DREDGED MATERIAL EVALUATION APPLICATION REPORT

Dredged Material Management Year 1991

Puget Sound
Dredged Disposal Analysis
Program

February 1992

DREDGED MATERIAL MANAGEMENT OFFICE

Seattle District
US Army Corps of Engineers

Puget Sound
Dredged Disposal Analysis

Dredged Material Evaluation Application Report

Dredged Material Management Year 1991

David Fox
U.S. Army Corps of Engineers
Seattle District
Dredged Material Management Office

Contributing Authors

David Kendall, Corps of Engineers
Richard Phipps, Department of Natural Resources
Thomas Gries, Department of Ecology

Technical Review

U.S. Army Corps of Engineers
Robert Parker, Frank Urabeck, Thomas Mueller, Stephanie Stirling
Hiram Arden, Patrick Cagney, Linda Cox, John Wakeman

Environmental Protection Agency
Justine Smith

Department of Ecology
Keith Phillips, Maria Peeler
Russ McMillan, Rick Vining, Desiree Brown

Department of Natural Resources
Gene Revelas

TABLE OF CONTENTS

LIST OF TABLES ii

LIST OF FIGURES iii

LIST OF ACRONYMS iv

I. INTRODUCTION 1

II. DY91 PROJECTS 3
- A. Project Ranking 3
- B. Sampling and Analysis Plan Approval for DY91 Projects 5
- C. Sampling 5
- D. Chemical Testing 8
- E. Biological Testing 9
- F. Suitability Decisions 11
- G. Cost Data 14

III. DY92 PROJECTS 18
- A. Project Ranking 18
- B. DY92 Projects with Approved Sampling and Analysis Plans 20

IV. PSDDA DISPOSAL SITE USE SUMMARY - Prepared by Richard Phipps 22
- A. Introduction 22
- B. Commencement Bay Disposal Site 24
- C. Elliott Bay Disposal Site 24
- D. Port Gardner Disposal Site 24
- E. Rosario Strait Disposal Site 25

V. UPLAND DISPOSAL SUMMARY - Prepared by Tom Gries 26

VI. SUMMARY AND ASSESSMENT OF DY91 DATA 27
- A. Summary of Testing Results 27
- B. Ranking Analysis 34
- C. Regulatory Processing 36
- D. Cost Analysis 39

VII. RECOMMENDATIONS FOR ANNUAL REVIEW MEETING ISSUES.
Prepared by David R. Kendall 45
- A. Sampling Guidelines. 45
- B. Bioassay Guidelines 45
- C. Chemistry Testing Guidelines 46
- D. Program Facilitation 46

LIST OF TABLES

		Page
Table 1	DY91 PSDDA Evaluation Activities	2
Table 2	DY91 Project Ranking	4
Table 3	DY91 Projects - Approved Sampling Plans	6
Table 4	DY91 Project Sampling	7
Table 5	DY91 Biological Testing Data	10
Table 6	DY91 Suitability Decisions	12
Table 7	DY92 Project Ranking	19
Table 8	DY92 Projects - Approved Sampling Plans	21
Table 9	PSDDA Site Disposal Seasons	22
Table 10	Summary of PSDDA Disposal Site Use During DY91	23
Table 11	DY91 Upland Disposal	26
Table 12	PSDDA Chemical Testing Summary	28
Table 13	Multiple Exceedances of PSDDA Guideline Values	30
Table 14	DY91 Bioassay "Hits"	31
Table 15	Summary of DY90-92 Reference Area Performance Failures	33
Table 16	Partial Characterization Ranking Algorithm	34
Table 17	Summary of Testing Data for Reranking Consideration	35

LIST OF FIGURES

		Page
Figure 1	DY91 Total Project Costs	15
Figure 2	DY91 Total Cost Per Dredged Material Management Unit	16
Figure 3	DY91 Total Project Cost Per Cubic Yard	17
Figure 4	Regulatory Processing Time	37
Figure 5	Cost Analysis - Project Size Versus Unit Cost	40
Figure 6	Rank Versus Unit Testing Costs - Dredging Year 1991	41
Figure 7	DY91 Chemistry Unit Cost Analysis	43
Figure 8	DY91 Bioassay Unit Cost Analysis	44

LIST OF ACRONYMS

ARM	Annual Review Meeting
AVS	Acid Volatile Sulfides
BP	British Petroleum
BT	Bioaccumulation Trigger
COC	Chemical of Concern
DAIS	Dredged Analysis Information System
DMEAR	Dredged Material Evaluation Application Report
DMMO	Dredged Material Management Office
DMMU	Dredged Material Management Unit
DNR	Department of Natural Resources
DO	Dissolved Oxygen
DY	Dredging Year
EPA	Environmental Protection Agency
EPTA	Evaluation Procedures Technical Appendix
FC	Full Characterization
GIS	Geographical Information System
HPAH	High-molecular-weight PAH
LPAH	Low-molecular-weight PAH
ML	Maximum Level
MPR	Management Plan Report
O&M	Operations and Maintenance
PAH	Polynuclear Aromatic Hydrocarbon
PC	Partial Characterization
PCBs	Polychlorinated Biphenyls
PPB	Parts Per Billion
PPM	Parts Per Million
PSDDA	Puget Sound Dredged Disposal Analysis
PSEP	Puget Sound Estuary Program
PSVTS	Puget Sound Vessel Traffic Service
QA/QC	Quality Assurance/Quality Control
RPD	Relative Percent Difference
SAP	Sampling and Analysis Plan
SL	Screening Level
TOC	Total Organic Carbon
USACE	U.S. Army Corps of Engineers

DREDGED MATERIAL EVALUATION APPLICATION REPORT
DREDGING YEAR 1991

I. INTRODUCTION

This is the third annual Dredged Material Evaluation Application Report (DMEAR) prepared by the Seattle District of the Corps of Engineers. The report summarizes the application of PSDDA evaluation guidelines to the sampling and testing of sediments proposed for dredging and disposal at one of the eight PSDDA open-water disposal sites in Puget Sound. This report has been prepared pursuant to requirements established in the PSDDA Phase I and II Management Plan Reports (MPR) and will be used by the Department of Ecology, in part, for the preparation of their annual Management Plan Assessment Report. Preliminary recommendations of issues for discussion and resolution at the PSDDA Dredging Year 1991 Annual Review Meeting are included.

The period covered by this report is Dredging Year 1991 (DY91), which is defined as June 16, 1990 to June 15, 1991. Two changes have been made to the approach used in the DY90 DMEAR: 1) all activities occurring during DY91 have been included. The focus of the report will be on the presentation of data for DY91 projects, defined as those projects for which suitability decisions were made within the dredging year. However, DY92 projects will also be presented briefly if ranking decisions or sampling plan approval occurred during DY91. The purpose of this change is to accurately reflect the level of activity which occurred during the dredging year and to provide more current information; 2) The Department of Natural Resources' dredged material disposal report has been incorporated into the DY91 DMEAR, as has upland disposal data compiled by the Department of Ecology. The purpose of this change is to consolidate reporting, as agreed upon at the DY90 Annual Review Meeting, and to provide a more comprehensive summary of dredged material management activities.

During DY91, there were twenty-five projects at some stage of the PSDDA process (see Table 1 for a summary of DY91 activities). Of these, twelve either had final suitability decisions made by June 15, 1991, or had their permit applications withdrawn subsequent to PSDDA sampling and testing. These twelve projects are considered DY91 projects for the purpose of this report. All other projects are assumed to be DY92 projects.

TABLE 1 - DY91 PSDDA EVALUATION ACTIVITIES

PROJECT	Project Volume	Ranking Determination	Sampling Plan Approval	Suitability Decision
Anchor Cove Marina	15,400			X
Ash Grove Cement West	10,000			[1]
B.P. Oil Refinery	569,000			X
Chevron USA	9,200			X
Hulbert Mill - 12th St. Marina	208,000	X	X	[1]
Hurlen Construction	4,000			X
Redmond, et al	378	X		X
Port of Silverdale	21,000	X	X	X
Tristar Marine	5,500			X
U.S. Oil & Refining	22,000			X
USACE Keystone Harbor	48,000	X	X	X
USACE Swinomish Channel	107,569	X		X
Day Island Yacht Club	9,000	X		
Day Island Yacht Harbor	22,000	X		
Port of Everett-10th St. Boat Ramp	9,500	X		
Harbor Pointe Marina	250,000	X		
LOTT Olympia Treatment Plant Outfall	7,975	X		
Salmon Bay Terminals	116,000	X		
Port of Seattle Terminal 5	12,000	X	X	
Port of Tacoma Blair Waterway	594,000	X	X	
U.S. Navy Keyport KB Dock	15,600	X		
U.S. Navy Bremerton-Pier D	170,400	X	X	
U.S. Navy Homeport-Element II	426,604	X	X	[2]
USACE/Port of Bellingham O&M	299,125	X	X	[2]
USACE Duwamish O&M	31,672	X	X	[3]
Total:	2,983,923			

[1]Sampling and testing was performed, but data was not submitted for regulatory decision-making.
[2]Preliminary suitability decisions were made in DY91. Final suitability decisions are anticipated for DY92.
[3]An additional 164,417 cubic yards were sampled and tested during DY92.

II. DY91 PROJECTS

A. Project Ranking

Sampling and analysis requirements under the PSDDA program are fully explained in the 1988 Phase I Evaluation Procedures Technical Appendix (EPTA) and the 1989 Phase II MPR. Under these guidelines, the initial appraisal of a proposed dredging project requires a careful examination of all existing sediment quality data within the dredging area. An initial area ranking is based on a "reason to believe" that chemicals of concern may or may not be present in the project area. The PSDDA agencies have established ranks for general areas (eg. Elliott Bay) and activities (eg. marinas) based on historical data or awareness of active sources of contamination. In the absence of project-specific data, representatives of the Corps of Engineers, Washington State Departments of Ecology and Natural Resources, and the Environmental Protection Agency apply an initial ranking based on guidance contained in the Phase I and Phase II documents (EPTA: page II-40; Phase II MPR: page A-10).

PSDDA guidelines allow for a reconsideration of the initial ranking if historical data at the site are adequate or the applicant conducts a partial characterization (PC) as described in EPTA (pages II-63 to II-65) to survey sediments in the project area for the PSDDA chemicals of concern (COCs). If the PC chemistry data support a lower ranking (using criteria stipulated in EPTA: pages II-63 to II-65), sampling and analysis requirements for surface and subsurface sediments may be reduced during the full characterization (FC) commensurate with the revised ranking requirements. Chemicals of concern may also be eliminated for analysis during the FC, based on the PC data. Table 2 contains the initial and full characterization rankings of all DY91 projects. The "initial rank" was taken from the PSDDA Phase II MPR, pages A-10 and A-11. The "full characterization" rank was the rank actually used in the full characterization of project sediments. Of the twelve projects included, three had changes made to their initial ranks. The justification for the ranking change for these three projects follows:

BP Oil. A PC was conducted at BP Oil, consisting of the analysis of six representative surface cores. The initial rank of "moderate" (for a ship berthing/fuel operation facility) was downranked to "low-moderate". Additionally, based on the results of the PC, volatile organics, pesticides and PCBs were eliminated from the list of COCs.

Hulbert Mill. A "pilot study" (the original name for a PC) was conducted at the Hulbert Mill site in 1987 and consisted of two analyses. The initial rank of "high" (intertidal areas of the Snohomish River) was downranked to "moderate" for the project, based on the results of the pilot study. No COCs were eliminated from the list for full characterization.

USACE Keystone Harbor. The initial rank established for this site during the PSDDA study was "low-moderate". Chemistry data collected during a 1988 study, however, showed phenol from the east side of the channel at the PSDDA maximum level (ML). As a precaution, the PSDDA agencies ranked the sediments in the east channel "high". Half of the sediment was characterized under this "high" ranking, the other half (west channel) under the original "low-moderate" ranking.

DY91 Project Ranking Summary. A summary of Table 2 shows that five projects had at least some of their sediments ranked "high", four projects "moderate", three projects "low-moderate" and one "low". USACE Keystone had dual rankings.

TABLE 2 - DY91 PROJECT RANKING

PROJECT	LOCATION	WATERBODY	INITIAL RANK	FULL CHARACTERIZATION RANK
Anchor Cove Marina	Anacortes	Guemes Channel	M	M
Ash Grove Cement West	Seattle	Duwamish River	H	H
B.P. Oil Refinery	Ferndale	Strait of Georgia	M	LM
Chevron USA	Point Wells	Puget Sound	M	M
Hulbert Mill - 12th St. Marina	Everett	Port Gardner Bay	H	M
Hurlen Construction	Seattle	Duwamish River	H	H
Redmond, et al	Bainbridge Island	Fletcher Bay	LM	LM
Port of Silverdale	Silverdale	Dyes Inlet	M	M
Tristar Marine	Seattle	Salmon Bay	H	H
U.S. Oil Refinery	Tacoma	Blair Waterway	H	H
USACE Keystone Harbor	Whidbey Island	Admiralty Bay	LM	H/LM
USACE Swinomish Channel	Skagit County	Swinomish Channel	L	L

B. Sampling and Analysis Plan Approval for DY91 Projects

Approved sampling and analysis plans are required before applicants collect representative sediment samples for either a PC or FC. The applicant or dredging consultant receives guidance in sampling plan development based on the ranking which has been assigned to the proposed project. In close coordination with the Dredged Material Management Office, a conceptual dredging plan and representative sampling plan are established. Protocols for station positioning, decontamination, field sampling, compositing, chemical analysis and biological testing are all included in the sampling and analysis plan. Once completed, the Dredged Material Management Office coordinates review and approval of the plan with representatives of the PSDDA agencies.

Table 3 contains data related to sampling plans approved for DY91 projects. Application of PSDDA sampling and analysis requirements resulted in the number of field samples and dredged material management units (DMMUs) formulated for each of the projects. Descriptions of those projects for which no testing was required, or for which best professional judgement was applied, follow:

Hulbert Mill. Due to the large quantity of native material existing in the dredging prism and the depth of sediments involved, the PSDDA agencies reduced the number of samples and analyses required for the subsurface sediments. This flexibility was clarified during the second annual review meeting. It was recognized that the "reason-to-believe" relative to chemical contamination does not exist for many native sediments and a reduction in sampling requirements was justified. In the case of Hulbert Mill, a field sample for every 6,000 cubic yards was required for the subsurface sediment, rather than the 4,000 cubic yards normally required in a moderate-ranked area. A total of thirteen surface cores, composited into four surface DMMUs, were required. Eight deep cores, yielding twenty-nine subsurface samples, were composited into four subsurface DMMUs.

Redmond, et al. This project involved six private landowners, each needing to perform maintenance dredging at their moorage facilities. The total volume of dredging to be performed was 378 cubic yards. The "no-test" volume for a project in an area ranked "low-moderate" is 500 cubic yards. Therefore, sampling and testing were not required for this project.

USACE Swinomish Channel. This project consisted of 107,569 cubic yards of material from an area ranked "low". Testing of material from the Swinomish Channel was last conducted in 1988. The data from this testing verified the "low" ranking, with all chemicals quantitated below screening levels (SL). Under frequency guidelines established in EPTA-Phase I for low-concern areas, testing needs to occur only every 5-7 years. Swinomish Channel is dredged approximately every two years. Because testing was conducted during the last dredging cycle, no testing was required for this round of dredging.

C. Sampling

Table 4 contains data related to sampling efforts during DY91. Two general requirements for PSDDA sampling are to sample to the depth of dredging (including overdepth), and to provide positioning data to a minimum precision of one-tenth of a second ($\pm$2 meters), latitude and longitude. The maximum sediment depths in the table, therefore, correspond to both the actual length of the deepest boring as well as to the maximum depth of the dredging prism including overdepth. In high-ranked areas there is an additional requirement to provide an archived sample from the one foot of sediment beyond the dredging prism. This additional depth is not reflected in the table. A variety of positioning techniques were used to provide the required precision. Great emphasis is placed on positioning in order to provide high-quality data. Precise positioning is important in providing repeatability in sampling and to provide data which can be utilized in a geographical information system (GIS).

