SAMPLING & ANALYSIS PLAN

PORT TOWNSEND MARINA
ENTRANCE CHANNEL

U.S. ARMY CORPS OF ENGINEERS
SEATTLE, WASHINGTON

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This is an example of a sampling and analysis plan (SAP) for a small PSDDA project. It was adapted from an actual SAP for the Port Townsend Marina. Some of the information regarding this project has been altered to provide examples of scenarios that dredging applicants might encounter for a small dredging project. Where this liberty was taken a note was included with the form: [NOTE:]. Additional notes of the same form were included where guidance regarding other possible scenarios was needed. These notes should be deleted if this example SAP is used as a template for SAP development for your project.

1.0 PROJECT TEAM AND RESPONSIBILITIES

Table 1. Project Team and Responsibilities

Task/Responsibility	Therese Littleton	David Fox	Mary Smith	Mike Jones	Bob White
Overall project management	✓				
Sampling plan development	✓	✓			
Agency coordination		✓			
Positioning			✓		
Sediment sampling			✓		
Compositing/subsampling			✓		
Chemical analysis & QA				✓	
Biological analysis & QA					✓
Final Report			✓		

Therese Littleton, Corps of Engineers, Seattle District, Environmental Resources Section
David Fox, Corps of Engineers, Seattle District, Dredged Material Management Office
Mary Smith, Marine Technologies, Tacoma
Mike Jones, Environmental Testing Service, Seattle
Bob White, Biological Testing Laboratories, Seattle

[NOTE: Contractors and Labs are fictitious; you won't find them in the yellow pages!)

2.0 PROJECT DESCRIPTION AND SITE HISTORY

2.1 Project Description. The Corps of Engineers proposes to perform maintenance dredging of the Port Townsend Marina entrance channel in December 1997. This project consists of clamshell dredging of approximately 6,200 cubic yards (cy) of sand and silt, including side-slopes and overdepth, from a shoal area near the U.S. Coast Guard boat basin. Dredged materials that pass PSDDA chemical and biological guidelines will be disposed of at the Port Townsend open-water disposal site. Materials which do not pass PSDDA guidelines will be disposed of at a Port of Port Townsend furnished upland disposal site. Figures 1 through 3 show the project location, dredging area and potential upland disposal sites respectively. [NOTE: the actual volume for this project was 1,000 cy.]

2.2 Site History. The existing entrance channel was authorized in 1958 at a depth of 14 to 16 feet and a width of 40 to 60 feet. Maintenance dredging was last conducted in 1973 when 3,300 cy of material was removed from the channel. Sediment testing was not conducted at that time. [NOTE: the actual authorized depth is 10 to 12 feet.] In July 1989, sediment information for the Port Townsend Marina was included in the Puget Sound Estuary Program report *Contaminant Loading to Puget Sound from Two Marinas* (EPA 910/9-89-014). Sediment chemistry data from twenty van Veen grab samples (top 2.0 cm) collected both inside and outside the marina were

included in the report. One sampling station (Station 10) was located within the proposed dredging area. At this station, LPAH and HPAH exceeded PSDDA screening levels with concentrations of 3,900 and 32,000 ug/kg respectively. Several individual PAHs also exceeded their screening levels. In addition, 23 ug/kg of TBT (as TBT) were found at this station. Appendix A includes excerpts from the PSEP report. [NOTE: The actual LPAH and HPAH concentrations were 870 and 3,800 ug/kg respectively.]

Potential sources of contaminants existing in the marina and entrance channel include a stormwater outfall in the Coast Guard boat basin and a fueling dock near the boat ramp. A past source was a boat repair facility that existed within the marina prior to 1982. Sandblasting and painting services were provided by the facility. The land was undeveloped prior to construction of the marina. There are no other major industrial or wastewater outfalls within a mile of the marina. [NOTE: The source information provided here is fictitious.]

Figure 1

Figure 2

Figure 3

3.0 PSDDA SAMPLING AND ANALYSIS REQUIREMENTS

3.1 PSDDA Ranking.

The Port Townsend Marina was assigned a rank of "high" in the PSDDA Management Plan Report - Phase II (page A-11). The data presented in *Contaminant Loading to Puget Sound from Two Marinas* supports this rank. While none of the chemicals-of-concern at Station 10 exceeded the PSDDA maximum level (ML), other stations from the marina did have chemical concentrations exceeding the ML. Therefore, a "high" rank was applied in this case. [NOTE: The actual rank in MPR-II is "moderate"; the PSEP report supports a rank of "moderate"].

3.2 Sampling and Analysis Requirements.

Based on a high rank, full characterization requirements for this project are as follows:

Surface Sediments: (0 to 4 ft.)	One core section for every 4,000 cubic yards and one laboratory analysis for each 4,000 cubic yards.
Subsurface Sediments: (> 4 ft.)	One core section for every 4,000 cubic yards and one laboratory analysis for each 12,000 cubic yards.

The estimated total volume of material to be characterized for PSDDA disposal is 6,200 cubic yards. The dredged material volume and related sampling requirements are distributed as follows:

Table 2. PSDDA sampling and testing requirements

Depth Interval	Volume (cy)	Minimum Number of Core Sections	Minimum Number of Analyses
0-4 ft.	3,500	.875	.875
>4 ft.	2,700	.675	.225
Total	6,200	1.55 (round up to 2)	1.1 (round up to 2)

The dredging depth ranges from 0-9 feet over the project area. Given the shoaling pattern, it is not practical to separate surface from subsurface material and the entire shoal will be dredged by clamshell to the design depth in one pass. Therefore, the dredging footprint will be divided spatially into the two required DMMUs. In order to represent sediment in DMMU C2, samples will be taken from two locations and composited. See Figure 2 for proposed DMMUs and sampling locations. [NOTE: actual dredging depth was 0-4 feet.]

