit; SH = single hit; NA = not analyzed.

Table 6. Total PCB (Arochlor 1254) Bioaccumulation Testing Summary (*Macoma nasuta* tissue) for DMMU S3.

Replicate #	Lipid Content (%)	Background ppb, wet wgt (1/2 DL)	Control ppb, wet wgt (1/2 DL)	Carr Inlet Reference ppb, wet wgt (1/2 DL)	DMMU S3 ppb, wet wgt	DMMU S3 ppb, dry wgt
A	0.063	6.9u (3.45)	7.1u (3.55)	6.9u (3.45)	410	3727
B	0.062	7u (3.5)	7u (3.5)	7.1u (3.55)	390	3900
C	0.053	6.9u (3.45)	7u (3.5)	7u (3.5)	520	4727
D	0.043	7.1u (3.55)	7u (3.5)	7.1u (3.55)	660	5077
E	0.046	7.1u (3.55)	7u (3.5)	6.9u (3.45)	550	5000
Mean	0.053	(3.5)	(3.51)	(3.5)	506	4486.3
Stnd Dev.	0.01	(0.04)	(0.02)	(0.04)	98.51	564.02
Moisture (%)	--	89.2	88	88.6	88.8	88.8

Table 7. Surface/subsurface sediment chemistry quality comparisons for two subsurface DMMU failing PSDDA disposal guidelines (metal concentrations, ppm; organic concentrations, ppb) .

Surface DMMU	S4 (Fail)	S5 (Fail)	S6 (Fail)	S7 (Fail)	S14 (Fail)	S15 (Pass)	S16 (Fail)	S17 (Pass)
	Cd (1.1)	Cd (1.5) Cu (160) Hg (0.28)	Cu (120) Hg (0.23) HCB (30)	Sb (240) Cd (1.8) Cu (220) Pb (160) Hg (0.27) Zn (360) IP (150) P (740) TP (2810) BP (6600) HCB (35) DDT (7u) PCB (320)	Cd (1.5)	Cd (1.2)	Cd (1.8) Cu (110) Hg (0.45) Zn (240)	Cd (1.5) Cu (94) Hg (0.54) Zn (740) PCB (250)
Subsurface DMMU	C2 (Fail) no SL exceedances				C5 (Fail) Cd (1.3)			

Legend: SB = Antimony; IP = indeno(1,2,3,cd)pyrene; P = pyrene; TP = total HPAH; BP = Bis(2-ethylhexyl)phthalae; HCB = hexachlorobutdiene