TABLE 3 - DY91 PROJECTS - APPROVED SAMPLING PLANS

PROJECT	Rank	Total Volume (CY)	Surface Volume (CY)	Number of Surface Samples	Number of Surface DMMUs	Subsurface Volume (CY)	Number of Subsurface Samples[2]	Number of Subsurface DMMUs
Anchor Cove Marina	M	15,400	15,400	4	1	0	0	0
Ash Grove Cement	H	10,000	10,000	3	5	0	0	0
B.P. Oil Refinery	LM	569,000	280,000	35	9	289,000	37	7
Chevron USA	M	9,200	3,700	3	2	5,500	1	1
Hulbert Mill	M	208,000	50,000	13	4	158,000	29	4
Hurlen Construction	H	4,000	4,000	4	1	0	0	0
Redmond, et al[1]	LM	378	--	--	--	--	--	--
Port of Silverdale	M	21,000	21,000	6	2	0	0	0
Tristar Marine	H	5,500	3,500	2	1	2,000	1	1
U.S. Oil Refinery	H	22,000	16,000	5	5	6,000	3	3
USACE Keystone	H/LM	48,000	48,000	9	7	0	0	0
USACE Swinomish[1]	L	107,569	--	--	--	--	--	--
Totals:		1,020,047	451,600[3]	84	37	460,500[3]	71	16

[1]No testing required.
[2]4-foot core sections.
[3]Does not include Redmond, et al or USACE Swinomish Channel

TABLE 4 - DY91 PROJECT SAMPLING

PROJECT	GRAIN SIZE (PERCENTAGES)				SAMPLING EQUIPMENT	MAXIMUM SEDIMENT DEPTH (FT)	MEAN SEDIMENT DEPTH (FT)
	GRAVEL >2 mm	SAND .063-2 mm	SILT .004-.063 mm	CLAY <.004 mm			
Anchor Cove Marina	0	50	35	15	Hollow-stem auger with Dames & Moore split-spoon sampler	4	3.5
B.P. Oil Refinery	0-1	24-48	34-54	16-24	Impact corer with 4-inch diameter 6061-TS structural aluminum tubes	20	8.6
Chevron USA	1-61	32-93	1-4	1-3	Impact corer with 4-inch diameter aluminum tubes	13	6
Hurlen Construction	0	51	37	10	Gravity piston corer	4	4
USACE Keystone Harbor	2-55	42-91	2-7	0-3	Vibracore with 4-inch diameter Lexan tubes	4	4
Port of Silverdale	52	36	2	0	1. Impact corer using 100-lb weights with diver vibrating sampler between blows. 2. Diver-operated stainless steel hand auger.	5	4.5
Tristar Marine	0-1	56-76	16-23	4-16	Impact corer with 4-inch diameter aluminum tubes	8	6
U.S. Oil & Refining	1-8	31-97	2-48	2-14	Impact corer with 4-inch diameter aluminum tubes	10	7.5

D. Chemical Testing

Chemical testing was conducted for ten DY91 projects. The other two projects, USACE Swinomish Channel and Redmond, et al, did not require chemical testing, based on frequency and no-test guidelines respectively. A complete listing of PSDDA sediment guideline exceedances is included in Appendix II. In general, the QA/QC for projects undergoing testing was excellent, and acceptable by the PSDDA agencies for regulatory decision-making. Projects requiring best professional judgement or additional explanation follow:

Ash Grove Cement. Chemical testing was performed for Ash Grove Cement. Exceedances of SLs occurred and biological testing was undertaken as a result. However, the final data were not submitted for decision-making, and no suitability decision was made for PSDDA disposal. The Corps section-404 permit application for open-water disposal was withdrawn.

BP Oil. Volatiles, pesticides and PCBs were not required for full characterization. These chemicals were eliminated as a result of data collected during the PC. No detected exceedances of any of the required COCs occurred during full characterization. There were marginal detection limit exceedances of the SL for 1,2,4-trichlorobenzene for several of the DMMUs. This had been a problem chemical in the past relative to detection limits. Bioassays were not required for this project for the following reasons:

- 1,2,4-trichlorobenzene was undetected in all analyses.
- The exceedances were marginal, ranging from 6.6 to 7.9 ug/kg (the SL was 6.4 ug/kg).
- 1,2,4-trichlorobenzene was undetected at all sampling locations in the PC at detection limits ranging from 3.9 to 4.2 ug/kg.
- all other chlorinated benzenes were undetected at detection limits below SL for all analyses.
- no other organics were detected above SL.
- There is no source of 1,2,4-trichlorobenzene in the project vicinity.

It should be noted that as a result of detection limit problems recurring for six of the PSDDA COCs, including 1,2,4-trichlorobenzene, the SLs for these chemicals were subsequently raised. The Department of Ecology conducted a reliability/sensitivity analysis for these six SLs and concluded that raising the SLs in question would not have a detrimental effect on environmental protectiveness. The results of this analysis were presented at the DY90 Annual Review Meeting. New SLs were adopted and implemented in June 1991 as part of the DY90 annual review process. The SL for 1,2,4-trichlorobenzene was raised to 13 ug/kg. None of the detection limits for 1,2,4-trichlorobenzene in the BP study exceeds the new SL.

Hurlen Construction. For this project, detected levels of numerous COCs exceeded maximum levels in both duplicates tested during chemical characterization. Precision was poor with numerous organic COCs exceeding 66.7 RPD, the precision performance standard. The data in Appendix II reflect the higher of the two concentrations found for the duplicates. Given the numerous exceedances of ML, and in the absence of an implemented test to assess chronic sublethal effects, the proposed dredged material was found unsuitable for unconfined open-water disposal.

U.S. Oil. Problems occurring during both chemical and biological testing for this project forced the PSDDA agencies to require a retest on some of the DMMUs. During chemical testing, detection limit exceedances for several BTs and MLs occurred. A retest for a limited number of COCs was needed to ensure that detection limits were brought below all BTs and MLs. Detection limit exceedances of BTs would have required the performance of expensive bioaccumulation tests. Detection limit exceedances of MLs could have caused the material to be considered unsuitable for open-water disposal in the absence of an implemented test to assess chronic sublethal effects. In the retest, detection limits were brought below BTs and MLs. Only data found acceptable from a QA/QC standpoint were used in making a suitability decision and only these data are reflected in Appendix II.

E. Biological Testing

Biological testing data can be found in Table 5. For those projects undergoing tiered testing, only those DMMUs which had exceedances of SLs were subjected to biological testing. Based on a reason-to-believe that at least one COC would exceed SL, and to save time in the testing process, several project proponents opted for concurrent biological testing. In these cases, bioassays were conducted for all DMMUs.

Two projects experienced difficulties during biological testing. These included protocol deviations in both cases and reference sediment performance problems in one case. Following are descriptions of these difficulties, the PSDDA-agency resolution of the problems, and other projects requiring further explanation.

Anchor Cove. In this project, a problem was encountered in obtaining a properly-matched reference sediment. The reference sediment run with the bioassays was significantly finer than the test sediment. In the sediment larval test, significant mortalities occurred for both the test and reference sediments. The PSDDA agencies determined that it was impossible to separate grain-size effects (or covarying effects) from chemical-induced effects. A retest of the sediment larval bioassay was required.

In the second round of sediment larval testing, the Anchor Cove test sediment was run in the same batch as the US Army Corps of Engineers/Port of Bellingham Waterways Round 1 bioassays. Three reference sediments from Sequim Bay were used. This batch of sediment larval tests exhibited generally high mortalities for all test and reference sediments. Ammonia toxicity was strongly implicated and all test sediments were rerun due to the reference sediment performance failure.

In response to a growing database showing a correlation of toxicity in the sediment larval test with bulk and aqueous ammonia concentrations, the PSDDA agencies proactively recommended aeration of test beakers during the sediment larval test when bulk ammonia values were elevated. The Anchor Cove sediment was rerun, this time in the same batch as the Bellingham Bay Round 2 bioassays. Aeration was conducted for this batch. Two reference sediments from Samish Bay were run. Potential ammonia effects appeared to have been ameliorated, although the reference sediments still exceeded the performance standard of 20% effective mortality. Bulk ammonia levels were high (840 mg/kg and 700 mg/kg) in the two Samish Bay reference sediments, and were implicated in the performance problem. Best professional judgement was required to interpret the test. The rationale for this interpretation can be found in the next section, which discusses suitability decisions.

TABLE 5 - DY91 BIOLOGICAL TESTING DATA

PROJECT	Number of Biological Analyses	Number of Analyses Failing Bioassays	Number Undergoing Concurrent Testing	Number Undergoing Tiered Testing	Bioassays Conducted (X = Yes)				Sediment Larval Species	Control Sediment Location	Reference Sediment Location
					Amphipod (1)	Sediment Larval	Microtox (2)	Juvenile Infaunal (3)			
Anchor Cove Round 1	1	retest required	--	X	X	X	X	X	*Dendraster excentricus*	Yaquina Bay Oregon	Samish Bay
Anchor Cove Round 2	1	retest required	--	--	--	X	--	--	*Dendraster excentricus*	Whidbey Island West Beach	Sequim Bay
Anchor Cove Round 3	1	0	--	--	--	X	--	--	*Dendraster excentricus*	Whidbey Island West Beach	Samish Bay
B.P. Oil Refinery	--	0	--	--	--	--	--	--	N/A	N/A	N/A
Chevron USA	3	1	X	--	X	X	X	X	*Strongiyocentrotus purpuratus*	Whidbey Island West Beach	Carr Inlet
Hurlen Construction	1	0	X	--	X	--	X	--	N/A	Whidbey Island West Beach	Carr Inlet
Port of Silverdale	0	0	--	--	--	--	--	--	N/A	N/A	N/A
Tristar Marine	2	1	X	--	X	X	X	X	*Strongiyocentrotus purpuratus*	Whidbey Island West Beach	Carr Inlet
U.S. Oil-Round 1	8	retest required	X	--	X	X	X	--	*Strongiyocentrotus purpuratus*	Whidbey Island West Beach	Carr Inlet*
U.S. Oil-Round 2	4	2	--	--	X	X	--	X	*Strongiyocentrotus purpuratus*	Whidbey Island West Beach	Carr Inlet
USACE Keystone Harbor	0	0	--	--	--	--	--	--	N/A	N/A	N/A
USACE Swinomish Channel	0	0	--	--	--	--	--	--	N/A	N/A	N/A

(1) *Rhepoxynius abronius*
(2) *Photobacterium phosphoreum*
(3) *Neanthes arenaceodentata*

*The reference sediment was not run for the sediment larval test. A retest was required.

Ash Grove Cement. Biological testing was conducted, based on the results of the chemical analysis. Neither chemical data nor bioassay results were submitted for decision-making by Ash Grove. The Corps section 404 application for dredging with unconfined open-water disposal was withdrawn.

Hulbert Mill. Chemical testing occurred for the Hulbert Mill site. SL exceedances occurred and biological testing was conducted. This property was subsequently sold to the Port of Everett, the proposal for dredging was withdrawn, and no data were submitted for decision-making.

Hurlen Construction. Biological testing was conducted concurrently with chemical testing. This project fit in the "small project" classification with only 4,000 cubic yards of sediment proposed for dredging. As such, it was subject to only two bioassays, the amphipod and Microtox bioassays.

U.S. Oil. The U.S. Oil project required two rounds of biological testing. In the first round, conducted concurrently with chemical testing, the sediment larval seawater control exceeded its performance standard of 10% abnormality, no reference sediment was run, and only three replicates were performed. The amphipod test exhibited unusually high emergence data for several of the test sediments even though the mortality in some cases did not result in "hits". As a result of these problems, a retest of the sediment larval bioassay was required. The amphipod test was also repeated on the recommendation of the PSDDA agencies, although this was not a requirement. In addition, subsequent to the first round of testing, the *Neanthes* acute toxicity test was formally adopted for use in the PSDDA program. Therefore, the *Neanthes* bioassay was required to be run during the second round of biological testing. Quality assurance standards were met for all three tests in this round and the data were acceptable for decision-making. The data reflected in this report are for the Microtox test from the first round and the amphipod, sediment larval and *Neanthes* tests from the second round.

F. Suitability Decisions

A suitability decision outlines the evaluation procedures used in the characterization of project sediments, summarizes chemical and biological testing data and associated QA/QC issues, and documents the interpretation of testing results. The suitability decision is a technical memorandum, drafted by the Corps' Dredged Material Management Office, and signed by PSDDA representatives from the Corps of Engineers, Environmental Protection Agency, Department of Ecology and Department of Natural Resources. The suitability decision documents the suitability of proposed dredged sediments for open-water disposal at one of the eight PSDDA sites. It does not, however, constitute final project approval by the agencies. Comprehensive agency comments on the overall project are provided through the regulatory public notice and review process.

Table 6 contains information taken from the suitability decisions for each of the projects which completed their PSDDA review during DY91. For the ten projects receiving suitability decisions in DY91, four had at least one DMMU which was found unsuitable for open-water disposal under PSDDA evaluation guidelines. Approximately three percent of all DY91 material covered by suitability decisions was found unsuitable, compared to approximately one percent during DY90. This does not include any material from the Hulbert Mill or Ash Grove Cement projects which may have been found unsuitable had testing data been submitted for regulatory decision-making. Following are descriptions of suitability decisions for which the use of best professional judgement was necessary, or which require further explanation:

TABLE 6 - DY 91 SUITABILITY DECISIONS

PROJECT	Rank	Total Volume	Number of Chemical Analyses	Number of Biological Analyses	DMMUs Failing	Volume Failing	DMMUs Passing	Volume Passing	Proposed PSDDA Disposal Site
Anchor Cove Marina	M	15,400	1	1	0	0	1	15,400	Rosario Strait
B.P. Oil Refinery	LM	570,100[1]	16	0	0	0	16	570,100	Rosario Strait
Chevron USA	M	9,600[1]	3	3	1	3,700	2	5,900	Port Gardner
Hurlen Construction	H	4,000	1	1	1	4,000	0	0	N/A
Redmond, et al	LM	378	0	0	N/A	0	N/A	378	Elliott Bay
Port of Silverdale	M	21,000	2	0	0	0	2	21,000	Elliott Bay
Tristar Marine	H	5,500	2	2	1	3,500	1	2,000	Elliott Bay
U.S. Oil Refinery	H	22,000	8	8	3	11,100	5	10,900	Commencement Bay
USACE Keystone Harbor	H/LM	48,000	7	0	0	0	7	48,000	Port Townsend
USACE Swinomish Channel	L	107,569	0	0	N/A	0	N/A	107,569	Rosario Strait
Total:	--	803,547	40	15	6	22,300	34	781,247	

[1]Volumes were adjusted from sampling plan volumes based on new hydrographic surveys.

Anchor Cove. The Anchor Cove data obtained for the amphipod, *Neanthes* and Microtox bioassays during the first round of biological testing were of adequate quality to be used in regulatory decision-making. However, as stated previously in the biological testing section, the sediment larval data were ambiguous and necessitated a rerun. Two additional rounds of sediment larval testing were conducted. These tests were run concurrently with bioassays for the USACE/Port of Bellingham project. The round 2 sediment larval test for Anchor Cove was run with round 1 of the Bellingham bioassays. The round 3 Anchor Cove sediment larval test was run with round 2 of Bellingham. A summary of USACE/Port of Bellingham biological testing follows.

Due to the size of the Bellingham project, and the number of DMMUs involved (see Table 8), it was originally intended to conduct both chemical and biological testing in two rounds. Problems were encountered during the first round of biological testing and necessitated a third round, in which Round 1 sediments were retested.

During the first round of biological testing for USACE/Port of Bellingham (Round 2 for Anchor Cove), three reference sediments from Sequim Bay were used. Reference sediment performance problems were encountered in the sediment larval test. Ammonia toxicity was strongly implicated in this bioassay with both bulk and aqueous ammonia statistically correlated with effective mortality (combined mortality and abnormality). A statistically significant correlation also existed between effective mortality and bulk sulfides concentrations. The sediment larval test was rerun during Round 3 (Bellingham).

During the second round of Bellingham testing (Round 3 for Anchor Cove), with Bellingham sediments different from the first round, aeration was conducted for the first time in the sediment larval test in an attempt to ameliorate potential ammonia and sulfides effects. Two reference sediments from Samish Bay were used. In the sediment larval test, the reference sediments still failed to meet the performance standard of 20% seawater-normalized effective mortality, although the exhibited mortalities were significantly less than those seen in Round 1.

The third round of Bellingham sediment larval testing was a retest of sediments from Round 1. Again, aeration was employed. Two reference sediments, from a location near Jetty Island (Everett) were used. In this round of testing, the reference sediments met the performance standard and the results from this round were deemed acceptable for decision-making.

In order to interpret data from Round 2 for USACE/Port of Bellingham, in which the Samish Bay reference sediments exceeded the performance standard for the sediment larval test, the data for the reference sediments from Rounds 2 and 3 were pooled. The mean reference effective mortality, and its associated variance, were calculated from the seawater-normalized effective mortalities for each of the reference sediments. These pooled reference sediment data were used in a statistical analysis, comparing each test sediment with the pooled reference using a t-test. The grain sizes for the Samish Bay and Jetty Island references bracketed the test sediment grain sizes, making this analysis possible. The pooled reference sediments had a mean effective mortality of 23.9%. This number still exceeded the performance standard for reference sediments and best professional judgement was exercised in using this number for interpretation.