4.0 SAMPLE COLLECTION AND HANDLING PROCEDURES

4.1 Sampling and Compositing Scheme.

Table 3 includes the existing elevation, design elevation (including overdepth), the total length of each sediment bore and the core section designations at each sampling location. Table 4 shows the compositing plan. The "Z" samples will be taken from the first foot beyond the overdepth at each station and archived for potential future analysis. [NOTE: "Z" samples must be taken for high-ranked projects only.]

Table 3. Sampling station elevations, boring depths and core sections

Sampling Station Number	Existing Elevation (MLLW)	Design + Overdepth Elevation (MLLW)	Length of Sediment Bore	Core Section Designations and Depths
1	-11	-17	6	A -11 to -15 B -15 to -17 Z -17 to -18
2	-10.5	-17	6.5	A -10.5 to -14.5 B -14.5 to -17.0 Z -17 to -18
3	-9	-17	8	A -9 to -13 B -13 to -17 Z -17 to -18

Table 4. Sample Compositing Plan

DMMU	Core Sections	Volume (CY)
C1	1AB	3,000
C2	2AB/3AB	3,200

4.2 Field Sampling Schedule. Sampling is planned for August 1997. All sampling will be completed in a single day using a vibracore deployed from the Corps of Engineers vessel "Puget". Compositing will occur in the field and laboratory samples will be delivered the same day to Environmental Testing Service.

4.3 Field Notes. Field notes will be maintained during sampling and compositing operations. Included in the field notes will be the following:

- Names of the vibracore operator, vessel captain and person(s) collecting and logging in the samples.
- Weather conditions.
- Mudline elevation of each sampling station as measured from mean lower low water (NAD83).
- Date and time of collection of each vibracore sample.
- The sample station number as derived from Figure 2 and Table 3.
- Descriptions of cores.
- Any deviation from the approved sampling plan.

4.4 Decontamination. The stainless steel compositing pans and sampling utensils will be thoroughly cleaned prior to use according to the following procedure:

- Wash with brush and Alconox soap
- Tap Water Rinse
- Rinse with distilled water
- Rinse with 10% nitric acid solution
- Rinse with methanol
- Rinse with distilled water

Volatiles sampling utensils will not receive the nitric acid or methanol rinse. All hand work will be conducted with disposable latex gloves which will be rinsed with distilled water before and after handling each individual sample, as appropriate, to prevent sample contamination. Gloves will be disposed of between composites to prevent cross contamination between the DMMUs.

4.5 Positioning. A differential global positioning system (DGPS) will be used aboard the "Puget" for station positioning. The Coast Guard's differential correction signal will be utilized to obtain an accuracy of $\pm$ 3 meters. The DGPS receiver will be placed above the block on the vibracore deployment boom to accurately record the position of the vibracore. Coordinates of the proposed sampling locations will be calculated in advance and programmed into the Puget's navigation system. Once the vibracore has been deployed, the actual position will be recorded when the vibracore quadrupod is on the channel bottom and the deployment cable is in a vertical position. Horizontal coordinates will be referenced to the Washington Coordinate System North Zone (NAD 83) and converted to latitude and longitude to the nearest 0.1 second.

Water depths will be measured directly by lead-line and converted to mudline elevations using the CURRENTMASTER tide program. The lead-line measurements also serve as a check on station positioning as the actual water depth at the station coordinates should match the predicted depth at those stations.

4.6 Sample Collection Method. Lexan tubes (4-inch diameter) are manually inserted into the vibracore, the vibracore quadrupod is mechanically lowered into position on the channel bottom,

activated and allowed to penetrate to the proper sampling depth. Painted markers, spaced one foot apart along the deployment cable, are used to measure penetration depth. When sampling is completed, the vibracore quadrupod is retrieved and the lexan tube is removed and placed in a yoke for processing.

A tape measure is used to determine the length of the recovered sediment core in the transparent lexan tube. This core length is divided by the depth of penetration to calculate the decimal percent recovery. There is no way of determining the actual recovery on a foot-by-foot basis so a uniform recovery factor will be applied to the entire core. Using this recovery factor, the lexan tube will be marked to show the lower extent of the dredging prism (including overdepth) and the "Z" samples. Marks will be made around the entire circumference of the tube. The tube will then be scored lengthwise on opposite sides of the tube using a circular saw set to a depth 1/32-inch less than the thickness of the tube wall. Once scored, a decontaminated carpet knife will be used to complete both cuts so that the top of the tube may be removed. Past analyses of lexan shavings have not resulted in detection of any PSDDA chemicals of concern, but every attempt will be made to prevent shavings from contacting the sediment samples inside the tube.

4.7 Volatiles Subsampling. From one core section for each composite, samples will be removed for volatile organics testing immediately upon removing the side of the tube. The samples will be taken from along the entire length of the core section representing the dredging depth.

Two separate 4-ounce containers will be completely filled with sample sediment for volatiles, with no headspace allowed. Two samples are collected to ensure that an acceptable sample with no headspace is submitted to the laboratory for analysis. Prior to sampling, the containers, screw caps, and cap septa (silicone vapor barriers) will have been washed with detergent, rinsed once with tap water, rinsed at least twice with distilled water, and dried at >105 C. A solvent rinse will not be used because it may interfere with the analysis.

To avoid leaving headspace in the containers, sample containers can be filled in one of two ways. If there is adequate water in the sediment, the vial will be filled to overflowing so that a convex meniscus forms at the top. Once sealed, the bottle will be inverted to verify the seal by demonstrating the absence of air bubbles. If there is little or no water in the sediment, jars will be filled as tightly as possible, eliminating obvious air pockets. With the cap liner's PTFE side down, the cap will be carefully placed on the opening of the vial, displacing any excess material.