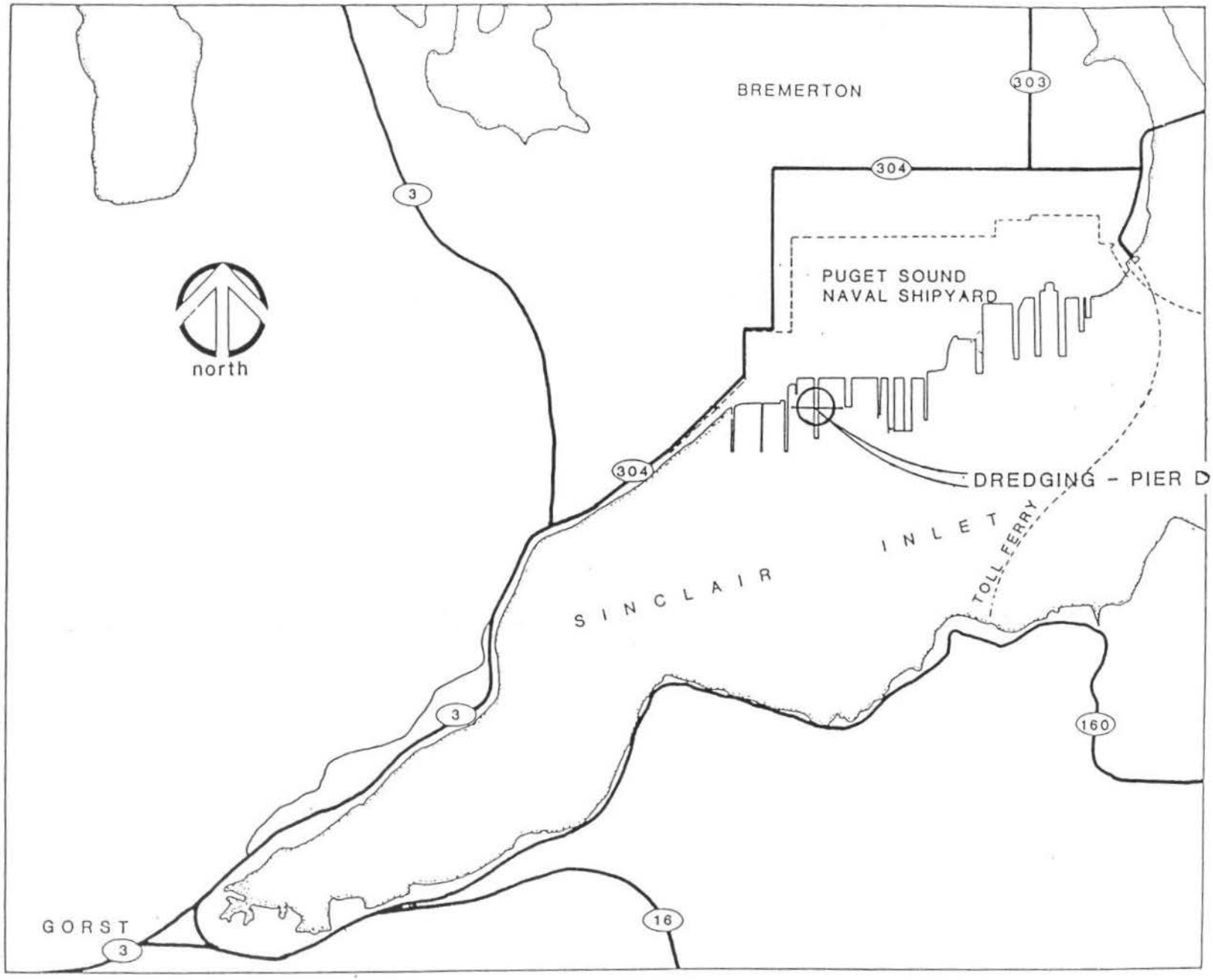
Table 8 Testing Determination Outcome Summary.

Strata	Suitable for UCOWD	Not Suitable for UCOWD	TOTALS
Surface	**25,200 cubic yards**	**37,900 cubic yards**	**63,100**
Subsurface	**26,500 cubic yards**	**15,500 cubic yards**	**42,000**
Totals:	**51,700 cubic yards**	**53,400 cubic yards**	**105,100 cubic yards**

Table 9. Comparative 1991 / 1993 Surface DMMU Suitability Determinations for the West Side of Pier.

1991 DMMU	Suitable/Unsuitable	1993 DMMU	Suitable/Unsuitable
S11	Unsuitable	S8	Unsuitable
S12	Unsuitable	S9	Unsuitable
S13	Unsuitable	S10	Suitable
S14	Unsuitable	S11	Suitable
S15	Suitable	S12	Suitable
S16	Unsuitable	S13	Suitable
S17	Unsuitable	S14	Unsuitable
S18	Unsuitable	S15	Suitable
S19	Unsuitable	S16	Unsuitable
S20	Unsuitable	S17	Suitable