Because the Round 3 Anchor Cove sediment was run in the same batch as the Round 2 Bellingham sediments, the same criteria were used to interpret the sediment larval data for this project. As a result of this interpretation, the Anchor Cove sediment was found suitable for open-water disposal.

Ash Grove Cement. Data were not submitted for decision-making. Ashgrove's application for dredging with open-water disposal was withdrawn. No suitability decision was made.

BP Oil. The suitability decision for this project was straightforward, based on the chemistry results (with the exception of the detection limit exceedance of 1,2,4-trichlorobenzene, which was fully described in the chemical testing section). The project applicant subsequently requested that the PSDDA agencies review a slightly revised project vis-a-vis the original suitability decision. The revision was necessitated by an error in the datum used during the presampling bathymetric survey of the site. The areal coverage increased by about fifteen percent for the revised project. To avoid large increases in dredging volume, the project depth was decreased slightly, resulting in a net increase in volume of only 0.2 percent. The additional area covered by the project was along the waterward edge where the full characterization showed the cleanest sediments to be. The PSDDA agencies concluded that the data collected for the FC were adequate to approve the revised plan.

Hulbert Mill. No data were submitted for regulatory decision-making. The permit application for dredging was withdrawn and the property sold to the Port of Everett. No suitability decision was made.

Hurlen Construction. While the sediment tested under the small-project guidelines passed the amphipod and Microtox bioassays, it was deemed unsuitable for open-water disposal. In the absence of an implemented test to assess chronic sublethal effects, it was assumed that the sediment was unacceptable for open-water disposal due to the numerous exceedances of ML.

US Oil. The suitability decision was made based on data collected during both rounds of testing. Chemistry data for a single DMMU (S4) from the first round included numerous exceedances of ML. This DMMU was found unsuitable for open-water disposal in the absence of an implemented test to assess chronic sublethal effects. Sediment represented by another DMMU (S3) was found unsuitable based on chemical and biological testing during Round 2. Multiple exceedances of ML, and bioassay hits for the amphipod, sediment larval and *Neanthes* test occurred during Round 2. A third DMMU (S2) failed due to a hit under the single-hit rule for the sediment larval test. All other tested sediment passed.

G. Cost Data

Figure 1 shows the total costs for DY91 projects. The only project for which cost data were not available was Ash Grove Cement. The sediment for this project underwent sampling and full characterization, but data were not submitted for regulatory decision-making. The sampling and testing costs associated with this project were likewise not submitted. Project costs for Hulbert Mill were submitted even though no suitability decision was made. Costs associated with resampling and retesting efforts for Anchor Cove and U.S. Oil were not included in this figure because they resulted from QA/QC problems not directly attributable to the PSDDA process itself. Additional costs for Anchor Cove amounted to approximately $1,700, while those for U.S. Oil amounted to $14,400. USACE Swinomish underwent testing in 1988. Under PSDDA frequency guidelines for low-ranked areas, no PSDDA testing was required in DY91 for this project and no sampling or testing costs were incurred.

Total project costs were divided by the total number of DMMUs for each project and are shown in Figure 2. Figure 3 exhibits total project costs on a per-cubic-yardage basis. The projects are grouped in this figure by rank. Costs for USACE Keystone were distributed between the "high" and "low-moderate" ranked subareas on a cost-per-DMMU basis.

FIGURE 1 - DY 91 TOTAL PROJECT COSTS

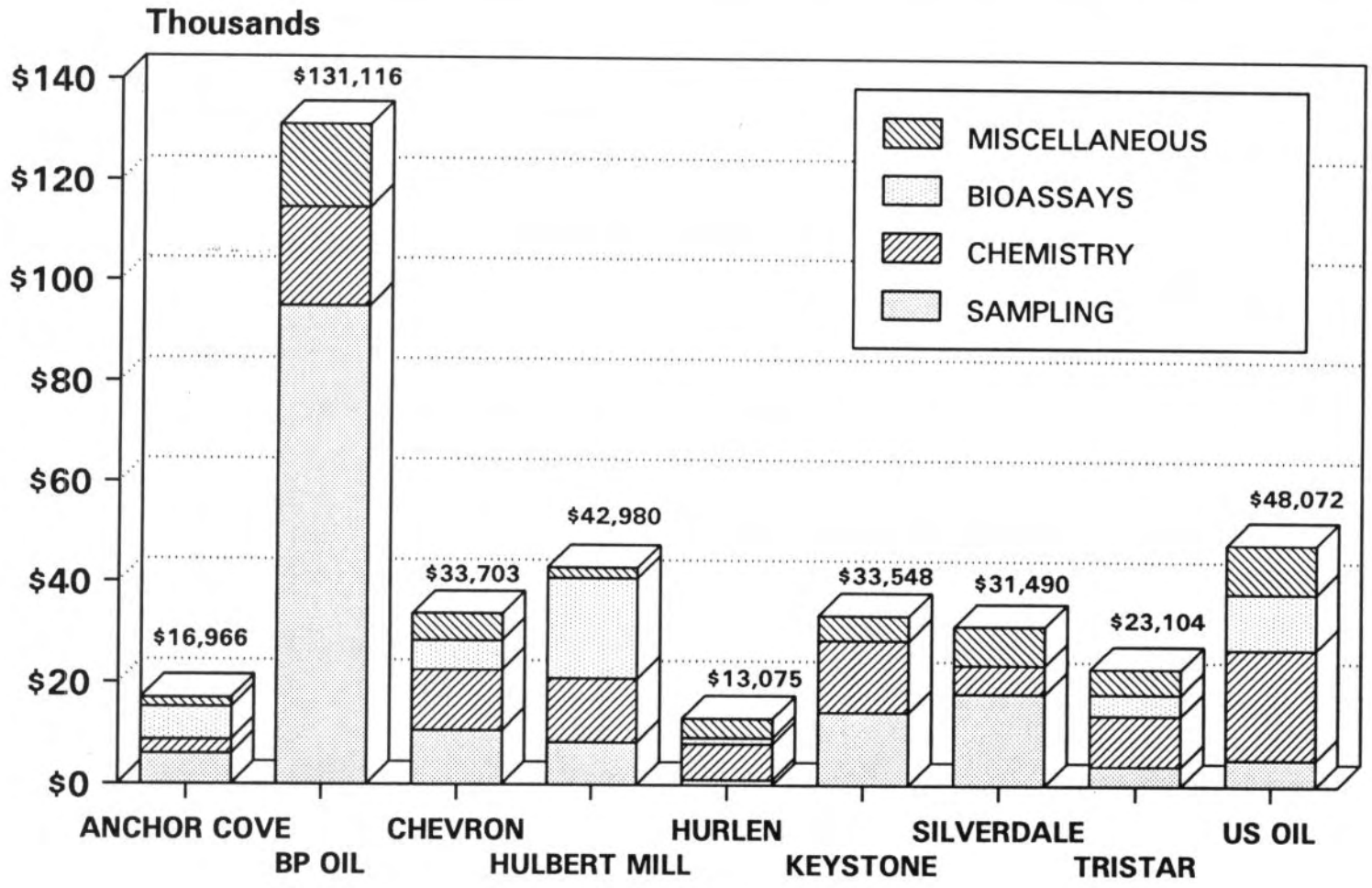


FIGURE 2 - DY 91 TOTAL COST PER DREDGED MATERIAL MANAGEMENT UNIT

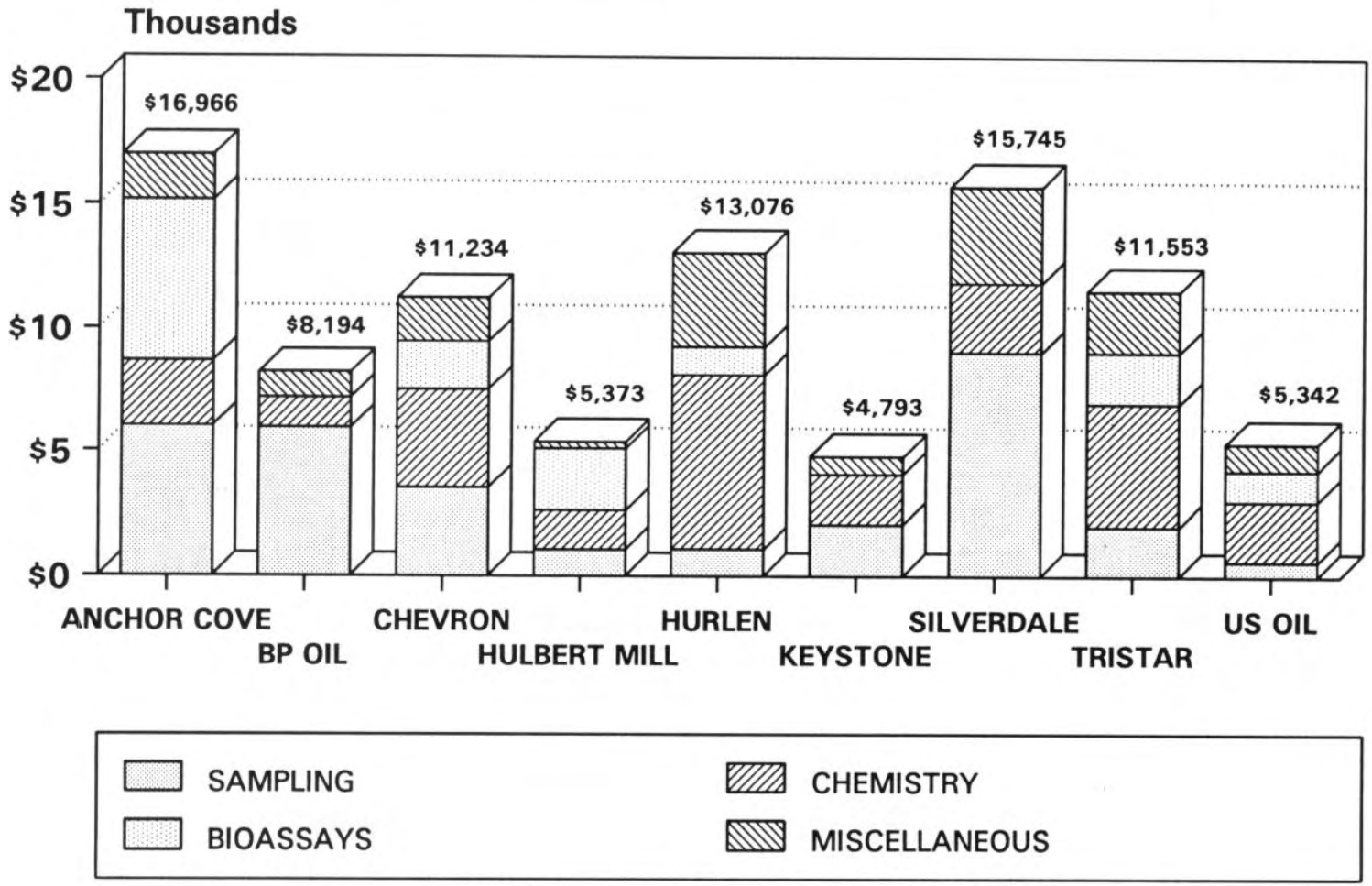
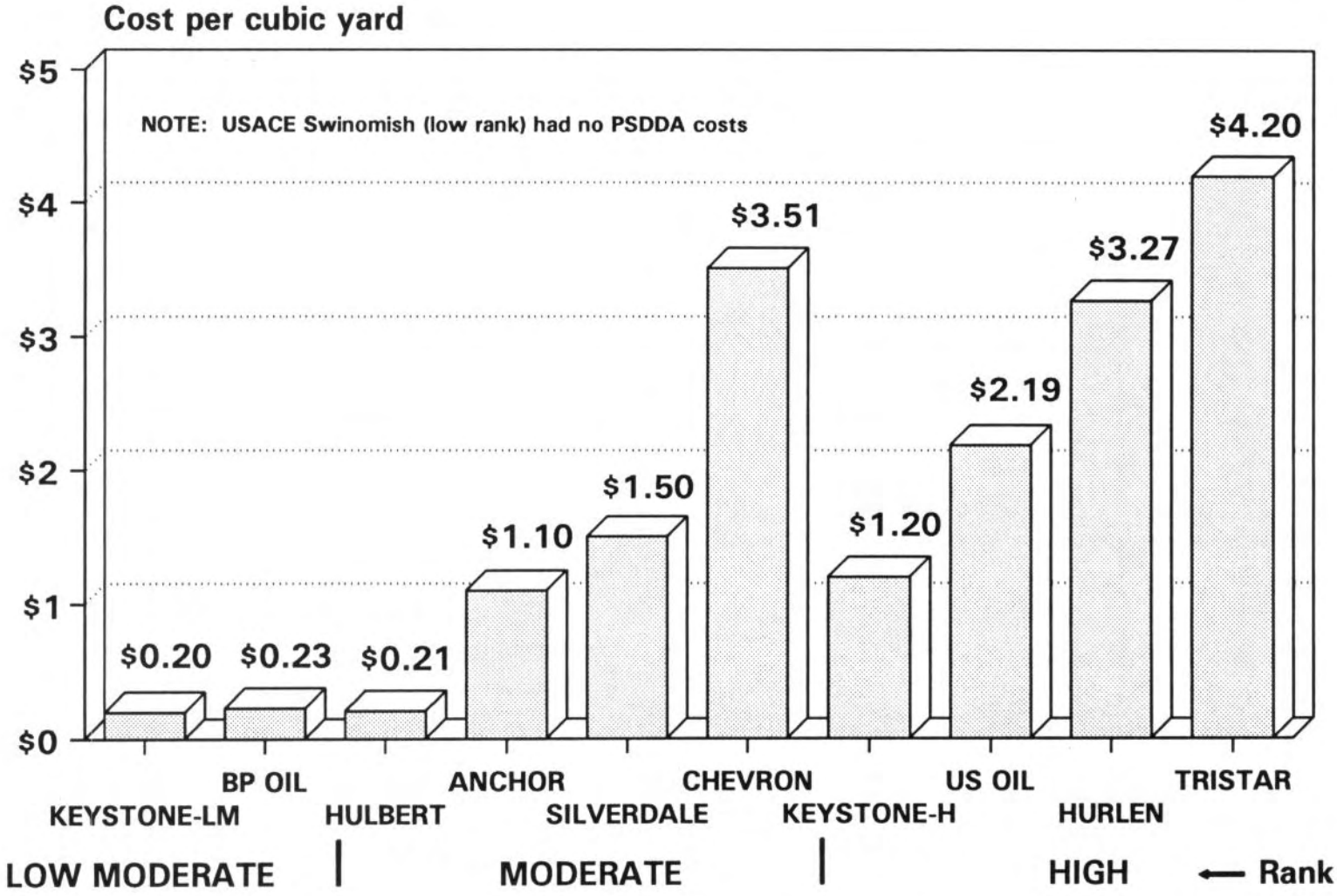


FIGURE 3 - DY91 TOTAL PROJECT
COST PER CUBIC YARD



III. DY92 PROJECTS

The following information is for thirteen projects which were in some phase of the PSDDA process during DY91, but for which final suitability decisions had not been made as of June 15, 1991. It is anticipated that most of these projects will have suitability decisions finalized within DY92. The purpose of this brief presentation is to more accurately reflect the level of activity occurring within the PSDDA program during DY91 and to provide more up-to-date information. Data related to ranking and/or sampling plans for these projects have been included.

Two of these projects, USACE/Port of Bellingham Waterways and US Navy Everett Homeport-Element II, had preliminary suitability decisions made during DY91. However, in both cases, additional testing was required and suitability decisions are not expected to be finalized until DY92.

A. Project Ranking

Table 7 contains the initial and full characterization ranks for all DY92 projects. Descriptions of projects requiring the application of best professional judgement, or for which additional explanation is needed, follow:

USACE/Port of Bellingham Waterways and Berths. Two of the waterways to be characterized in this sampling effort, the I&J and Whatcom Waterways, were ranked high. The Squalicum Waterway was last maintenance dredged in 1979 and has no major active sources of contaminants. Because Squalicum shoaling was more recent than in the I&J and Whatcom Waterways, and because historical data for Squalicum did not create the same level of concern as for the other two waterways, the area of Bellingham Bay which includes Squalicum Waterway was ranked "moderate" in the MPR-Phase II.

Blair Waterway. The initial ranking of sediments in Commencement Bay (except Milwaukee Waterway) was "high". A large data set was compiled for the Blair Waterway, however, during three studies conducted between 1984 and 1990. Efforts to determine the vertical extent of elevated concentrations of COCs were included in these studies. The PSDDA agencies deemed the data adequate to downrank both the surface and subsurface sediments, and further, to provide differential ranks for the surface and subsurface sediments. Although the existing data supported downranking the surface sediments to "low-moderate" in the project area, the age of some of the data and the presence of active sources cautioned against downranking two levels. The surface sediments were, therefore, downranked to "moderate". Because the entire subsurface volume was native material, however, and because an earlier study had established the deepest point of moderate-ranked material in the entire Blair Waterway at 2.7 feet below the surface, the subsurface sediments were downranked to "low-moderate".