The volatiles sampling jars will be clearly labeled with the project name, sample/composite identification, type of analysis to be performed, date and time, and initials of person(s) preparing the sample, and referenced by entry into the log book

4.8 Core Logging. After the volatiles sample has been taken, each core section will then be inspected and described. For each vibracore sample, the following data will be recorded on the core log:

- Depth interval of each core section as measured from MLLW.
- Sample recovery

- Physical soil description in accordance with the Unified Soil Classification System (includes soil type, density/consistency of soil, color)
- Odor (e.g., hydrogen sulfide, petroleum products)
- Visual stratifications and lenses
- Vegetation
- Debris
- Biological Activity (e.g., detritus, shells, tubes, bioturbation, live or dead organisms)
- Presence of oil sheen
- Any other distinguishing characteristics or features

4.9 Compositing. After the core section has been logged, the remaining contents of the vibracore tube from above the dredging design depth (including overdepth) will be placed in a stainless-steel pan and the pan covered with foil. Separate pans will be kept for the individual "Z" samples. Once all core sections for a composite have been collected and placed into the same stainless steel pan, the sample will be stirred and homogenized until a consistent color and texture is achieved.

At least 7 liters of homogenized sample will be prepared to provide adequate volume for laboratory analyses. Physical, chemical and bioassay samples will be taken from the same homogenate. Portions of each composite sample will be placed in appropriate containers obtained from the chemical and biological laboratories ("Z" samples will be archived for physical and chemical testing only). Each sample container will be clearly labeled with the project name, sample/composite identification, type of analysis to be performed, date and time, and initials of person(s) preparing the sample, and referenced by entry into the log book. See Table 5 for sample volume and storage information.

Approximately 15-20 additional liters of sediment would be required for bioaccumulation testing. This additional volume will not be collected at this time. If a bioaccumulation trigger is exceeded, a decision will be made at that time whether or not to conduct bioaccumulation testing. A decision to conduct bioaccumulation testing will require a second field mobilization to retrieve additional sediment for testing.

4.10 Sample Transport and Chain-of-Custody Procedures. After sample containers have been filled they will be packed on blue ice in coolers. The coolers will be transferred to Environmental Testing Service at the end of the day. Chain-of-custody procedures will commence in the field and will track delivery of the samples to Environmental Testing Service. Specific procedures are as follows:

- Samples will be packaged and shipped in accordance with U.S. Department of Transportation regulations as specified in 49 CFR 173.6 and 49 CFR 173.24.
- Individual sample containers will be packed to prevent breakage.
- The coolers will be clearly labeled with sufficient information (name of project, time and date container was sealed, person sealing the cooler and Marine Technologies' office name and address) to enable positive identification.
- A sealed envelope containing chain-of-custody forms will be enclosed in a plastic bag and taped to the inside lid of the cooler.
- Signed and dated chain-of-custody seals will be placed on all coolers prior to shipping.

Upon transfer of sample possession to the testing laboratory, the chain-of-custody form will be signed by the persons transferring custody of the coolers. Upon receipt of samples at the laboratory, the shipping container seal will be broken and the condition of the samples will be recorded by the receiver.

Table 5. Sample volume and storage

Sample Type	Holding Time	Sample Size[a]	Temperature[b]	Container	Archive[c]
Particle Size	6 Months	200g	4°C	1-liter Glass (combined)	X
Total Solids	14 Days	125g	4°C		
Total Volatile Solids	14 Days	125 g	4°C		
Total Organic Carbon	14 Days	125 g	4°C		
Metals (except Mercury)	6 Months	50 g	4°C		
Semivolatiles, Pesticides and PCBs	14 Days until extraction 1 Year until extraction 40 Days after extraction	150 g	4°C -18°C 4°C		
Mercury	28 Days	5 g	-18°C	125 ml Glass	
Volatile Organics	14 Days	100 g	4°C	2-40 ml Glass	
Bioassay	8 Weeks	4 L	4°C	6-1 liter Glass[d]	

a. Required sample sizes for one laboratory analysis. Actual volumes to be collected have been increased to provide a margin of error and allow for retests.
b. During transport to the lab, samples will be stored on blue ice.
c. For every DMMU, a 250 ml container is filled and frozen to run any or all of the analyses indicated.
d. Containers will be completely filled with no headspace allowed.

5.0 LABORATORY PHYSICAL AND CHEMICAL SEDIMENT ANALYSIS

The composited samples will be analyzed for all the parameters listed in Appendix B and will be compared to PSDDA guidelines for open-water disposal, as well as the SMS sediment quality standards (SQS) to determine the potential for beneficial use [NOTE: sediment from a high-ranked project would not normally be evaluated for beneficial use. This evaluation is included here to address those cases in which beneficial use is a real alternative.]

5.1 Laboratory Analyses Protocols. Laboratory testing procedures will be conducted in accordance with the PSDDA Evaluation Procedures Technical Appendix, June 1988; the PSDDA Phase II Management Plan Report, September 1989; and with the PSEP Recommended Protocols. Several details of these procedures are discussed below.

5.1.1 Chain-of-custody. A chain-of-custody record for each set of samples will be maintained throughout all sampling activities and will accompany samples and shipment to the laboratory. Information tracked by the chain-of-custody records in the laboratory include sample identification number, date and time of sample receipt, analytical parameters required, location and conditions of storage, date and time of removal from and return to storage, signature of person removing and returning the sample, reason for removing from storage, and final disposition of the sample.

5.1.2 PSDDA Limits of Detection. For purposes of PSDDA testing, detection limits of all chemicals of concern must be below PSDDA screening levels. Failure to achieve this may result in a requirement to reanalyze or perform bioassays. The testing laboratory will be specifically cautioned by Marine Technologies to make certain that it complies with the PSDDA detection limit requirements. All reasonable means, including additional cleanup steps and method modifications, will be used to bring all limits-of-detection below PSDDA SLs. In addition, an aliquot (250 ml) of each sediment sample for analysis will be archived and preserved at -18 C for additional analysis if necessary.