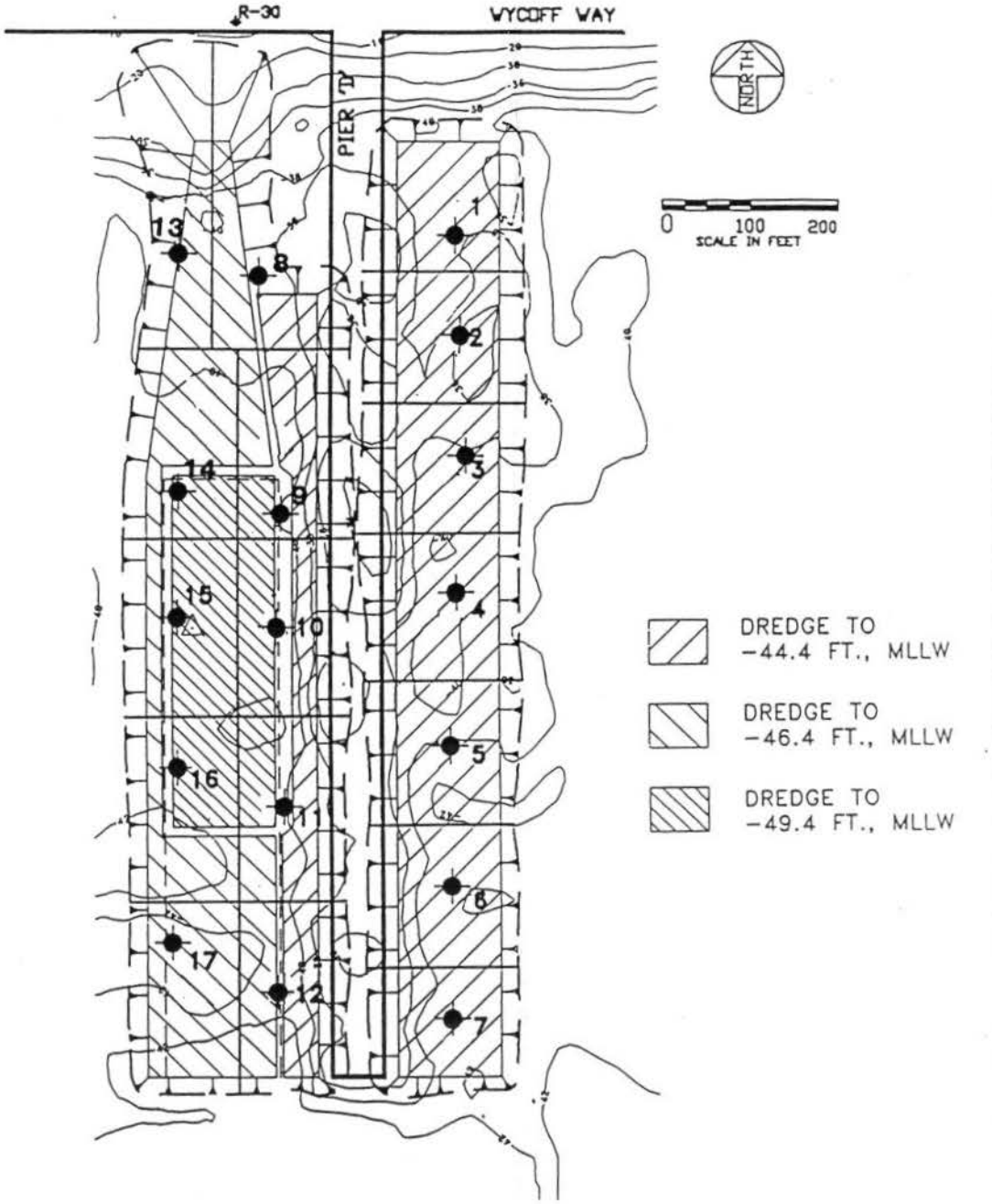
0144-146-T03 SLF/BWC 11/8/93



Geo Engineers

VICINITY MAP

FIGURE 1



FULL DEPTH CORE
(SURFACE & SUBSURFACE)