U.S. Navy Homeport-Element II. The initial rank for subtidal areas of the Snohomish River is "moderate". Based on the extensive sampling and testing which occurred for Element I, the proximity of the two elements, the sedimentological similarity of two-thirds of Element II to Element I and the high-energy environment of the remaining one-third, the sediments for Element II were downranked to "low-moderate".

DY92 Project Ranking Summary. A summary of Table 7 shows that six projects had at least some of their sediments ranked "high", six projects "moderate", four projects "low-moderate" and none "low". USACE/Port of Bellingham, USACE Duwamish, and Port of Tacoma's Blair Waterway had dual rankings.

TABLE 7 - DY92 PROJECT RANKING

PROJECT	LOCATION	WATERBODY	INITIAL RANK	FULL CHARACTERIZATION RANK
Day Island Yacht Club	Tacoma	Day Island Waterway	M	M
Day Island Yacht Harbor	Tacoma	Day Island Waterway	M	M
Port of Everett-10th Street Boat Ramp	Everett	Port Gardner Bay	M	M
Harbor Pointe Marina	Mukilteo	Possession Sound	LM	LM
LOTT Olympia Treatment Plant Outfall	Olympia	Budd Inlet	H	H
Salmon Bay Terminals	Seattle	Salmon Bay	H	H
Port of Seattle Terminal 5	Seattle	West Waterway	H	H
Port of Tacoma Blair Waterway	Tacoma	Blair Waterway	H	M/LM
U.S. Navy Keyport KB Dock	Bangor	Hood Canal	M	M
U.S. Navy Bremerton-Pier D	Bremerton	Sinclair Inlet	H	H
U.S. Navy Homeport-Element II	Everett	Port Gardner Bay	M	LM
USACE/Port of Bellingham Waterways	Bellingham	Bellingham Bay	H	H/M
USACE Duwamish	Seattle	Duwamish River	H/LM	H/LM

B. DY92 Projects with Approved Sampling and Analysis Plans

Table 8 contains data related to approved sampling plans for DY92 projects. Application of PSDDA sampling and analysis requirements resulted in the number of field samples and dredged material management units formulated for each of the projects. Descriptions of projects requiring the application of best professional judgement, or for which additional explanation is needed, follow:

Blair Waterway. Based on dredging records, the maximum historical depth of the Blair Waterway was known and the volume of infill above this maximum depth was calculated. These calculations indicated that eighty-eight percent of the surface sediment proposed for dredging was native material, while one hundred percent of the subsurface sediments were native. Due to the large volume of native material present in the surface stratum, the sampling requirements were reduced below those required under the "moderate" ranking assigned. The number of samples required, per surface DMMU, was reduced from four to three. Instead of the eighty-six surface samples which would normally be needed for a "moderate" rank, only sixty-five were required. The areal coverage provided by the sampling plan was deemed adequate by the PSDDA agencies. For the subsurface sediments, the thirty-one samples required for a "low-moderate" rank were collected.

USACE Duwamish. The sampling conducted during DY91, for the Duwamish O&M dredging, covered only a fraction of the volume projected for dredging during DY92. A total of 31,672 cubic yards were characterized during DY91. An additional 164,417 cubic yards of sediments were sampled and tested during DY92. A suitability decision for the entire volume will be made in DY92.

USACE/Port of Bellingham. The sampling and analysis plan for this project included the full characterization of sediments in the I&J and Squalicum Waterways. It also included a reconnaissance effort, involving three surface cores from Whatcom Creek Waterway, to determine the level of contamination in the berthing areas. It was confirmed that Whatcom Creek Waterway sediments would not be eligible for dredging with PSDDA disposal.

TABLE 8 - DY92 PROJECTS - APPROVED SAMPLING PLANS

PROJECT	Rank	Total Volume (CY)	Surface Volume (CY)	Number of Surface Samples	Number of Surface DMMUs	Subsurface Volume (CY)	Number of Subsurface Samples	Number of Subsurface DMMUs
Day Island Yacht Club	M	9,000	9,000	5	1	0	0	0
Port of Seattle Terminal 5	H	12,000	12,000	6	3	0	0	0
Port of Tacoma Blair Waterway	M/LM	594,000	345,000	65	22	249,000	31	5
U.S. Navy Bremerton Pier D	H	170,400	77,600	20	20	92,800	24	8
U.S. Navy Homeport-Element II	LM	426,604	86,604	11	3	340,000	47	9
USACE/Port of Bellingham Waterways	H/LM	299,125	207,599	57	27	91,526	37	6
USACE Duwamish	H/LM	31,672	31,672	8	8	0	0	0

IV. PSDDA DISPOSAL SITE USE SUMMARY - Prepared by Richard Phipps, Department of Natural Resources, Division of Aquatic Lands

A. Introduction

The Washington Department of Natural Resources (DNR) is responsible for preparation of a report that documents the use of each PSDDA disposal site during the previous dredging year. This report is compiled from information supplied by each project proponent that uses a PSDDA disposal site.

During DY91, disposal operations occurred at four of the PSDDA disposal sites. These sites, along with their respective open disposal seasons, are presented in Table 9.

TABLE 9 - PSDDA SITE DISPOSAL SEASONS

PSDDA DISPOSAL SITE	DY91 OPEN DISPOSAL SEASON
Commencement Bay	June 16, 1990 to March 14, 1991
Elliott Bay	June 16, 1990 to March 31, 1991
Port Gardner	June 16, 1990 to March 14, 1991
Rosario Strait	June 16, 1990 to March 14, 1991

A total of 606,503 cubic yards of dredged material were deposited at the four above-referenced sites during DY91. Details of the disposal operations at each site are provided in Table 10 and the following sections. The remaining sites were open and available for use, but were not utilized by any projects during DY91.

TABLE 10 - SUMMARY OF PSDDA DISPOSAL SITE USE DURING DY 91

Disposal Site	Project Proponent	Contractor	Permitted Volume (CY)	Volume Taken To Site (CY)	Number of Barge Loads	Number of Compliance Inspections[1]	Any Offsite Disposal? (Yes/No)[2]	Dates of Disposal
Commencement Bay	U.S. Oil & Refining	Great Lakes Dredge & Dock Company	10,900	10,548	8	1	No	03/12/91 to 3/24/91
Elliott Bay	U.S. Navy-Manchester	American Construction	50,000	12,000[3]	10	1[4]	No	02/17/91 to 02/28/91
Port Gardner	Port of Everett Marina	Nahalem River Dredging	20,000	17,261	56	9	No	11/02/90 to 12/02/90
Rosario Strait	B.P. Oil	Great Lakes Dredge & Dock Company	570,000	459,125	125	1[4]	No	11/21/90 to 01/30/91
Rosario Strait	USACE Swinomish Channel	Sinclair Towboat Company	---	107,569	64	---[4]	No	12/06/90 to 03/13/91

[1] The number of compliance inspections is the sum of the inspections performed by the Corps of Engineers and DNR.

[2] Offsite disposals are defined as those occurring outside the disposal zone of the disposal site.

[3] Project not yet complete. Remaining volume to be disposed of during DY92.

[4] Disposal monitored by U.S. Coast Guard Vessel Traffic Service.

B. COMMENCEMENT BAY DISPOSAL SITE

U.S. Oil & Refining Company. U.S. Oil & Refining Company received a DNR permit to dispose of a portion of the sediments removed from their Blair Waterway Terminal facility during maintenance dredging. Of the 22,000 cubic yards originally proposed for dredging, only 10,900 cubic yards were approved for open-water disposal. The remaining volume was sent to an upland site for bioremediation of petroleum hydrocarbons in the sediment.

Great Lakes Dredge & Dock Company was contracted to perform the dredging operation using clamshell dredges and bottom dump barges. A survey technician from David Evans & Associates was present during all disposal events to ensure the proper location of the dump and to complete disposal site use reports. Between March 12, 1991 and March 24, 1991, 8 barge loads containing a total of 10,548 cubic yards of dredged material were disposed of at the site.

All disposal occurred within the disposal site target area. There were no permit violations.

C. ELLIOTT BAY DISPOSAL SITE

U.S. Navy - Manchester

The U.S. Navy was granted a DNR permit to dispose of sediments removed during the replacement of their existing substandard fuel pier at the Manchester fuel depot. American Construction was contracted to perform the dredging operation using clamshell dredges and bottom dump barges. Between February 17, 1991 and February 28, 1991, 10 barge loads containing a total of 12,000 cubic yards of dredged material were disposed of at the site. Additional dredging and disposal will occur during the 1992 dredging year, subject to the completion of demolition work for the existing pier.

Each disposal event was coordinated through the U.S. Coast Guard's Puget Sound Vessel Traffic Service (PSVTS). PSVTS records show that all disposal occurred within the disposal site target area. There were no permit violations.

D. PORT GARDNER DISPOSAL SITE

Port of Everett

The Port of Everett received a DNR permit to dispose of sediments removed from the Port of Everett Marina during maintenance dredging. Nahalem River Dredging was contracted to perform the dredging operation using hydraulic dredges and bottom dump barges. Dunlap Towing was contracted to transport the barges to the disposal site. A representative from Reid Middleton, Inc. (Project Engineer) was present on all disposal events to ensure the proper location of the dump and to complete the disposal site use reports. Between November 2, 1990 and December 2, 1990, 56 barge loads containing a total of 17,261 cubic yards of dredged material were disposed of at the site.

All disposal occurred within the disposal site target area. There were no permit violations.

E. ROSARIO STRAIT DISPOSAL SITE

A disposal permit was granted to B.P. Oil Company resulting in the disposal of 459,125 cubic yards of dredged material at the Rosario Strait PSDDA site. Additionally, the U.S. Army Corps of Engineers (Corps) disposed of 107,569 cubic yards of dredged material from Swinomish Channel. Because Corps-sponsored maintenance projects are allowed under the PSDDA management program, there was no separate DNR permit issued for their use of the site. The site was used between November 21, 1990 and March 13, 1991.

B.P. Oil Company

B.P. Oil Company received a DNR permit to dispose of material dredged for their Ferndale Dock Dredging and Reconstruction Project. Great Lakes Dredge & Dock Company was contracted to perform the dredging using clamshell dredges and bottom dump barges. Foss Maritime was contracted to transport the barges to the disposal site. Between November 21, 1990 and January 30, 1991, 125 barge loads containing 459,125 cubic yards of dredged material were disposed of at the site. Additional dredging and disposal will occur during the 1992 dredging year, in order to dispose of an estimated 15,000 - 25,000 cubic yards of material which sloughed into the berthing area since the original dredging work was done.

Each disposal event was coordinated through PSVTS. The PSVTS records show that all disposals occurred within the disposal zone of the site. There were no permit violations.

U.S. Army Corps of Engineers

Maintenance dredging using a clamshell dredge and bottom dump barge was conducted by the Corps in the Swinomish Channel. Sinclair Towboat Company was contracted to transport the barge to the disposal site. Between December 6, 1990 and March 13, 1991, 64 barge loads containing a total of 107,569 cubic yards of dredged material were disposed of at the site.

Each disposal event was coordinated through PSVTS. PSVTS records show that all disposal events occurred within the disposal zone of the site.

V. UPLAND DISPOSAL SUMMARY - Prepared by Tom Gries, Department of Ecology, Sediment Management Section.

To put into perspective the significance of the PSDDA program for characterization and management of dredged material in Puget Sound, it is important to note that some dredged material is placed in upland sites for economic reasons. For example, transport of small volumes of relatively clean dredged material to an unconfined, open-water disposal site is generally uneconomical.

During DY91, approximately 34,850 yards of material from 8 projects were either permitted for upland disposal or failed to pass the PSDDA open-water disposal guidelines (Table 11). This reflected 22,300 cubic yards which failed PSDDA guidelines and 12,550 cubic yards which was permitted for confined disposal outside of the PSDDA program. The projects involving confined disposal were relatively small maintenance dredgings of private docks, marinas and industrial berthing facilities. This total volume, some having yet to be dredged and disposed, represented approximately 4 percent of the total dredged material evaluated.

The volumes of dredged material cited in this section are based on PSDDA test volumes and permit records. Records on the exact volumes of materials dredged and placed at upland sites are not readily obtainable.

TABLE 11 - DY91 UPLAND DISPOSAL

Project Name/Applicant	County	Waterbody	Volume (CY)
U.S. Oil & Refining[1]	Pierce	Blair Waterway Commencement Bay	11,100
ITT Rayonier[2]	Clallam	Port Angeles Harbor Strait of Juan de Fuca	7,500
Bridgehaven Community Club[2]	Jefferson	Hood Canal	4,000
Hurlen Construction[1]	King	Duwamish River	3,900
Chevron USA[1]	Snohomish	Admiralty Inlet Puget Sound	3,700
Tristar Marine[1]	King	Salmon Bay Lake Washington Ship Canal	3,500
Birch Bay Village[2]	Whatcom	Strait of Georgia	1,000
Concrete Technology[2]	Pierce	Blair Waterway Commencement Bay	150
Total:			34,850

[1]Project tested under PSDDA having partial volume unsuitable for unconfined, open-water disposal
[2]Project not tested under PSDDA. Material destined for confined disposal.

VI. SUMMARY AND ASSESSMENT OF DY91 DATA

A. Summary of Testing Results

Chemical Testing. Table 12 summarizes the chemical testing results from DY91. A total of 41 of the 58 PSDDA COCs had their screening levels exceeded for at least one project. These included both detected exceedances (23 COCs) and detection limit exceedances (21 COCs). Only one COC had detected concentrations above the BT, while 11 COCs were detected above the ML. Table 13 highlights those chemicals which had detected concentrations exceeding SL, BT and ML most often in DY91. Also included are those chemicals for which the detection limit exceeded SL the most often.

The most salient feature of Table 13 is that all the chemicals most often detected above SL, BT and ML are PAHs, with the exception of dibenzofuran. Individual metals, for example, were detected above guidelines or regulatory levels in no more than three of the eight projects which underwent chemical testing. This reflects the sources at the majority of the DY91 project sites, which included three refineries and several small moorage facilities.

The chemicals for which detection limits most often exceeded SL include two groups: 1) chemicals whose quantification has been problematic since the implementation of PSDDA; and 2) the pesticides and PCBs.

The first group includes 2-methylphenol; 2,4-dimethylphenol and benzyl alcohol. To avoid recurring analytical problems (DY89-91) with these chemicals, the PSDDA agencies proactively considered raising the SLs for these chemicals through the annual review process. The Department of Ecology performed a sensitivity/efficiency analysis prior to making these changes to ensure that the environmental protectiveness of the SLs would not be affected. The SL changes made during the DY90 annual review process did not go into effect until June 16, 1991, the beginning of DY92. The DY91 data were evaluated before the changes occurred. The majority of the detection limit problems in this group would disappear if the revised SLs had been used for DY91 projects.

The second group includes the PSDDA pesticides and total PCBs. Matrix interference was reported as the reason for the detection limit problems in these instances. All detection limit exceedances for these COCs occurred for projects for which concurrent biological testing was conducted. As a result, the detection limit problems were inconsequential and the suitability decisions were based on the bioassay results.