The following scenarios are possible and will be handled appropriately:

1. One or more chemicals-of-concern (COC) have limits of detection exceeding screening levels while all other COCs are quantitated or have limits of detection at or below the screening levels: the requirement to conduct biological testing would be triggered solely by limits of detection. In this case the chemical testing subcontractor will do everything possible to bring limits of detection down to or below the screening levels, including additional cleanup steps, re-extraction, etc. This is the only way to prevent unnecessary biological testing. If problems or questions arise, the chemical testing subcontractor will be directed to contact the Dredged Material Management Office.

2. One or more COCs have limits of detection exceeding screening levels for a lab sample, but below respective bioaccumulation triggers (BT) and maximum levels (ML), and other COCs have quantitated concentrations above screening levels: The need to do bioassays is based on the detected exceedances of SLs and the limits of detection above SL become irrelevant. No further action is necessary.

3. One or more COCs have limits of detection exceeding SL and exceeding BT or ML, and other COCs have quantitated concentrations above screening levels: the need to do bioassays is based on the detected exceedances of SLs but all other limits of detection must be brought below BTs and MLs to avoid the requirement to do bioaccumulation testing or special biological testing. As in case i) everything possible will be done to lower the limits of detection.

4. Onby more than 100%, or more than one COC concentration exceeds ML: there is reason to believe that the test sediment is unsuited for open-water disposal without additional chronic sublethal testing data. In the absence of chronic sublethal data, problems with limits of detection for other COCs are irrelevant. No further action is necessary.

In all cases, to avoid potential problems and leave open the option for retesting, sediments or extracts will be kept under proper storage conditions until the chemistry data is deemed acceptable by the PSDDA agencies.

5.1.3 SMS Limits of Detection. For purposes of comparison to SQS, a tiered approach will be used to evaluate detection limits [NOTE: this evaluation is only necessary for beneficial use projects and the analysis of "Z" samples]:

- Detection limits will be compared to the July 1996 draft SMS detection limits. While the laboratory will be instructed to attempt to meet these recommended detection limits, it should be noted that some of these are very low (e.g. Aroclors) and may be unobtainable.
- If the recommended SMS detection limits cannot be met, a secondary comparison will be made directly to SQS, carbon-normalizing where appropriate.
- In addition, the 1988 dry-weight LAETs may be used if necessary to evaluate detection limits.

See Appendix B for a complete listing of these guidelines.

5.1.4 Sediment Conventionals. Analysis of total solids and total volatile solids will follow the *Recommended Protocols for Measuring Conventional Sediment Variables in Puget Sound* (PSEP, 1986). Appendix D of *Recommended Guidelines for Measuring Organic Compounds in Puget Sound Water, Sediment and Tissue Samples* (PSEP, 1996) will be followed for analysis of total organic carbon.

Particle size will be determined by ASTM Method D-422, using the following sieve numbers: 4, 10, 20, 40, 60, 140, 230. The fine-grained fraction will be classified by phi size (+5,

+6, +7, +8, >8) using hydrometer analysis. Hydrogen peroxide will not be used in preparations for grain-size analysis. Water content will be determined using ASTM D 2216. Sediment classification designation will be made in accordance with U.S. Soil Classification System, ASTM D 2487.

5.1.5 Holding Times. All samples for physical and chemical analysis will be maintained at the testing laboratory at the temperatures specified in Table 5 and analyzed within the holding times shown in the table. Sediment samples reserved for potential bioassays will be stored under chain-of-custody by Marine Technologies.

5.1.6 Quality Assurance/Quality Control. The chemistry QA/QC procedures found in Table 6 will be followed.

5.2 Laboratory Written Report. A written report will be prepared by the analytical laboratory documenting all the activities associated with sample analyses. As a minimum, the following will be included in the report:

- Results of the laboratory analyses and QA/QC results.
- All protocols used during analyses.
- Chain of custody procedures, including explanation of any deviation from those identified herein.
- Any protocol deviations from the approved sampling plan.
- Location and availability of the data.

As appropriate, this sampling plan may be referenced in describing protocols.

In addition, QA2 data required by Ecology for the SEDQUAL database will be submitted to the DMMO along with the report (see Appendix C for QA2 requirements).

Table 6. Minimum Laboratory QA/QC

Analysis Type	Method Blank[2]	Duplicate[2]	RM[2,4]	Matrix Spikes[2]	Surrogates[7]
Volatile Organics[1]	X	X[3]		X	X
Semivolatiles[1]	X	X[3]	X[5]	X	X
Pesticides/PCBs[1]	X	X[3]	X[5]	X	X
Metals	X	X	X[6]	X	
Total Organic Carbon	X	X	X[6]		
Total Solids		X			
Total Volatile Solids		X			
Particle Size		X			

1. Initial calibration required before any samples are analyzed, after each major disruption of equipment, and when ongoing calibration fails to meet criteria. Ongoing calibration required at the beginning of each work shift, every 10-12 samples or every 12 hours (whichever is more frequent), and at the end of each shift.

2. Frequency of Analysis = one per batch

3. Matrix spike duplicate will be run

4. Reference Material

5. Canadian standard SRM-1

6. NIST certified reference material 2704

7. Surrogate spikes will be included with every sample, including matrix-spiked samples, blanks and reference materials

6.0 BIOLOGICAL TESTING

6.1 Bioassay Laboratory Protocols. The tiered testing approach will be used. Biological testing will be undertaken on any composite sample which has one or more chemicals of concern above the PSDDA screening level (SL). If more than one COC exceeds the PSDDA maximum level (ML) or if a single COC is greater than two times its ML, then biological testing will not be conducted. If any COC exceeds a bioaccumulation trigger (BT), a decision will be made as to whether or not to pursue biological testing. To the maximum extent practicable, chemical results will be provided for bioassay decisions within 28 days of first sample collection. The remaining four-week period will allow time for bioassay preparation as well as time for retests if necessary.

Marine Technologies will coordinate with DMMO in selection of an appropriate PSDDA-approved reference sediment. Wet-sieving in the field, using a 63-micron sieve, will be utilized in identifying a suitable reference station.