USN PUGET SOUND NAVAL SHIPYARD
BREMERTON, WA

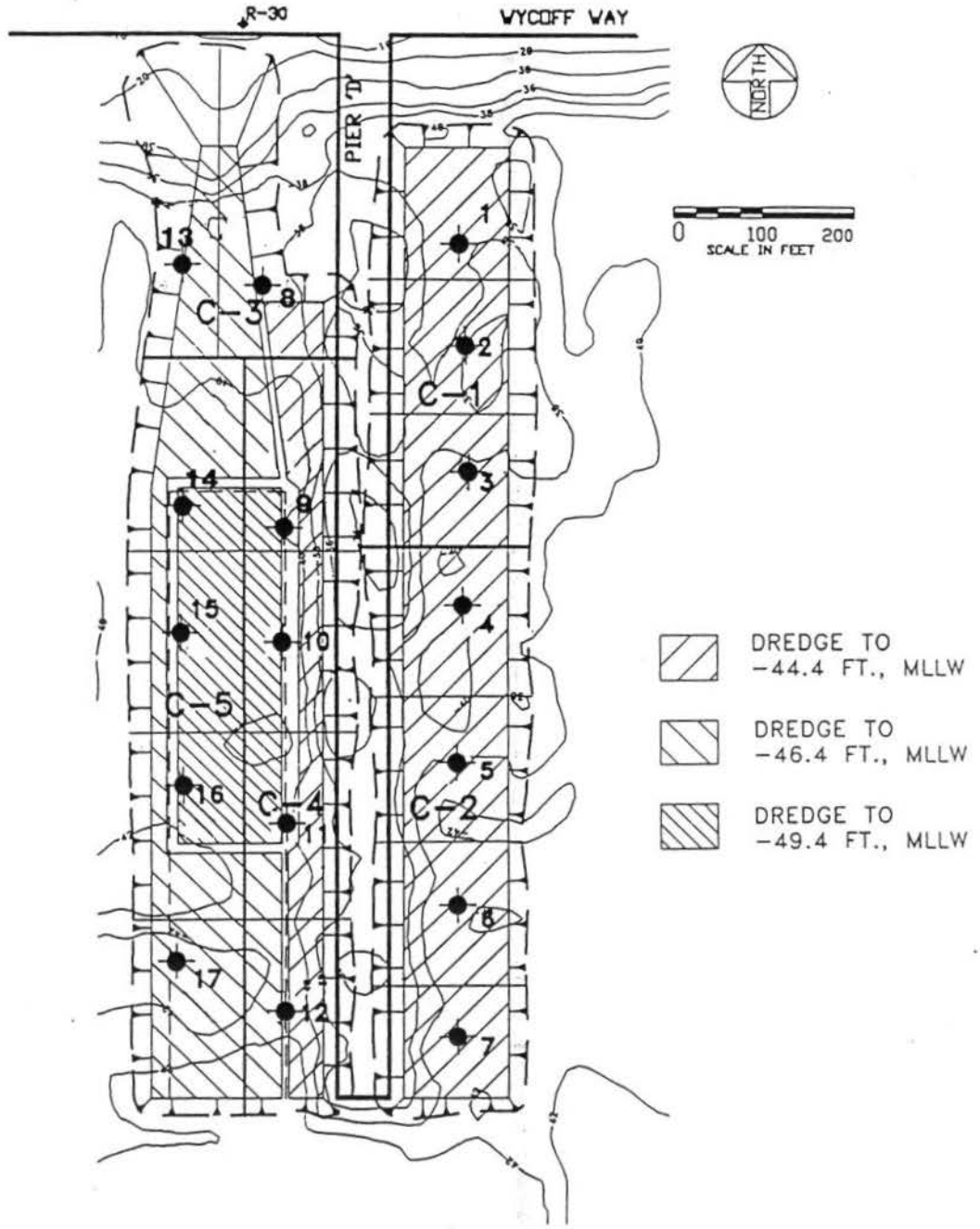
PIER D DREDGING

0144-146-T03 SLF/BWC 11/8/93

Geo Engineers

SURFACE DMMUs AND SAMPLING LOCATIONS

FIGURE 3



FULL DEPTH CORE (SURFACE & SUBSURFACE)

USN PUGET SOUND NAVAL SHIPYARD
BREMERTON, WA

PIER D DREDGING

0144-146-T03 SLF/BWC 11/8/93

Geo Engineers

SUBSURFACE DMMUs, SAMPLING LOCATIONS AND COMPOSITING SCHEME

FIGURE 4