TABLE 12 - PSDDA CHEMICAL TESTING SUMMARY

CHEMICAL OF CONCERN	# of DMMU D>SL	Project Frequency	# of DMMU D>BT	Project Frequency	# of DMMU D>ML	Project Frequency	# of DMMU U>SL	Project Frequency	# of DMMU U>BT	Project Frequency	# of DMMU U>ML	Project Frequency
METALS												
Cadmium (1)	2	2										
Copper (1)	1	1										
Lead (1)	1	1										
Mercury	1	1										
Zinc (1)	1	1										
LPAH												
2-Methylnaphthalene (1)	5	4			1	1						
Acenaphthene (1)	8	5			3	2						
Acenaphthylene (1)	5	4			1	1						
Anthracene (1)	8	4			4	3						
Fluorene (1)	9	5			3	3						
Naphthalene (1)	4	3			1	1						
Phenanthrene (1)	9	5			4	3						
Total LPAH (1)	9	5			4	3						
HPAH												
Benzo(a)anthracene (1)	4	3			1	1						
Benzo(a)pyrene	3	2										
Benzofluoranthenes (1)	4	3										
Chrysene (1)	4	3										
Dibenzo(a,h)anthracene (1)	1	1					1	1				
Fluoranthene	6	5	4	3	3	2						
Indeno(1,2,3-c,d)pyrene (1)	7	4					1	1				
Pyrene (1)	9	5			4	3						
Total HPAH (1)	8	5			1	1						
CHLORINATED HYDROCARBONS												
1,2,4-Trichlorobenzene (1)							1	1				
Hexachlorobenzene							3	2	1	1		

D=Detected U=Undetected SL=Screening Level BT=Bioaccumulation Trigger ML=Maximum Level

(1)=No BT exists (2)=No ML exists (3)=No BT or ML exists

TABLE 12 (CONTINUED) - PSDDA CHEMICAL TESTING SUMMARY

CHEMICAL OF CONCERN	# of DMMU D>SL	Project Frequency	# of DMMU D>BT	Project Frequency	# of DMMU D>ML	Project Frequency	# of DMMU U>SL	Project Frequency	# of DMMU U>BT	Project Frequency	# of DMMU U>ML	Project Frequency
PHTHALATES												
Diethyl Phthalate (3)							1	1				
Dimethyl Phthalate (2)							1	1				
PHENOLS												
2 Methylphenol (1)							5	3			1	1
2,4-Dimethyl phenol (1)							4	3			1	1
4 Methylphenol (1)	1	1										
Pentachlorophenol							3	2	1	1		
Phenol	2	2					1	1				
MISCELLANEOUS EXTRACTABLES												
Benzoic Acid (1)							3	2			1	1
Benzyl Alcohol (1)							4	3			1	1
Dibenzofuran (1)	8	5			2	2						
Hexachlorobutadiene							1	1				
N-Nitrosodiphenylamine							1	1	1	1		
PESTICIDES AND PCBs												
Aldrin (2)							12	3	1	1		
Chlordane (2)							12	3	1	1		
Dieldrin (2)							12	3	1	1		
Heptachlor (2)							12	3	1	1		
Lindane (2)							12	3	1	1		
Total DDT							12	3	1	1		
Total PCBs							12	3				

D=Detected U=Undetected SL=Screening Level BT=Bioaccumulation Trigger ML=Maximum Level

(1)=No BT exists (2)=No ML exists (3)=No BT or ML exists

TABLE 13 - MULTIPLE EXCEEDANCES OF PSDDA GUIDELINE VALUES

CHEMICAL	CHEMICALS EXCEEDING SL IN AT LEAST HALF OF THE PROJECTS	CHEMICALS EXCEEDING BT IN AT LEAST TWO PROJECTS	CHEMICALS EXCEEDING ML IN AT LEAST TWO PROJECTS	CHEMICALS WITH DETECTION LIMITS EXCEEDING SL IN AT LEAST THREE PROJECTS
2-Methylnaphthalene	X			
Acenaphthene	X		X	
Acenaphthylene	X			
Anthracene	X		X	
Fluorene	X		X	
Phenanthrene	X		X	
Total LPAH	X		X	
Fluoranthene	X	X	X	
Indeno(1,2,3-c,d)pyrene	X			
Pyrene	X		X	
Total HPAH	X			
2 Methylphenol				X
2,4-Dimethylphenol				X
Benzyl alcohol				X
Dibenzofuran	X		X	
Aldrin				X
Chlordane				X
Dieldrin				X
Heptachlor				X
Lindane				X
Total DDT				X
Total PCBs				X

Biological Testing. Biological testing was required for five of the eight projects which underwent chemical testing during DY91. Table 14 shows the number of times each of the four bioassays was conducted and the number of hits for each.

TABLE 14 - DY91 BIOASSAY "HITS"

BIOASSAY	Number of DMMUs Tested	Number of Hits Under the "Two-Hit Rule"	Number of Hits Under the "Single-Hit Rule"
Amphipod	15	1	1
Sediment Larval	14	1	4
Neanthes	10	1	1
Microtox	15	0	0

The most salient observation from this tabulation is that during DY91 there were no hits for Microtox whatsoever. The general pattern for the Microtox data during DY91 showed either no light diminution or, in many cases, light enhancement. Research is ongoing at several facilities to determine the implications of light enhancement. Currently, the PSDDA agencies regard light enhancement as a nontoxic response. The DY91 bioassay data were interpreted using this guideline. No retests were required for any Microtox tests.

The *Neanthes* bioassay had only two hits but proved to be a relatively trouble-free bioassay. Only one retest was conducted. For the Anchor Cove project, some of the worms at the end of the test were smaller than the 0.425 mm screen used to separate the worms from the sediment. As a result, some worms were inadvertently lost and the bioassay had to be repeated. This resulted in the only holding time violation for DY91 bioassays. The biological testing subcontractor conducted a retest at its own expense, starting on day 73. Mortality in the retest was only ten percent. These results were accepted by the PSDDA agencies using best professional judgement, rather than penalizing an applicant for complying with established protocols (in fact, the 0.425 mm screen used in the first test was finer than the screen specified in the PSEP protocols. The 0.5 mm screen specified in PSEP would have been even less effective in retaining worms at the end of the test).

The amphipod bioassay was also relatively trouble-free. Only one project, U.S. Oil, had a retest conducted for the amphipod bioassay. For U.S. Oil, high emergence data created doubts about the test results and the applicant opted for a retest.

The sediment larval bioassay proved to be the most sensitive bioassay during DY91 and also the most problematic. Two of the five projects with biological testing required retests for this bioassay. These were Anchor Cove and U.S. Oil. For both Round 2 and Round 3 of sediment larval testing for Anchor Cove, problems occurred with the reference sediment performance for this bioassay. The retest for U.S. Oil was necessitated by protocol deviations, including the lack of a reference sediment, only three replicates and relatively high abnormality in the seawater control.

Reference Area Performance. For biological testing, it is necessary to include both control and reference sediments in the experimental design. Control sediments are typically native, coarse-grained sediments in which the test organisms are expected to survive. As such, control sediments serve as a check on laboratory performance. Control sediment performance is rarely a problem. Reference sediments are chosen to closely match the grain size of proposed dredged material in order to separate biological responses to chemicals in the dredged material from responses to physical factors. Reference sediments are taken from areas of Puget Sound thought to be free of pollution sources and having sediment chemical concentrations at or below the SL values for chemicals of concern.

Under PSDDA testing guidelines, the biological response in reference sediments is not to exceed twenty percent over the response exhibited in the control. This performance standard is sometimes not achieved, particularly in the sediment larval test, and occasionally in the amphipod test. The cause of this problem is not completely known but it is suspected that fine-grained sediments may create physical effects in the amphipod test, while ammonia and sulfides have been implicated in the sediment larval test. When reference sediment performance standards are not achieved, the PSDDA agencies are forced to either set aside the results of the test, use best professional judgement in the interpretation of data, or call for a retest. This situation can adversely impact dredging projects by increasing sampling and testing costs and by delaying projects while the problem is resolved.

Problems with reference sediment performance were encountered in both DY90 and DY91 and have continued on into DY92. Table 15 summarizes the reference sediment performance problems encountered in DY90-92. The table clearly shows that performance problems are not isolated to a single reference area. All reference areas have experienced problems. The PSDDA agencies are working on the resolution of these difficulties through the bioassay review process initiated at the last annual review meeting. The agencies have been proactive in recommending aeration in the sediment larval test to ameliorate the effects of ammonia and sulfides. Additional data analysis is being conducted in an attempt to establish solid relationships between mortality and parameters such as percent fines and aqueous ammonia. Additional protocol modifications are being investigated to further reduce the scope of the problem.

TABLE 15 - SUMMARY OF DY90-92 REFERENCE AREA PERFORMANCE FAILURES

DY	PROJECT	Reference Sediment	Reference Sediment Performance (X = fails to meet standard)	
			Amphipod	Sediment Larval
1990	USACE Duwamish O&M Round 1	Samish Bay[1]	X	
1990	USACE Duwamish O&M Round 2	Carr Inlet		X
1990	USACE Duwamish O&M Round 3			X
1991	Anchor Cove Round 2 (see Bellingham Round 1)			
1991	Anchor Cove Round 3 (see Bellingham Round 2)			
1992	USACE/Port of Bellingham Round 1	Sequim Bay	X	X
1992	USACE/Port of Bellingham Round 2	Samish Bay		X
1992	U.S. Navy Bremerton Pier D	Samish Bay	X	
1992	Day Island Yacht Club	Carr Inlet		X
1992	Port of Tacoma Blair Waterway	Jetty Island		X
1992	U.S. Navy Everett Homeport Element II - Round 2	Jetty Island		X
1992	USACE Duwamish O&M Phase 1	Samish Bay		X

[1]QA/QC limits for temperature and salinity were also exceeded.

B. Ranking Analysis

The PSDDA process allows for reranking of a project if sufficient data have been collected to support this decision. Although the PSDDA Phase I Evaluation Procedures Technical Appendix recommends obtaining consistent results over two testing periods before an overall area ranking can be lowered, specific projects within an area may be ranked higher or lower based on sediment characterization of the site. This may be done through the partial characterization process or the review of historical data.

The algorithm shown in Table 16 is used to rerank sediments based on partial characterization data. Partial characterization is meant to be a "worst-case" look at the sediments within a project area or subarea. Therefore, compositing is not allowed, as "hot spots" could be masked by dilution with less-contaminated sediments. However, to obtain a qualitative look at reranking considerations for DY91 projects, the PC algorithm in Table 16 was applied to the testing results for these projects. Table 17 summarizes the project-specific rankings for surface and subsurface DMMUs based on this algorithm. Biological testing results take precedence over chemical data, however, so that a DMMU given a nominal rank of "moderate" based on chemistry, was ranked "high" if that DMMU failed biological testing.

TABLE 16 - PARTIAL CHARACTERIZATION RANKING ALGORITHM

AREA RANK	DATA EVALUATION ALGORITHM
HIGH	ANY COC GREATER THAN ML
MODERATE	ONE OR MORE COC GREATER THAN (SL + ML)/2 AND LESS THAN ML
LOW-MODERATE	ONE OR MORE COC GREATER THAN SL AND LESS THAN (SL + ML)/2
LOW	ALL COCs BELOW SL

The highest ranking DMMU within any project will generally dictate the overall rank for the project, except in the case of large projects or projects with physically disparate subareas. It must be kept in mind too, that this algorithm applies correctly only to uncomposited surface samples. Many of the DMMUs in DY91 were composited samples. All DMMUs labelled "C" are composited DMMUs.

Table 17 compares the rank assigned initially to each project to the rank resulting from this analysis. Hurlen Construction, Tristar Marine and U.S. Oil were all ranked appropriately. Anchor Cove, and the high-ranked portion of USACE Keystone appear to have been overranked initially. Chevron USA was underranked, receiving a "high" rank as a result of this analysis. While the initial ranks for B.P. Oil, Port of Silverdale, and the "low-moderate" ranked portion of USACE Keystone appear to be too high, the "low-moderate" ranks were appropriate. To be ranked "low", sufficient data must be available to verify that concentrations of all chemicals-of-concern are below SL.

This analysis is accompanied by two caveats. The first is a reiteration of the fact that an algorithm, meant for use with uncomposited samples, was used in the present case with many DMMUs which were composites. The second caveat is that the presence and nature of active sources on-site, spill events, and changed site-use or management practices, all play a role in the determination of rank. As a tool, the PC algorithm may prove useful in the reranking of project areas. Ultimately, however, the PSDDA agencies must continue to use best professional judgement in ranking determinations.

TABLE 17 - SUMMARY OF TESTING DATA FOR RERANKING CONSIDERATION

PROJECT	ACTUAL FULL CHARACTERIZATION RANK	TESTED STRATUM	PC ALGORITHM RANK OF ---------- INDIVIDUAL DMMUs ---------- LOW	LOW-MODERATE	MODERATE	HIGH	PROJECT RERANK BASED ON PC ALGORITHM
ANCHOR COVE MARINA	M	SURFACE		1			LM
		SUBSURFACE					
B.P. OIL	LM	SURFACE	9				L
		SUBSURFACE	7				
CHEVRON USA	M	SURFACE		1		1	H
		SUBSURFACE		1			
HURLEN CONSTRUCTION	H	SURFACE				1	H
		SUBSURFACE					
PORT OF SILVERDALE	M	SURFACE	2				L
		SUBSURFACE					
TRISTAR MARINE	H	SURFACE				1	H
		SUBSURFACE		1			
U.S. OIL	H	SURFACE		2		3	H
		SUBSURFACE		3			
USACE KEYSTONE	H/LM	SURFACE	7				L
		SUBSURFACE					

C. Regulatory Processing

There is a sequence of steps in the regulatory process which dredging proponents must take before receiving a permit under Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act. These are as follows:

(1) Submit application for permit.

(2) Prepare sampling and analysis plan for characterization of proposed dredged material.

(3) Receive approval of sampling and analysis plan from PSDDA agencies.

(4) Perform sampling and chemical/biological analysis.

(5) Submit testing results.

(6) Receive suitability decision for open-water disposal from PSDDA agencies.

(7) Complete application details required to issue public notice.

(8) Issue public notice, undergo 30-day public comment period.

(9) Public interest review and permit decision.

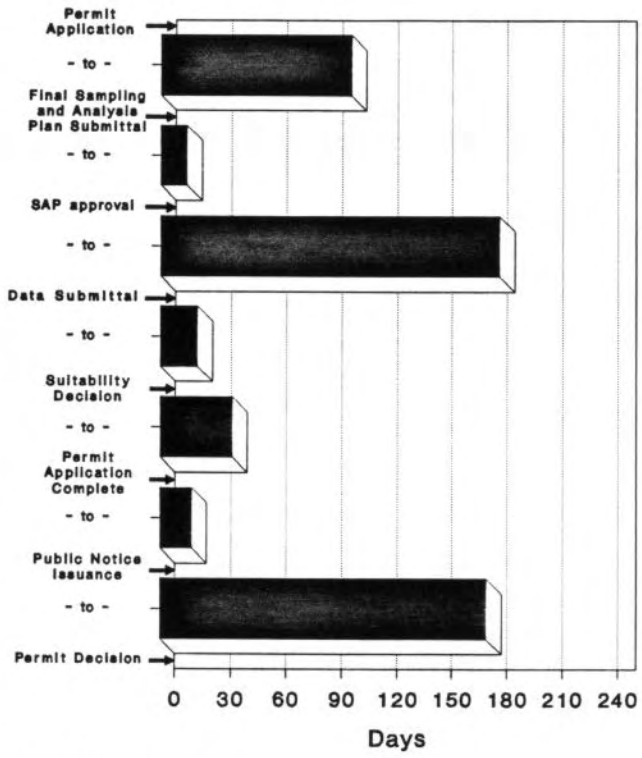
The average time requirements for these steps are included in Figure 4, which was constructed using data from DY91 dredging projects.

Permit Application. An application for a Corps of Engineers' Section 10/404 permit for dredging and dredged material disposal must be submitted before any PSDDA processing may take place. An application number and Regulatory Branch Project Manager are assigned at this time and the Dredged Material Management Office begins review of information relevant to the proposed dredging.

Sampling and Analysis Plan (SAP) Development. A plan for characterization of the proposed dredged material must be developed. This may include a review of historical data for ranking considerations, identification of sources of contamination, computation of dredging volumes, division of the dredging volume into dredgeable management units, development of a field sampling plan adequately characterizing each dredged material management unit, a chemical analysis plan including adequate QA/QC, contingencies for biological analysis, and reporting and data submittal requirements, among other important elements. While not part of the sampling plan submitted for PSDDA-agency review, cost estimates for PSDDA sampling and testing can influence the scope of the project vis-a-vis budgetary constraints and may increase the time required for SAP development. The SAP may be submitted at the time of permit application. Dredging applicants are required to submit plans which are complete and fully adequate to characterize the proposed dredged material.

In Figure 4, 103 days was the average time required for SAP development. This number includes the entire time from submittal of the permit application to submittal of the final SAP. In some cases (5 projects in DY91), a preliminary SAP is submitted for review by the PSDDA agencies and a revised SAP is requested of the applicant. This time has been included in the "Sampling and Analysis Plan Development" phase of the process. The mean time for preliminary SAP review for these five projects

Time Elapsing For Each Regulatory Stage:



PSDDA Processing Time:

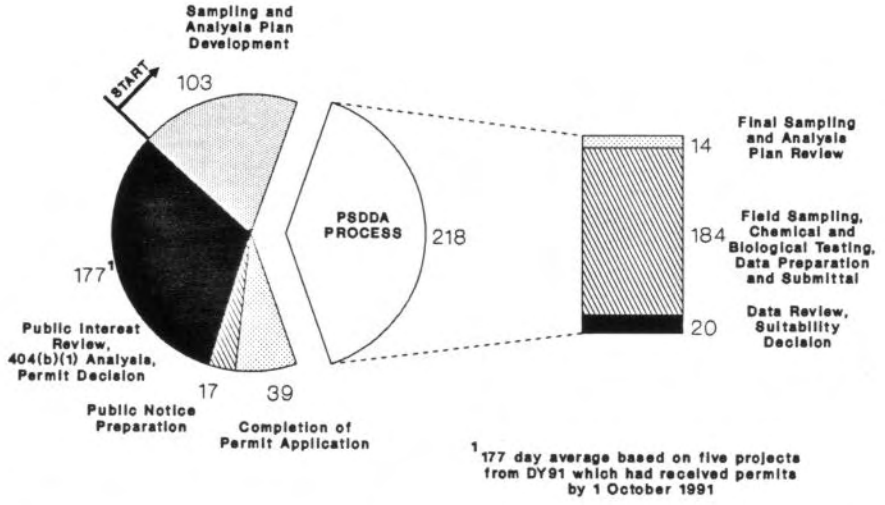


FIGURE 4 - REGULATORY PROCESSING TIME

Means for DY91 Projects

was 24 days, with an average of 43 days required for SAP revision by the applicant. Because a revised sampling plan is only required when the preliminary SAP has major flaws, and because the time taken by the applicant to revise the SAP is highly variable (7-63 days), this time was not included in the "PSDDA Process" time in Figure 4.