The 10-day amphipod mortality, sediment larval combined mortality and abnormality, and *Neanthes* growth bioassays will be conducted on each sample identified for biological testing. All biological testing will be in strict compliance with *Recommended Protocols for Conducting Laboratory Bioassays on Puget Sound sediments* (1995), with appropriate modifications as specified by PSDDA in the MPR-Phase II, public workshops and the annual review process. General biological testing procedures and specific procedures for each sediment bioassay are summarized below:

6.2 General Biological Testing Procedures.

- All reference sediments will be analyzed for total solids, total volatile solids, total organic carbon and grain-size.

- Five laboratory replicates of test sediments, reference sediments and negative controls will be run for each bioassay.

- Cadmium chloride will be used as a reference toxicant for all three bioassays, using standardized concentrations specified by PSDDA.

- For the *Neanthes* and amphipod bioassays, sacrificial beakers will be used to determine interstitial salinity, ammonia and sulfides for all test and reference sediments at the beginning and end of the test period. Overlying ammonia and sulfides will be determined at test initiation and termination for the larval test.

- Water quality monitoring will be conducted, consisting of daily measurements of salinity, temperature, pH and dissolved oxygen for the amphipod and sediment larval bioassays and measurements every three days for the *Neanthes* test. Monitoring will be conducted for all test and reference sediments and negative controls (including seawater controls). Parameter measurements must be within the limits specified for each bioassay. Measurements for each

treatment will be made on a separate chemistry beaker set up to be identical to the other replicates within the treatment group, including the addition of test organisms.

6.3 Bioassay-specific Procedures.

6.3.1 Amphipod Bioassay. The test organism once the results of the particle size analysis are known. Data to be reported for this bioassay include survival, daily emergence and the number of amphipods failing to rebury at the end of the test. The control sediment has a performance standard of 10 percent mortality. The reference sediment has a performance standard of 20 percent mortality greater than control.

6.3.2 Sediment Larval Bioassay. The test organism will be selected in consultation with the testing lab and DMMO. Initial counts will be made for a minimum of five 10-ml aliquots. The test will be run until the appropriate stage of development is achieved in a sacrificial seawater control (PSDDA MPR-Phase II, pp. 5-20). Aeration will be conducted throughout the test to minimize effects from hydrogen sulfide. At the end of the test, larvae from each test sediment exposure will be examined to quantify abnormality and mortality. Final counts for seawater control, reference sediment and test sediment will be made on 10-ml aliquots.

The seawater control has a performance standard of 30 percent combined mortality and abnormality. The reference sediment has a performance standard of 35 percent combined mortality and abnormality normalized to seawater control.

6.3.4 *Neanthes* Growth Test. *Neanthes arenaceodentata* will be obtained from Dr. Don Reish in Long Beach, California. Because *Neanthes* take 2 or 3 weeks to culture and deliver, test organisms will be ordered early enough to begin testing four weeks after the sediment sampling date.

The control sediment has a performance standard of 10 percent mortality. The reference sediment has performance standards of 20 percent mortality and 80 percent of the control growth rate.

6.4 Interpretation. Test interpretations consist of endpoint comparisons to control and reference on an absolute percentage basis as well as statistical comparison to reference. Test interpretation will follow the guidelines established in the PSDDA Management Plan Report-Phase II (page 5-17) for the amphipod and sediment larval bioassays, and the minutes of the dredging year 1991 annual review meeting for the *Neanthes* bioassay, as modified by subsequent annual review proceedings and workshops.

6.5 Bioassay Retest. Any bioassay retests must be fully coordinated with, and approved by, the PSDDA agencies. The DMMO will be contacted to handle this coordination.

6.6 Laboratory Written Report. A written report will be prepared by the biological laboratory documenting all the activities associated with sample analyses. As a minimum, the following will be included in the report:

- Results of the laboratory bioassay analyses and QA/QC results, including all DAIS data found in Appendix D.
- All protocols used during analyses, including explanation of any deviation from PSEP and the approved sampling plan.
- Chain of custody procedures, including explanation of any deviation from the identified protocols.
- Location and availability of data, laboratory notebooks and chain-of-custody forms.

As appropriate, this sampling plan may be referenced in describing protocols.

7.0 REPORTING

7.1 QA Report. The project quality assurance representative will prepare a quality assurance report based upon activities involved with the field sampling and review of the laboratory analytical data. The laboratory QA/QC reports will be incorporated by reference. This report will identify any field and laboratory activities that deviated from the approved sampling plan and the referenced protocols and will make a statement regarding the overall validity of the data collected. The QA/QC report will be incorporated into the Final Report.

7.2 Final Report. A written report shall be prepared by Marine Technologies documenting all activities associated with collection, compositing, transportation of samples, and chemical and biological analysis of samples. The chemical and biological reports will be included as appendices. As a minimum, the following will be included in the Final Report:

- Type of sampling equipment used.
- Protocols used during sampling and testing and an explanation of any deviations from the sampling plan protocols.
- Descriptions of each sample.
- Locations where the sediment samples were collected. Locations will be reported in latitude and longitude to the nearest tenth of a second.
- A plan view of the project showing the actual sampling location.
- Chain of-custody procedures used, and explanation of any deviations from the sampling plan procedures.
- Description of sampling and compositing procedures.
- Final QA report for Section 7.1 above.
- Chemical and biological testing data, with comparisons to PSDDA and SMS guidelines.

- QA2 data required by the Department of Ecology for data validation prior to entering data in their Sediment Quality database. These data are listed in Appendix C.
- Sampling and analysis cost data will be submitted upon project completion on forms provided by the Dredged Material Management Office.

8.0 REFERENCES

PSEP, *Recommended Protocols for Measuring Selected Environmental Variables in Puget Sound*, 1986-1996, Puget Sound Estuary Program.

PSDDA, 1988. *Evaluation Procedures Technical Appendix - Phase I*, prepared by the PSDDA agencies.