During DY91, through an iterative process involving several projects, dredging consultants and the PSDDA agencies, a prototype sampling and analysis plan was developed. The final prototype selected was a modification of the sampling plan developed for the U.S. Navy's Pier D project. This prototype is available from the Dredged Material Management Office (764-3768) in both hardcopy and WordPerfect formats. The availability of this prototype should cut down the amount of time required in the future for sampling plan development and reduce the number of times that revisions of SAPs are required.

Sampling Plan Approval. Once a complete sampling plan has been submitted, the Dredged Material Management Office coordinates review of the SAP with the other PSDDA agencies: the Environmental Protection Agency and State of Washington Departments of Ecology and Natural Resources. An approval letter is sent which includes PSDDA-agency comments and recommended modifications of the SAP. Once these comments and modifications have been acknowledged by the applicant (via telephone or letter), sampling and analysis may proceed. It is the goal of the Dredged Material Management Office to complete the review of SAPs within three weeks. During DY91 the average time from submittal of the final SAP for a project to SAP approval was 14 days. When preliminary SAP review time is included, the mean is 18 days.

Sampling and Analysis. During this phase, field sampling and chemical/biological analysis are completed following the protocols established in the approved SAP. Data is compiled and submitted both in a hardcopy report and in the Corps' Dredged Analysis Information System (DAIS) format. Sampling and characterization consume a substantial portion of the PSDDA Process time budget, averaging 218 days during DY91. There was a high degree of variability in this phase with projects ranging from 81 to 326 days. This was due, in part, to the requirement to conduct resampling efforts for Anchor Cove and US Oil. Factors influencing the time required for this phase include weather, laboratory capacity and turn-around, QA problems arising during chemical or biological testing, and report compilation time.

Data Review. Once a full set of chemical/biological testing data is submitted along with a sampling report, the Dredged Material Management Office coordinates data review with the other PSDDA agencies. The result of this review is the signing by PSDDA agency representatives of a memorandum-for-record documenting the decision reached on the suitability/unsuitability of each of the dredged material management units defined in the approved SAP. Once again, the goal of the Dredged Material Management Office is to complete this review within 3 weeks of data submittal. In DY91 the average time required was 20 days.

Complete Permit Application. When the suitability decision has been made, the Dredged Material Management Office informs the Regulatory Branch project manager and preparations are made to go out to public notice. At the time of original application, construction details may not have been known for the project. Alternatively, construction plans may be altered due to the suitability decision reached. In these cases new drawings may be required of the applicant along with any other information pertinent to the preparation of the Public Notice for the project.

Often times the local shorelines process runs concurrently with PSDDA testing. The decision may be made to wait to go out to public notice until the local shorelines jurisdiction has issued a permit. In this case there may be a time lapse between the suitability decision and the public notice.

For DY91, an average of 39 days was required to finalize the permit application before a public notice could be prepared, with times ranging from 14 to 96 days.

Public Notice Preparation. By regulation, the Regulatory Branch must issue a public notice within 15 days of completion of the permit application. Because of regulatory workloads elevated significantly beyond levels seen during DY90, the average time for Public Notice preparation was 17 days in DY91.

Public Interest Review and Permit Decision. A PSDDA dredging project typically undergoes a 30-day public comment period. Comments received during this period are considered during a public interest review. A Section 404(b)(1) evaluation is performed after the 30-day comment period closure. The Corps Project Manager prepares a permit decision upon completion of the public interest review. This stage of the process may be very time-consuming. Dredging and PSDDA processing are often only parts of complex projects. Other elements may be involved, such as wetland fills or eelgrass bed impacts. Resolution of controversial issues such as these may consume additional time after the PSDDA suitability decision has been made. To improve regulatory response time, the Washington Department of Ecology recommends that applicants seek an hydraulic project approval (HPA) from the Department of Fisheries and resolve other problems (e.g., wetlands-related) earlier in the permit process. Pre-application meetings could serve to improve turn-around times and could be held earlier in the process.

This stage required an average of 177 days per project during DY91, ranging from 56 to 256 days. Analysis for this stage was based on the five projects from DY91 which received permits prior to October 1, 1991: BP Oil, Chevron USA, Hurlen Construction, Tristar Marine and US Oil.

PSDDA Processing Time. PSDDA processing time, as depicted in the lower part of Figure 4, includes final sampling and analysis plan review and approval, field sampling and analysis, data review and suitability decision-making. This took an average of 218 days per project for DY91, with the majority of that time taken up by sampling, testing and data preparation. Sampling and analysis plan preparation, although part of the PSDDA process, was not included because of the variability in time which can elapse between permit application and sampling and analysis plan submittal. This is largely outside the control of the PSDDA agencies.

D. Cost Analysis

Total Costs. Total sampling and testing costs are generally related to the size of the project and the rank. Larger projects have lower unit costs than smaller projects due to economy of scale. Higher ranked projects are more costly due to the larger number of samples and analyses required. Figure 5 relates the average total cost per cubic yard to the total volume tested for each of the DY91 projects. Figure 6 relates the average cost per cubic yard to the rank. Both figures verify the general relationships expected. Total PSDDA sampling and testing costs for DY91 were $376,863. These costs include sampling plan development, sampling, chemical and biological testing, reporting, data entry and other miscellaneous costs. The total volume of proposed dredged material handled under PSDDA evaluation guidelines was 1,004,169 cubic yards. This includes the USACE Swinomish project which, under PSDDA frequency guidelines, did not incur any sampling or testing costs for DY91 dredging. The average unit cost for all projects was less than thirty-eight cents per cubic yard.

Sampling Costs. The costs reported for each of the constituent activities shown in Figure 2 (sampling, bioassays, chemistry, miscellaneous), varied widely. Sampling costs, in particular, exhibited

FIGURE 5 - COST ANALYSIS
PROJECT SIZE VERSUS UNIT COST

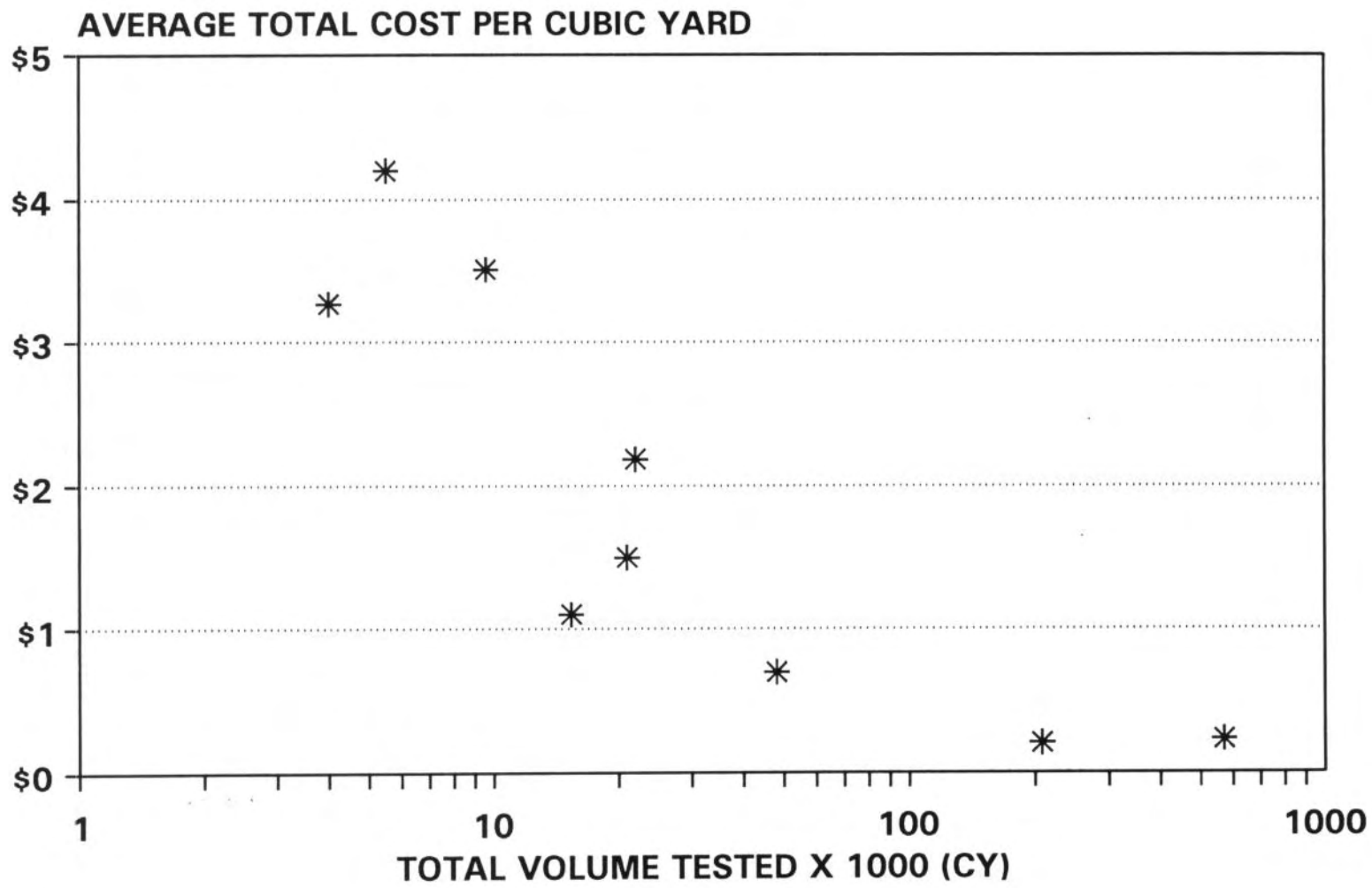
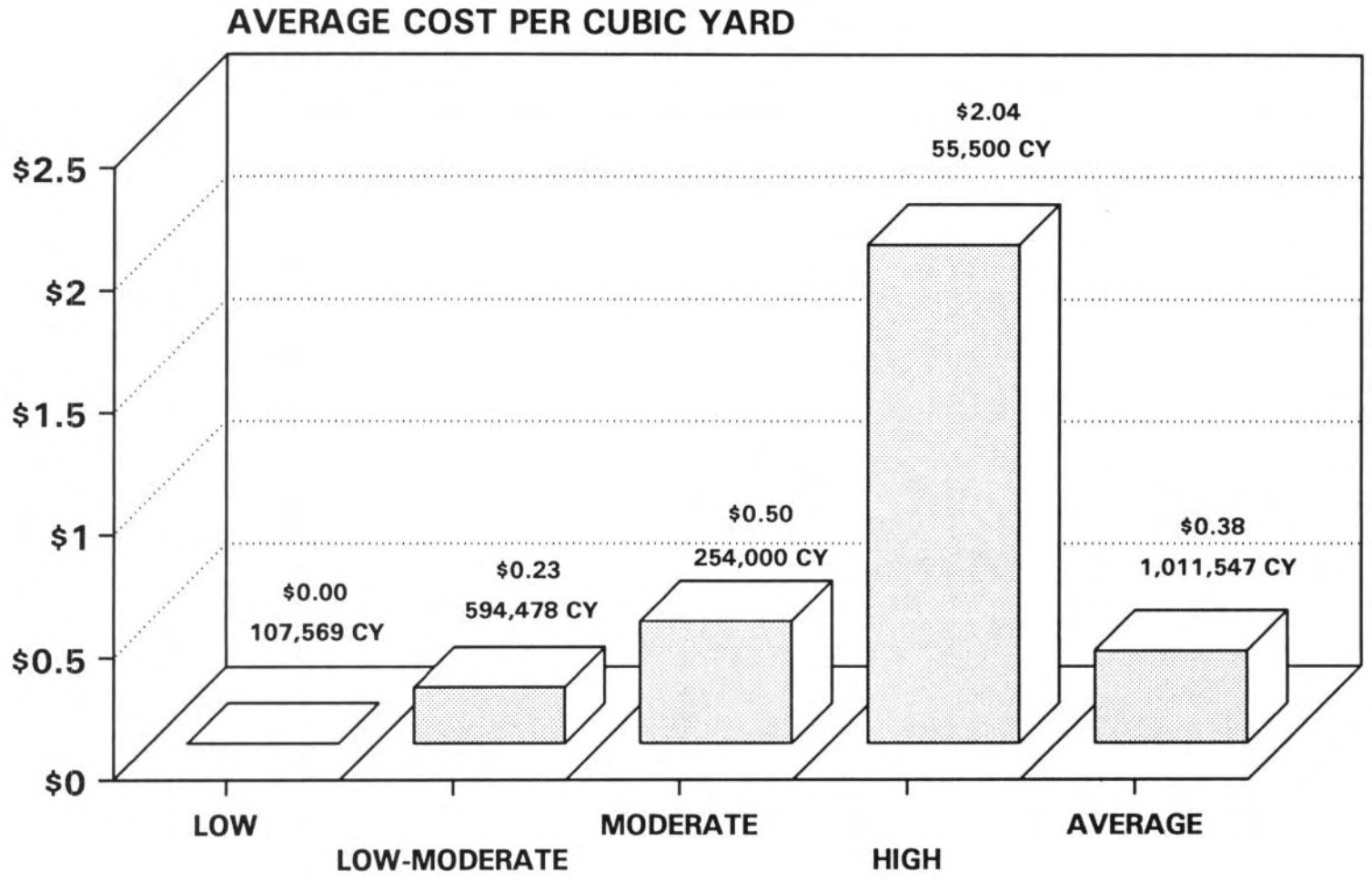


FIG. 6 - RANK VERSUS UNIT TESTING COSTS DREDGING YEAR 1991

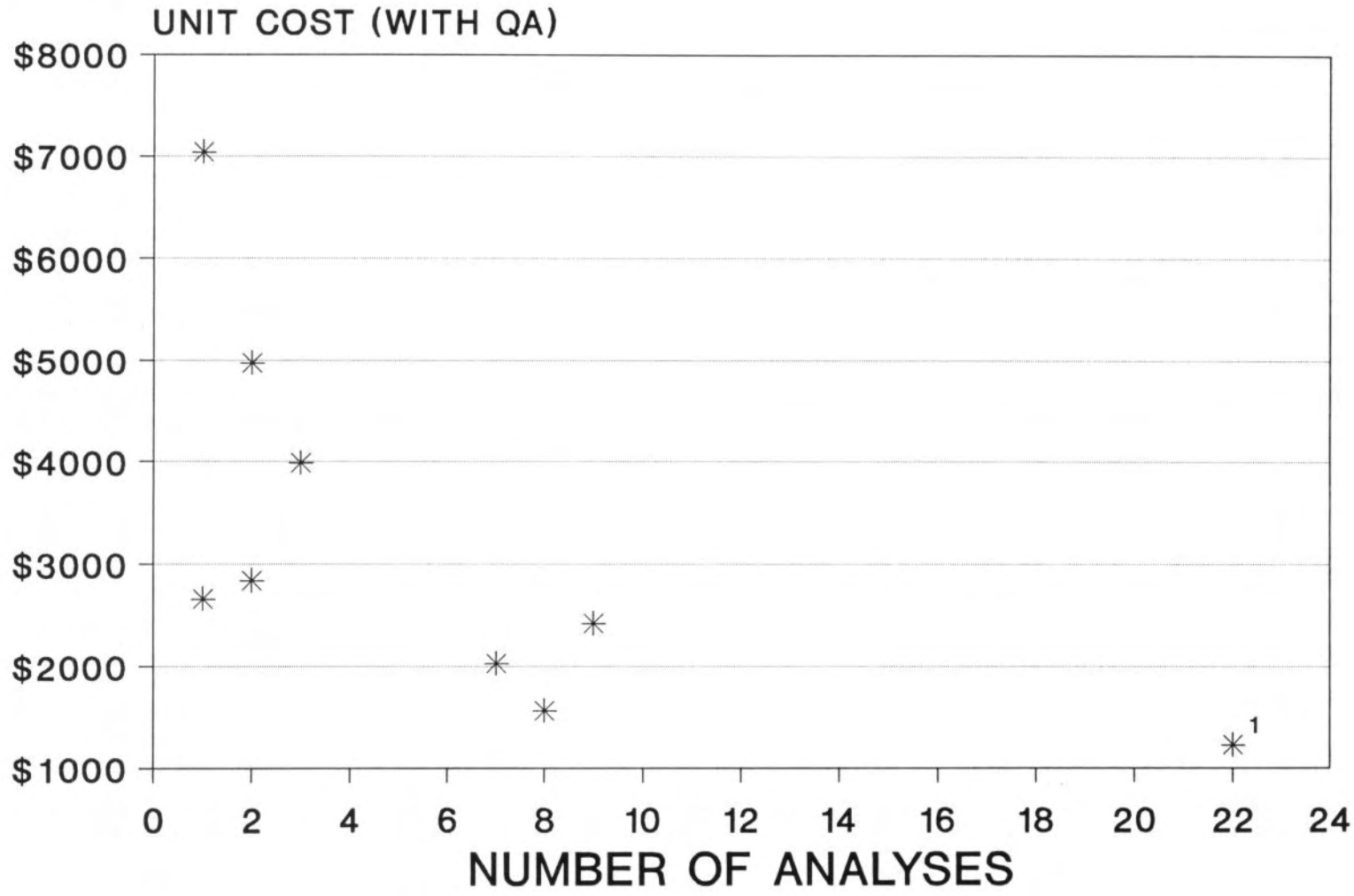


high variability and are the most difficult to analyze. An analysis of sampling costs relative to project size, maximum sampling depth and mean sampling depth resulted in no discernible pattern, although these are certainly factors which affect cost. Additional analysis was conducted which attempted to relate sampling costs to a combination of these factors, so as to indirectly include mobilization costs, economy-of-scale effects, and actual field sampling time. Such a relationship would be useful in estimating sampling costs but could not be established for the present data set. As more sampling cost data is compiled, an empirical relationship will be pursued.

Testing Costs. Chemistry testing costs are the most straightforward of all costs. Quotes on unit prices can be obtained from the various analytical laboratories doing PSDDA analyses. These unit prices may include QA/QC costs or additional samples may need to be added to the number of field samples to be analyzed to account for QA/QC. In either case, the number of samples to be analyzed dictates the average cost per analysis. Figure 7 depicts this relationship. As the number of samples increases, the cost per analysis decreases. Projects with only one analysis are especially costly, as the QA/QC costs cannot be distributed over several samples. BP Oil, with 22 total analyses between PC and FC, has abnormally low per unit costs. This was due, in part, to the fact that volatiles, pesticides and PCBs were eliminated from the list of COCs as a result of the PC.

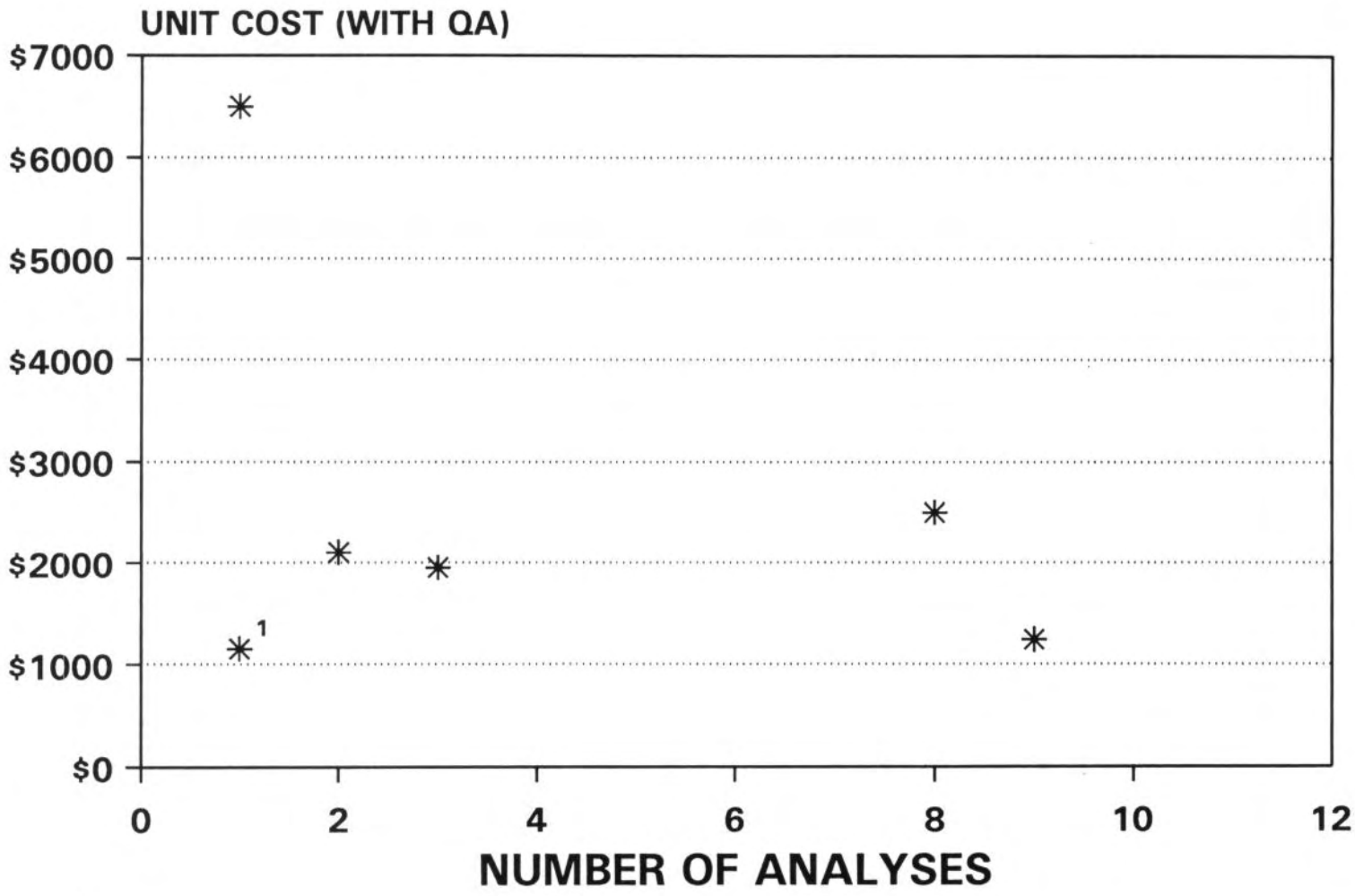
Unit costs for bioassays (Figure 8) related well to the total number of analyses. It should be kept in mind that Hurlen Construction, tested under small project guidelines, was required to run the Microtox and amphipod bioassays only. The data point associated with that project is therefore biased low.

FIGURE 7 - DY 91
CHEMISTRY UNIT COST ANALYSIS



[1] BP Oil - no volatiles, pesticides or PCBs for 16 of 22 analyses

FIGURE 8 - DY91
BIOASSAY UNIT COST ANALYSIS



[1] Hurlen Construction - only Microtox and amphipod bioassays

VII. RECOMMENDATIONS FOR ANNUAL REVIEW MEETING ISSUES. Prepared by David R. Kendall, Corps of Engineers, Dredged Material Management Office

Recommendations for issues which the Dredged Material Management Office feels need to be addressed are presented in this section. These have been divided into issues related to sampling, chemical testing, biological testing and program facilitation.

A. Sampling Guidelines.

Greater flexibility in areas subject to high deposition rates. The current sampling guidelines (EPTA, page II-44) stipulate that when more than two feet of additional sediments have been deposited over sediments already characterized, sampling and testing of the newly deposited material is necessary.

An example is the sampling and testing for maintenance dredging in the Duwamish River, which normally commences during the summer/fall of a dredging year in order to allow tiered testing of the material. Winter freshets, commencing in late November, and continuing through December, January and February, wash down large amounts of bedload sand, which is largely deposited in the upper turning basin of the Duwamish River, and usually exceeds two feet in depth. Testing of such material during February 1990 confirmed that this material had low concentrations of PSDDA chemicals of concern (less than SL). Testing of the material in the same areas will be accomplished during February 1992 to further document that this material is not contaminated and is suitable for unconfined open-water disposal.

Pending the confirmation of low levels of PSDDA COCs, it is recommended that future maintenance dredging in areas subject to high sedimentation rates, resulting in greater than two feet of additional accumulation, be allowed greater flexibility on the testing requirements currently prescribed. Sampling and characterization of this material over two dredging cycles is necessary before a specified dredging reach or project area may be proposed for "no testing" of these sediments prior to dredging and disposal. Decisions will be made on a case-by-case basis, following review and concurrence of all four PSDDA agencies.

B. Bioassay Guidelines.

Aeration of Sediment Larval Test in presence of high sediment ammonia and sulfide levels. During DY91, it became apparent that high sediment ammonia and sulfide levels were resulting in reference sediment performance failures. The current protocol stipulates aeration of all samples within a batch if the dissolved oxygen (DO) drops below 5 ppm (DMEAR,1990; ARM,1991), but does not give specifications for aerating test beakers due to high sediment sulfide or ammonia levels.

The Dredged Material Management Office, after consulting the PSDDA agencies, recommended aerating all within-batch test beakers, when bulk ammonia or sulfide levels were elevated or sediments smelled strongly of sulfur dioxide. This corrective action helped to ameliorate but not eliminate reference sediment performance problems attributable to these compounds.

Additional studies are underway to address the effects of ammonia toxicity on *Dendraster excentricus* and *Crassostrea gigas* larvae as part of a technical review of the PSDDA bioassays. Recommendations on whether to recommend this action as a future protocol change will be addressed as

part of a technical issue paper after these studies are completed. In the meantime, aeration will continue to be recommended if ammonia or sulfides levels are elevated in the test sediments.

Neanthes 10-day Acute Bioassay: Static versus Static Renewal. The Dredged Material Management Office recommends changing the protocol for the *Neanthes* 10-day acute bioassay, so that the test is conducted as a static bioassay over the 10-day test duration. The current protocol stipulates static-renewal of 1/3 of the water every 3 days. This change would make the protocol for conducting the test consistent with the amphipod bioassay.

Microtox Bioassay Sensitivity. An issue of some concern to the PSDDA agencies is the decrease in "hits" noted for the Microtox bioassay during the three-year PSDDA implementation period. The apparent lack of test sensitivity to identify toxic from nontoxic sediments has not been due to a decrease in organism sensitivity (*Photobacterium phosphoreum*), as positive control data provided by the labs have not shown any decline in EC50 values. The PSDDA agencies will be convening a practitioners' workshop before the ARM with representatives from Microbics Inc., who will go over the current protocol to ascertain consistency in its application among laboratories. It is anticipated that the outcome of this workshop may result in some recommendations for corrective actions to make the test more sensitive, or a recommendation to drop the test from the PSDDA suite of bioassays.

C. Chemistry Testing Guidelines

Acid Volatile Sulfides (AVS). The PSDDA program proposes to replace the total sulfides analysis with AVS analysis. Nationally, this technique is being adopted as a predictive tool in ascertaining the potential toxicity of various heavy metals in sediments. While it has long been recognized that metals can form insoluble sulfides, it has only recently been recognized that AVS is a reactive pool of solid phase sulfide that is available to bind with metals. Its use in predicting cadmium and nickel toxicity in sediments was recently discussed in papers by Di Toro et al. (1990, 1991). The PSDDA program will utilize the 1991 EPA draft analytical method (Allen et al., 1991) developed at EPA Headquarters for the analysis of AVS in sediments.

D. Program Facilitation.

Communication Improvements/Data Submittal Requirements. The PSDDA Agencies are anxious to improve communications with dredging agents and laboratories conducting testing, so as to minimize QA/QC problems, coordinate corrective actions and retests, and to facilitate data transfer. A major concern of the PSDDA agencies has been the dissemination of a project-specific PSDDA-approved sampling and analysis plan to each testing laboratory, so as to provide clear, unambiguous directions on PSDDA sampling and analysis requirements. In spite of the time and effort put into these SAPs by both dredging consultants and PSDDA-agency representatives, the details laid out in the SAP are not always followed. QA/QC problems and data submittal omissions many times result from this situation.

To improve communication and generally facilitate the PSDDA process, the following actions will be taken:

- a "red flag" list will be compiled by the PSDDA agencies. Problems associated with the elements on this list should be immediately brought to the attention of the Dredged Material Management Office. An example would be a reference sediment performance problem in the sediment larval bioassay.

- conference calls will be instituted by the prime contractor as part of the SAP review process. These conference calls will include sampling, and chemical and biological testing subcontractors. The purpose is to verify with each of the subcontractors that the procedures in the SAP are accurate and will be followed, and to open lines of communication with all involved parties.

- a preset schedule for phone contact between the prime contractor and DMMO during sampling and testing will be drafted by DMMO. This would facilitate a smoother testing sequence and prevent data omissions and protocol violations. An example would be a phone call to DMMO the day after sampling is completed to discuss any problems encountered.

- a checklist for data submittals will be prepared for use by the prime contractor, to ensure that complete data packages are submitted, to verify that all with-in batch QA/QC has been reported by testing subcontractors, and to assist prime contractors in determining what data needs to be collected prior to testing.

DAIS Input Screens. The Dredged Material Management Office has formally implemented new Dredged Analysis Information System (DAIS) input screens for all testing data submittals. The DAIS input screens were designed to replace Lotus 1-2-3 spreadsheets utilized for DAIS data submittals since 1989. The new input screens were designed to provide a user-friendly interface for inputting data, and should decrease the time required for data entry.

References

Allen, H.E., F. Gongmin, W. Boothman, D.M. DiToro, and J.D. Mahony. 1991. Determination of Acid Volatile Sulfides and simultaneously extractable metals in sediment. EPA draft amalytical method for determination of Acid Volatile Sulfide in Sediment. (in press).

DiToro, D.M., J.D. Mahony, D.J. Hansen, K.J. Scott, M.B. Hicks, S.M. Mayr, and M.S. Redmond. 1990. Toxicity of cadmium in sediments: The role of Acid Volatile Sulfide. Environ. Tox. Chem. Vol. 9: 1487-1502.

DiToro, D.M., J.D. Mahony, D.J. Hansen, K.J. Scott, A.R. Carlson, and G.T. Ankley. 1991. Acid Volatile Sulfide predicts the acute toxicity of cadmium and nickel in sediments. Environ. Science Technol. (in press).