PSDDA, 1989. *Management Plan Report - Phase II*, prepared by the PSDDA agencies.

Puget Sound Estuary Program, 1989, *Contaminant Loading to Puget Sound from Two Marinas* (EPA 910/9-89-014).

APPENDIX A

Excerpts from

Contaminant Loading to Puget Sound from Two Marinas

Puget Sound Estuary Program
1989

(EPA 910/9-89-014)

APPENDIX B

PSDDA PARAMETERS AND METHODS

Parameter	Prep Method	Analysis Method	PSDDA SL	PSDDA BT	PSDDA ML	SMS SQS	July 96 draft SMS detection limits (1)	1988 LAET
CONVENTIONALS:								
Total Solids (%)	---	Pg.17 (2)	---	---	---	---	---	---
Total Volatile Solids(%)	---	Pg.20 (2)	---	---	---	---	---	---
Total Organic Carbon (%)	---	DOE (3)	---	---	---	---	---	---
Grain Size	---	Modified ASTM with Hydrometer	---	---	---	---	---	---
METALS			units: mg/kg dw (4)			units: mg/kg dw	units: mg/kg dw	
Antimony	3050 (5)	GFAA (6)	150	150	200	---	---	150
Arsenic	3050	GFAA	57	507.1	700	57	19	57
Cadmium	3050	GFAA	5.1	---	14	5.1	1.7	5.1
Chromium	3050	GFAA	---	---	---	260	87	260
Copper	3050	ICP (7)	390	---	1,300	390	130	390
Lead	3050	ICP	450	---	1,200	450	150	450
Mercury	7471 (8)	7471	0.41	1.5	2.3	0.41	0.14	0.59
Nickel	3050	ICP	140	370	370	---	---	>140
Silver	3050	GFAA	6.1	6.1	8.4	6.1	2.0	>0.56
Zinc	3050	ICP	410	---	3,800	410	137	410
ORGANICS								
LPAH			units: ug/kg dw			units: mg/kg oc	units: ug/kg dw	
Naphthalene	3540 (9)	8270 (10)	2,100	---	2,400	99	700	2100
Acenaphthylene	3540	8270	560	---	1,300	66	433	>560
Acenaphthene	3540	8270	500	---	2,000	16	167	500
Fluorene	3540	8270	540	---	3,600	23	180	540
Phenanthrene	3540	8270	1,500	---	21,000	100	500	1500
Anthracene	3540	8270	960	---	13,000	220	320	960
2-Methylnaphthalene	3540	8270	670	---	1,900	38	223	670
Total LPAH			5,200	---	29,000	370	---	5200
HPAH			units: ug/kg dw			units: mg/kg oc	units: ug/kg dw	
Fluoranthene	3540	8270	1,700	4600	30,000	160	567	1700
Pyrene	3540	8270	2,600	---	16,000	1000	867	2600
Benzo(a)anthracene	3540	8270	1,300	---	5,100	110	433	1300
Chrysene	3540	8270	1,400	---	21,000	110	467	1400
Benzofluoranthenes	3540	8270	3,200	---	9,900	230	1067	3200
Benzo(a)pyrene	3540	8270	1,600	3,600	3,600	99	533	1600
Indeno(1,2,3-c,d)pyrene	3540	8270	600	---	4,400	34	200	600
Dibenzo(a,h)anthracene	3540	8270	230	---	1,900	12	77	230
Benzo(g,h,i)perylene	3540	8270	670	---	3,200	31	223	670
Total HPAH			12,000	---	69,000	960		12000
CHLORINATED HYDROCARBONS			units: ug/kg dw			units: mg/kg oc	units: ug/kg dw	
1,3-Dichlorobenzene	P&T (11)	8260 (11)	170	1,241	---	---	---	>170
1,4-Dichlorobenzene	P&T	8260	110	120	120	3.1	37	110

Parameter	Prep Method	Analysis Method	PSDDA SL	PSDDA BT	PSDDA ML	SMS SQS	July 96 draft SMS detection limits (1)	1988 LAET
1,2-Dichlorobenzene	P&T	8260	35	37	110	2.3	35	35
1,2,4-Trichlorobenzene	3540	8270	31	---	64	0.81	31	31
Hexachlorobenzene (HCB)	3540	8270	22	168	230	0.38	22	22
PHTHALATES			units: ug/kg dw			units: mg/kg oc	units: ug/kg dw	
Dimethyl phthalate	3540	8270	1,400	1,400	---	53	24	71
Diethyl phthalate	3540	8270	1,200	---	---	61	67	>48
Di-n-butyl phthalate	3540	8270	5,100	10,220	---	220	467	1400
Butyl benzyl phthalate	3540	8270	970	---	---	4.9	21	63
Bis(2-ethylhexyl)phthalate	3540	8270	8,300	13,870	---	47	433	1300
Di-n-octyl phthalate	3540	8270	6,200	---	---	58	2067	>420
PHENOLS			units: ug/kg dw			units: ug/kg dw	units: ug/kg dw	
Phenol	3540	8270	420	876	1,200	420	140	420
2 Methylphenol	3540	8270	63	---	77	63	63	63
4 Methylphenol	3540	8270	670	---	3,600	670	223	670
2,4-Dimethylphenol	3540	8270	29	---	210	29	29	29
Pentachlorophenol	3540	8270	400	504	690	360	120	>140
MISCELLANEOUS EXTRACTABLES			units: ug/kg dw			units: ug/kg dw	units: ug/kg dw	
Benzyl alcohol	3540	8270	57	---	870	57	57	57
Benzoic acid	3540	8270	650	---	760	650	217	650
			units: ug/kg dw			units: mg/kg oc	units: ug/kg dw	
Dibenzofuran	3540	8270	540	---	1,700	15	180	540
Hexachloroethane	3540	8270	1,400	10,220	14,000	---	---	---
Hexachlorobutadiene	3540	8270	29	212	270	3.9	11	11
N-Nitrosodiphenylamine	3540	8270	28	130	130	11	28	28
VOLATILE ORGANICS			units: ug/kg dw				units: ug/kg dw	
Trichloroethene	P&T	P&T	160	1,168	1,600	---	---	---
Tetrachloroethene	P&T	P&T	57	102	210	---	---	57
Ethylbenzene	P&T	P&T	10	27	50	---	---	10
Total Xylene	P&T	P&T	40	---	160	---	---	40
PESTICIDES & PCBs			units: ug/kg dw			units: mg/kg oc	units: ug/kg dw	
Total DDT	---	---	6.9	50	69	---	---	---
p,p'-DDE	3540	8081 (12)	---	---	---	---	---	9
p,p'-DDD	3540	8081	---	---	---	---	---	16
p,p'-DDT	3540	8081	---	---	---	---	---	>6
Aldrin	3540	8081	10	37	---	---	---	---
Chlordane	3540	8081	10	37	---	---	---	---
Dieldrin	3540	8081	10	37	---	---	---	---
Heptachlor	3540	8081	10	37	---	---	---	---
Lindane	3540	8081	10	---	---	---	---	---
Total PCBs	3540	8081	130	38 (13)	3,100	12	6	130