APPENDIX I - DY91 PSDDA SEDIMENT GUIDELINE VALUES

CHEMICAL	SL	BT	ML	(SL+ML)/2
METALS (ppm dry wgt):				
Antimony	20	146	200	110
Arsenic	57	507.1	700	378.5
Cadmium	0.96		9.6	5.3
Copper	81		810	445.5
Lead	66		660	363
Mercury	0.21	1.5	2.1	1.2
Nickel	140	1,022		
Silver	1.2	4.6	6.1	3.7
Zinc	160		1,600	880
ORGANIC CHEMICALS (ppb dry wgt):				
LPAH				
2-Methylnaphthalene	67		670	368.5
Acenaphthene	63		630	346.5
Acenaphthylene	64		640	352
Anthracene	130		1,300	715
Fluorene	64		640	352
Naphthalene	210		2,100	1,155
Phenanthrene	320		3,200	1,760
Total LPAH	610		6,100	3,355
HPAH				
Benzo(a)anthracene	450		4,500	2,475
Benzo(a)pyrene	680	4,964	6,800	3,740
Benzo(g,h,i)perylene	540		5,400	2,970
Benzofluoranthenes	800		8,000	4,400
Chrysene	670		6,700	3,685
Dibenzo(a,h)anthracene	120		1,200	660
Fluoranthene	630	4,600	6,300	3,465
Indeno(1,2,3-c,d)pyrene	69		5,200	2,634.5
Pyrene	430		7,300	3,865
Total HPAH	1,800		51,000	26,400
CHLORINATED HYDROCARBONS				
1,2,4-Trichlorobenzene	6.4		64	35.2
1,2-Dichlorobenzene	19	37	350	184.5
1,3-Dichlorobenzene	170	1,241		
1,4-Dichlorobenzene	26	190	260	143
Hexachlorobenzene	23	168	230	126.5

APPENDIX I - DY91 PSDDA SEDIMENT GUIDELINE VALUES

CHEMICAL	SL	BT	ML	(SL+ML)/2
PHTHALATES				
Bis(2-ethylhexyl) phthalate	3,100	13,870		
Butyl benzyl phthalate	470			
Di-n-butyl phthalate	1,400	10,220		
Di-n-octyl phthalate	6,200			
Diethyl Phthalate	97			
Dimethyl Phthalate	160	1,168		
PHENOLS				
2-Methylphenol	10		72	41
2-4-Dimethylphenol	10		50	30
4-Methylphenol	120		1,200	660
Pentachlorophenol	100	504	690	395.0
Phenol	120	876	1,200	660
MISCELLANEOUS EXTRACTABLES				
Benzoic Acid	216		690	453
Benzyl Alcohol	10		73	41.5
Dibenzofuran	54		540	297
Hexachlorobutadiene	29	212	290	159.5
Hexachloroethane	1,400	10,220	14,000	
N-Nitrosodiphenylamine	22	161	220	121
VOLATILE ORGANICS				
Ethylbenzene	10	27	50	30
Tetrachloroethene	14	102	210	112
Total Xylene	12		160	86
Trichloroethene	160	1,168	1,600	880
PESTICIDES and PCBs				
Aldrin	10	37		
Chlordane	10	37		
Dieldrin	10	37		
Heptachlor	10	37		
Lindane	10	37		
Total DDT	6.9	50	69	38
Total PCBs	130	38*	2,500	1,315

* Value in ppm normalized to Total Organic Carbon

APPENDIX II-LEGEND

S	=	reported concentration exceeds screening level
B	=	reported concentration exceeds bioaccumulation trigger
M	=	reported concentration exceeds maximum level
BM	=	reported concentration exceeds bioaccumulation trigger and maximum level
u	=	undetected at the concentration reported
e	=	estimated concentration
j	=	the analyte was detected at a concentration greater than the SDL, but less than the CRDL. The value reported should be considered an estimate
(1)	=	no bioaccumulation trigger exists for this analyte
(2)	=	no maximum level exists for this analyte
(3)	=	no bioaccumulation trigger or maximum level exists for this analyte
X	=	a hit under the two-hit rule
XX	=	a hit under the single-hit rule
QC	=	bioassay results were set aside due to QA/QC problems
P	=	test sediment passed PSDDA guidelines for open-water unconfined disposal
F	=	test sediment failed PSDDA guidelines for open-water unconfined disposal
NA	=	not applicable; this test sediment was included in a partial characterization or planning study; no suitability decision was made for this test sediment
-	=	this test was not done

APPENDIX II - DY91 PSDDA SEDIMENT GUIDELINE VALUE EXCEEDANCES

Project:	ANCHOR COVE	CHEVRON USA			HURLEN CONSTR.	TRISTAR MARINA	
	C1	C1	C2	S1	C1	C1	S1
METALS							
Cadmium (1)	S					S	
Copper (1)						S	
Lead (1)						S b	
Mercury						S	
Zinc (1)						S b	
LPAH							
2-Methylnaphthalene (1)			S		M	S	
Acenaphthene (1)	S		S		M b	S	
Acenaphthylene (1)			S		M	S	
Anthracene (1)	S	S	M		M		
Fluorene (1)	S		M		M	S	S j
Naphthalene (1)					M	S	
Phenanthrene (1)	S		M	S	M	S	
Total LPAH (1)	S		M	S	M	S	
HPAH							
Benzo(a)anthracene (1)			S		M		
Benzo(a)pyrene					S		
Benzofluoranthenes (1)			S		S		
Chrysene (1)			S		S		
Dibenzo(a,h)anthracene (1)					S		
Fluoranthene	S		B		BM	S	
Indeno(1,2,3-c,d)pyrene (1)	S		S	S	S		
Pyrene (1)	S		M	S	M b	S	
Total HPAH (1)	S		S	S	M	S	
CHLORINATED HYDROCARBONS							
1,2,4-Trichlorobenzene (1)	S u						
Hexachlorobenzene					S u		
PHTHALATES							
Diethyl Phthalate (3)							
Dimethyl Phthalate (2)							
PHENOLS							
2 Methylphenol (1)	S u				S u		
2,4-Dimethyl phenol (1)	S u				S u		
4 Methylphenol (1)						S	
Pentachlorophenol					S u		
Phenol					S b	S b	
MISCELLANEOUS EXTRACTABLES							
Benzoic acid (1)					S u		
Benzyl alcohol (1)	S u				S u		
Dibenzofuran (1)	S		S		M	S	
Hexachlorobutadiene							
N-Nitrosodiphenylamine							
PESTICIDES AND PCBs							
Aldrin (2)		S u	S u	S u		S u	S u
Chlordane (2)		S u	S u	S u		S u	S u
Dieldrin (2)		S u	S u	S u		S u	S u
Heptachlor (2)		S u	S u	S u		S u	S u
Lindane (3)		S u	S u	S u		S u	S u
Total DDT		S u	S u	S u		S u	S u
Total PCB's		S u	S u	S u		S u	S u
BIOASSAYS							
Amphipod							
Sediment Larval		X	XX		-	XX	
Juvenile Infaunal				X	-		
Microtox							
PASS/FAIL	P	P	F	P	F	F	P

APPENDIX II - DY91 PSDDA SEDIMENT GUIDELINE VALUE EXCEEDANCES

Project:	U.S. OIL							
	S1	S2	S3	S4	S5	S6	S7	S8
METALS								
Cadmium (1)								
Copper (1)								
Lead (1)								
Mercury								
Zinc (1)								
LPAH								
2-Methylnaphthalene (1)			S	S				
Acenaphthene (1)	S		M	M				
Acenaphthylene (1)			S	S				
Anthracene (1)	S		M	M	S			
Fluorene (1)	S		M	S				
Naphthalene (1)			S	S j				
Phenanthrene (1)	S		M	M				
Total LPAH (1)	S		M	M				
HPAH								
Benzo(a)anthracene (1)			S	S				
Benzo(a)pyrene			S	S				
Benzofluoranthenes (1)			S	S				
Chrysene (1)			S	S				
Dibenzo(a,h)anthracene (1)				S u				
Fluoranthene			BM	BM				
Indeno(1,2,3-c,d)pyrene (1)			S	S	S u			
Pyrene (1)	S		M	M				
Total HPAH (1)	S		S	S				
CHLORINATED HYDROCARBONS								
1,2,4-Trichlorobenzene (1)								
Hexachlorobenzene			S u	B u				
PHTHALATES								
Diethyl Phthalate (3)				S u				
Dimethyl Phthalate (2)				S u				
PHENOLS								
2 Methylphenol (1)			S u	M u			S u	
2,4-Dimethyl phenol (1)			S u	M u				
4 Methylphenol (1)				S u				
Pentachlorophenol			S u	B u				
Phenol				S u				
MISCELLANEOUS EXTRACTABLES								
Benzoic acid (1)			S u	M u				
Benzyl alcohol (1)			S u	M u				
Dibenzofuran (1)	S		M	S				
Hexachlorobutadiene				S u				
N-Nitrosodiphenylamine				B u				
PESTICIDES AND PCBs								
Aldrin (2)	S u		S u	B u		S u	S u	S u
Chlordane (2)	S u		S u	B u		S u	S u	S u
Dieldrin (2)	S u		S u	B u		S u	S u	S u
Heptachlor (2)	S u		S u	B u		S u	S u	S u
Lindane (3)	S u		S u	B u		S u	S u	S u
Total DDT	S u		S u	B u		S u	S u	S u
Total PCB's	S u		S u	B u		S u	S u	S u
BIOASSAYS								
Amphipod			XX	X				
Sediment Larval		XX	XX	QC		QC	QC	QC
Juvenile Infaunal			XX	-		-	-	-
Microtox								
PASS/FAIL	P	F	F	F	P	P	P	P

APPENDIX III - RANKING ANALYSIS

In this appendix, the ranking of each analysis appearing in Appendix II has been calculated. The comparative rank for each chemical-of-concern is based on the concentration of that chemical. Rankings were calculated using the partial characterization reranking formulas found in EPTA, page II-64. These formulas appear on page 34 of this report. The highest calculated rank for each analysis is indicated and biological testing results are included.

LEGEND

L	=	reported concentration was below SL
LM	=	reported concentration was between SL and (SL + ML)/2
M	=	reported concentration was between (SL + ML)/2 and ML
H	=	reported concentration exceeds ML
u	=	undetected at the concentration reported
e	=	estimated concentration
j	=	the analyte was detected at a concentration greater than the SDL, but less than the CRDL. The value reported should be considered an estimate
(1)	=	no bioaccumulation trigger exists for this analyte
(2)	=	no maximum level exists for this analyte
(3)	=	no bioaccumulation trigger or maximum level exists for this analyte
P	=	test sediment passed PSDDA guidelines for open-water unconfined disposal
F	=	test sediment failed PSDDA guidelines for open-water unconfined disposal
NA	=	not applicable; this test sediment was included in a partial characterization or planning study; no suitability decision was made for this test sediment
-	=	this test was not done
*	=	no ML exists for this analyte; comparative rank determined by setting ML = 10 x SL
H*	=	overall sediment rank based on biological testing results

APPENDIX III - PC ALGORITHM RANKING OF DY91 DMMU

Project:	ANCHOR COVE	CHEVRON USA			HURLEN CONSTR.	TRISTAR MARINA	
Sample ID:	C1	C1	C2	S1	C1	C1	S1
METALS							
Cadmium (1)	L	L u	L u	L u	L u	LM	L u
Copper (1)	L	L	L	L	L	LM	L
Lead (1)	L	L b	L b	L b	L	L b	L b
Mercury	L u	L u	L u	L u	L u	LM	L u
Zinc (1)	L	L b	L b	L b	L	L b	L b
LPAH	L						
2-Methylnaphthalene (1)	L	L j	LM	L	H	LM	L j
Acenaphthene (1)	LM	L u	M	L	H b	LM	L u
Acenaphthylene (1)	L	L j	LM	L	H	LM	L u
Anthracene (1)	LM	LM	H	L	H	L	L j
Fluorene (1)	LM	L	H	L	H	LM	L j
Naphthalene (1)	L	L j	L	L	H	LM	L j
Phenanthrene (1)	LM	L	H	LM	H	LM	L
Total LPAH (1)	LM	L	H	LM	H	LM	L
HPAH							
Benzo(a)anthracene (1)	L	L	L	L	H	L	L
Benzo(a)pyrene	L	L j	L	L	LM	L	L j
Benzofluoranthenes (1)	L	L j	LM	L	LM	L	L j
Chrysene (1)	L	L	LM	L	M	L	L
Dibenzo(a,h)anthracene (1)	L	L u	L	L u	LM	L u	L u
Fluoranthene	LM	L	H	L	H	LM	L
Indeno(1,2,3-c,d)pyrene (1)	LM	L j	LM	LM	LM	L	L j
Pyrene (1)	LM	L	H	LM	H b	LM	L
Total HPAH (1)	LM	L	LM	LM	H	LM	L
CHLORINATED HYDROCARBONS							
1,2,4-Trichlorobenzene (1)	L u	L u	L u	L u	L u	L u	L u
Hexachlorobenzene	L u	L u	L u	L u	L u	L u	L u
PHTHALATES							
Diethyl Phthalate (3)	L u	L u	L u	L u	L u	L u	L u
Dimethyl Phthalate (2)	L u	L u	L u	L u	L u	L u	L u
PHENOLS							
2 Methylphenol (1)	L u	L u	L u	L u	L u	L u	L u
2,4-Dimethyl phenol (1)	L u	L u	L u	L u	L u	L u	L u
4 Methylphenol (1)	L u	L u	L u	L u	L	LM	L u
Pentachlorophenol	L u	L u	L u	L u	L u	L u	L u
Phenol	L u	L u	L u	L u	L b	L b	L b
MISCELLANEOUS EXTRACTABLES							
Benzoic acid (1)	L u	L u	L u	L u	L u	L u	L u
Benzyl alcohol (1)	L u	L u	L u	L u	L u	L u	L u
Dibenzofuran (1)	LM	L	LM	L	H	LM	L j
Hexachlorobutadiene	L u	L u	L u	L u	L u	L u	L u
N-Nitrosodiphenylamine	L u	L u	L u	L u	L u	L u	L u
PESTICIDES AND PCB's							
Aldrin (2)	L u	L u*	L u*	L u*	L u	L u*	L u*
Chlordane (2)	L u	L u*	L u*	L u*	L u	L u*	L u*
Dieldrin (2)	L u	L u*	L u*	L u*	L u	L u*	L u*
Heptachlor (2)	L u	L u*	L u*	L u*	L u	L u*	L u*
Lindane (3)	L u	L u*	L u*	L u*	L u	L u*	L u*
Total DDT	L	L u	L u	L u	L u	L u	L u
Total PCB's	L u	L u	L u	L u	L	L u	L u
Bioassay Pass/Fail	P	P	F	P	F	F	P
HIGHEST RANKING:	LM	LM	H	LM	H	H*	LM

APPENDIX III - PC ALGORITHM RANKING OF DY91 DMMU

Project:	U.S. OIL							
Sample ID:	S1	S2	S3	S4	S5	S6	S7	S8
METALS								
Cadmium (1)	L u	L u	L u	L u	L u	L u	L u	L u
Copper (1)	L	L	L	L	L	L	L	L
Lead (1)	L u	L	L	L	L u	L u	L u	L u
Mercury	L u	L u	L	L	L u	L u	L u	L u
Zinc (1)	L b	L b	L b	L b	L b	L b	L b	L b
LPAH								
2-Methylnaphthalene (1)	L	L	LM	LM	L u	L u	L	L
Acenaphthene (1)	LM	L	H	H	L u	L u	L j	L u
Acenaphthylene (1)	L	L j	LM	LM	L u	L u	L j	L u
Anthracene (1)	LM	L	H	H	LM	L u	L u	L u
Fluorene (1)	LM	L	H	M	L j	L u	L j	L j
Naphthalene (1)	L	L j	LM	L j	L j	L u	L	L j
Phenanthrene (1)	LM	L	H	H	L	L	L	L
Total LPAH (1)	LM	L	H	H	L	L	L	L
HPAH								
Benzo(a)anthracene (1)	L	L	M	LM	L	L j	L	L u
Benzo(a)pyrene	L	L	LM	LM	L j	L j	L j	L j
Benzofluoranthenes (1)	L	L	LM	LM	L	L j	L	L u
Chrysene (1)	L	L	LM	LM	L	L	L	L
Dibenzo(a,h)anthracene (1)	L u	L j	L u	L u	L u	L u	L u	L u
Fluoranthene	L	L	H	H	L	L	L	L
Indeno(1,2,3-c,d)pyrene (1)	L	L j	LM	LM	L u	L u	L u	L u
Pyrene (1)	LM	L	H	H	L	L	L	L
Total HPAH (1)	LM	L	M	LM	L	L	L	L
CHLORINATED HYDROCARBONS								
1,2,4-Trichlorobenzene (1)	L u	L u	L u	L u	L u	L u	L u	L u
Hexachlorobenzene	L u	L u	L u	M u	L u	L u	L u	L u
PHTHALATES								
Diethyl Phthalate (3)	L u	L u	L u	L u*	L u	L u	L u	L u
Dimethyl Phthalate (2)	L u	L u	L u	L u*	L u	L u	L u	L u
PHENOLS								
2 Methylphenol (1)	L u	L u	L u	H u	L u	L u	L u	L u
2,4-Dimethyl phenol (1)	L u	L u	L u	H u	L u	L u	L u	L u
4 Methylphenol (1)	L u	L u	L	L u	L u	L u	L u	L u
Pentachlorophenol	L u	L u	L u	H u	L u	L u	L u	L u
Phenol	L u	L u	L u	L u	L u	L u	L u	L u
MISCELLANEOUS EXTRACTABLES								
Benzoic acid (1)	L u	L u	L u	H u	L u	L u	L u	L u
Benzyl alcohol (1)	L u	L u	L u	H u	L u	L u	L u	L u
Dibenzofuran (1)	LM	L	H	M	L j	L u	L j	L j
Hexachlorobutadiene	L u	L u	L u	M u	L u	L u	L u	L u
N-Nitrosodiphenylamine	L u	L u	L u	M u	L u	L u	L u	L u
PESTICIDES AND PCB's								
Aldrin (2)	L u*	L u	L u*	H u*	L u	L u*	L u*	L u*
Chlordane (2)	L u*	L u	L u*	H u*	L u	L u*	L u*	L u*
Dieldrin (2)	L u*	L u	L u*	H u*	L u	L u*	L u*	L u*
Heptachlor (2)	L u*	L u	L u*	H u*	L u	L u*	L u*	L u*
Lindane (3)	L u*	L u	L u*	H u*	L u	L u*	L u*	L u*
Total DDT	L u	L u	L u	H u	L u	L u	L u	L u
Total PCB's	L u	L u	L u	M u	L u	L u	L u	L u
Bioassay Pass/Fail	P	F	F	F	P	P	P	P
HIGHEST RANKING:	LM	H*	H	H	LM	LM	LM	LM