1. *Recommended* Sample Preparation Methods, Cleanup Methods, Analytical Methods and Detection Limits for Sediment Management Standards, Chapter 173-204 WAC, Draft - July 1996.

2. *Recommended Protocols for Measuring Conventional Sediment Variables in Puget Sound*, Puget Sound Estuary Program, March, 1986.

3. *Recommended Methods for Measuring TOC in Sediments*, Kathryn Bragdon-Cook, Clarification Paper, Puget Sound Dredged Disposal Analysis Annual Review, May, 1993.

4. units: ug = microgram, mg = milligram, kg = kilogram, dw = dry weight, oc = organic carbon.

5. *Test Methods for Evaluating Solid Waste. Laboratory manual physical/chemical methods*. Method 3050, SW-846, 3rd ed., Vol 1A, Chapter 3, Sec 3.2, Rev 1. Office of Solid Waste and Emergency Response, Washington, DC.

6. Graphite Furnace Atomic Absorption (GFAA) Spectrometry - SW-846, *Test Methods for Evaluating Solid Waste Physical/Chemical Methods*, EPA 1986.

7. Inductively Coupled Plasma (ICP) Emission Spectrometry - SW-846, *Test Methods for Evaluating Solid Waste Physical/Chemical Methods*, EPA 1986.

8. *Test Methods for Evaluating Solid Waste. Laboratory manual physical/chemical methods*. Method 7471, SW-846, 3rd ed., Vol 1A, Chapter 3, Sec 3.3. Office of Solid Waste and Emergency Response, Washington, DC.

9. Soxhlet Extraction - Method 3540, SW-846, *Test Methods for Evaluating Solid Waste Physical/Chemical Methods*, EPA 1986.

10. GCMS Capillary Column - Method 8270, SW-846, *Test Methods for Evaluating Solid Waste Physical/Chemical Methods*, EPA 1986.

11. Purge and Trap Extraction and GCMS Analysis - Method 8260, *Test Methods for Evaluating Solid Waste Physical/Chemical Methods*, EPA 1986.

12. GCMS Capillary Column - Method 8081, SW-846, *Test Methods for Evaluating Solid Waste Physical/Chemical Methods*, EPA 1986.

13. Total PCBs BT value in mg/kg oc.

APPENDIX C

QA2 DATA REQUIREMENTS

CHEMICAL VARIABLES

ORGANIC COMPOUNDS

The following documentation is needed for organic compounds:

- A cover letter referencing or describing the procedure used and discussing any analytical problems
- Reconstructed ion chromatograms for GC/MS analyses for each sample
- Mass spectra of detected target compounds (GC/MS) for each sample and associated library spectra
- GC/ECD and/or GC/flame ionization detection chromatograms for each sample
- Raw data quantification reports for each sample
- A calibration data summary reporting calibration range used [and decafluorotriphenylphosphine (DFTPP) and bromofluorobenzene (BFB) spectra and quantification report for GC/MS analyses]
- Final dilution volumes, sample size, wet-to-dry ratios, and instrument detection limit
- Analyte concentrations with reporting units identified (to two significant figures unless otherwise justified)
- Quantification of all analytes in method blanks (ng/sample)
- Method blanks associated with each sample
- Recovery assessments and a replicate sample summary (laboratories should report all surrogate spike recovery data for each sample; a statement of the range of recoveries should be included in reports using these data)
- Data qualification codes and their definitions.

METALS

For metals, the data report package for analyses of each sample should include the following:

- Tabulated results in units as specified for each matrix in the analytical protocols, validated and signed in original by the laboratory manager
- Any data qualifications and explanation for any variance from the analytical protocols
- Results for all of the QA/QC checks initiated by the laboratory
- Tabulation of instrument and method detection limits.

All contract laboratories are required to submit metals results that are supported by sufficient backup data and quality assurance results to enable independent QA reviewers to conclusively determine the quality of the data. The laboratories should be able to supply legible photocopies of original data sheets with sufficient information to unequivocally identify:

- Calibration results
- Calibration and preparation blanks
- Samples and dilutions
- Duplicates and spikes
- Any anomalies in instrument performance or unusual instrumental adjustments.

BIOASSAYS

Amphipod Mortality Test

The following data should be reported by all laboratories performing this bioassay:

- Daily water quality measurements during testing (e.g., dissolved oxygen, temperature, salinity, pH) (plus ammonia & sulfides at test initiation and termination)
- Daily emergence for each beaker and the 10-day mean and standard deviation for each treatment
- 10-day survival in each beaker and the mean and standard deviation for each treatment
- Interstitial salinity values of test sediments
- 96-hour LC_{50} values with reference toxicants.
- Any problems that may have influenced data quality.

Neanthes Growth Test

The following data should be reported by all laboratories performing this bioassay:

- Water quality measurements at test initiation and termination and every three days during testing (e.g., dissolved oxygen, temperature, salinity, pH) (plus ammonia & sulfides at test initiation and termination)
- 20-day survival in each beaker and the mean and standard deviation for each treatment.
- Initial biomass
- Final biomass (20-day) for test, reference and control treatments.
- 96-hour LC_{50} values with reference toxicants.
- Any problems that may have influenced data quality.

Sediment Larval Test

The following data should be reported by all laboratories performing this bioassay:

- Daily water quality measurements (e.g., dissolved oxygen, temperature, salinity, pH) (plus ammonia + sulfides at test initiation & termination)
- Individual replicate and mean and standard deviation data for larval survival at test termination.
- Individual replicate and mean and standard deviation data for larval abnormalities at test termination
- 48-hour LC_{50} and EC_{50} values with reference toxicants.
- Any problems that may have influenced data quality.

APPENDIX D - DAIS DATA REQUIREMENTS

Sample Locations and Compositing				
	Test Sediment	Reference Sediment	Control Sediment	Seawater Control
Latitude and Longitude (to nearest 0.1 second)				
NAD 1927 or 1983				
USGS Benchmark ID				
Station name (e.g. Carr Inlet)				
Water depth (corrected to MLLW)				
Drawing showing sampling locations and ID numbers				
Compositing scheme (sampling locations/depths for composites)				
Sampling method				
Sampling dates				
Estimated volume of dredged material represented by each DMMU				
Positioning method				
Sediment Conventionals				
Preparation and analysis methods				
Sediment conventional data and QA/QC qualifiers				
QA qualifier code definitions				
Triplicate data for each sediment conventional for each batch				
Units (dry weight except total solids)				
Method blank data (sulfides, ammonia, TOC)				
Method blank units (dry weight)				
Analysis dates (sediment conventionals, blanks, TOC CRM)				
TOC CRM ID				
TOC CRM analysis data				
TOC CRM target values				
Grain Size Analysis				
Fine grain analysis method				
Analysis dates				
Triplicate for each batch				
Grain size data (complete sieve and phi size distribution)				

Chemicals of Concern Analysis Data				
	Metals	Semivol.	Pest./ PCBs	Volatiles
Extraction/digestion method				
Extraction/digestion dates (test sediment, blanks, matrix spike, reference material)				
Analysis method				
data and QA qualifier included for:				
test sediments				
reference materials including 95% confidence interval (each batch)				
method blanks (each batch)				
matrix spikes (each batch)				
matrix spike added (dry weight basis)				
replicates (each batch)				
Units (dry weight)				
Method blank units (dry weight)				
QA/QC qualifier definitions				
Surrogate recovery for test sediment, blank, matrix spike, ref. material				
Analysis dates (test sediment, blanks, matrix spike, reference material)				

Shaded areas indicate required data

BIOASSAYS

Amphipod Mortality and Emergence				
	Each Batch	Test Sediment	Reference Sediment	Control Sediment
Species Name				
Mortality and Emergence:				
Start date				
Daily emergence (for 10 days)				
Survival at end of test				
Number failing to rebury at end of test				
Positive Control:				
Toxicant used				
Toxicant concentrations				
Exposure time				
LC50				
LC50 method of calculation				
Start date				
Survival data				
Water Quality Measurement Methods:				
Dissolved oxygen				
Ammonia				
Interstitial salinity				
Sulfide				
Water salinity				
Water Quality:				
Temperature (day 0 through day 10)				
pH (day 0 through day 10)				
Dissolved oxygen (day 0 through day 10)				
Water salinity (day 0 through day 10)				
Sulfide (day 0, day 10)				
Ammonia (day 0, day 10)				
Interstitial water salinity (day 0)				

Neanthes 20-day Growth Test				
	Each Batch	Test Sediment	Reference Sediment	Control Sediment
Starting age (in days post-emergence)				
Food type				
Quantity (mg/beaker/interval)				
Feeding interval (hours)				
Biomass and Mortality:				
Start date				
Initial counts and weights (mg dry weight)				
Number of survivors and final weights (mg dry weight)				
Positive Control:				
Toxicant used				
Toxicant concentration				
Exposure time				
LC50				
LC50 method of calculation				
Start date				
Survival data				
Water Quality Measurement Methods				
Dissolved oxygen				
Ammonia				
Interstitial salinity				
Sulfide				
Water salinity				
Water Quality:				
Temperature (days 0, 3, 6, 9, 12, 15, 18, 20)				
pH (days 0, 3, 6, 9, 12, 15, 18, 20)				
Dissolved oxygen (days 0, 3, 6, 9, 12, 15, 18, 20)				
Water salinity (days 0, 3, 6, 9, 12, 15, 18, 20)				
Interstitial salinity (day 0)				
Sulfide (initial and final)				
Ammonia (initial and final)				

Sediment Larval Mortality and Abnormality				
	Each Batch	Test Sediment	Reference Sediment	Seawater Control
Species Name				
Bioassay Parameters				
Inoculation time (hours)				
Exposure time (hours)				
Stocking beaker density (#/ml)				
Stocking aliquot size (ml)				
Aeration (yes/no)				
Mortality and Abnormality:				
Start date				
Initial count (minimum of five 10-ml aliquots)				
Final Count:				
Aliquot size (ml)				
Number normal per aliquot				
Number abnormal per aliquot				
Water Quality Measurement Methods:				
Dissolved oxygen				
Ammonia				
Sulfide				
Water salinity				
Water Quality:				
Temperature (daily)				
pH (daily)				
Dissolved oxygen (daily)				
Water salinity (daily)				
Sulfide (initial and final)				
Ammonia (initial and final)				
Positive Control:				
Toxicant used				
Toxicant concentrations				
Exposure time				
EC50				
EC50 method of calculation				
Start date				
Normal/abnormal counts				