

YAQUINA BAY SOUTH BEACH MARINA
SEDIMENT EVALUATION
JUNE 1991

Abstract

1. Based on the results of the physical, chemical and the biological tests conducted as prescribed in the testing manual Evaluation of Dredged Material Proposed for Ocean Disposal, February 1991, the material contained in the South Beach Marina Project as described in Public Notice #: NPPOP-YQA-F91-002 has been determined to be suitable for unconfined inwater disposal.

Introduction

2. This evaluation covers the approximately 30,000 cubic yards of material to be excavated from the South Beach Marina Federal project channel. The U.S. Army Corps of Engineers is responsible for maintaining federally authorized navigation channels in Yaquina Bay, Yaquina River, Depot Slough as well as the South Beach Marina. The authorized South Beach Marina Federal project channel is 10 feet deep, 100 feet wide and 2,035 feet long. The project is shown on Figure 1. The channel has not been dredged since its construction in 1978, and will be dredged to a depth of -11 feet MLLW to ensure that the authorized depth is maintained for as long as possible between dredging events.

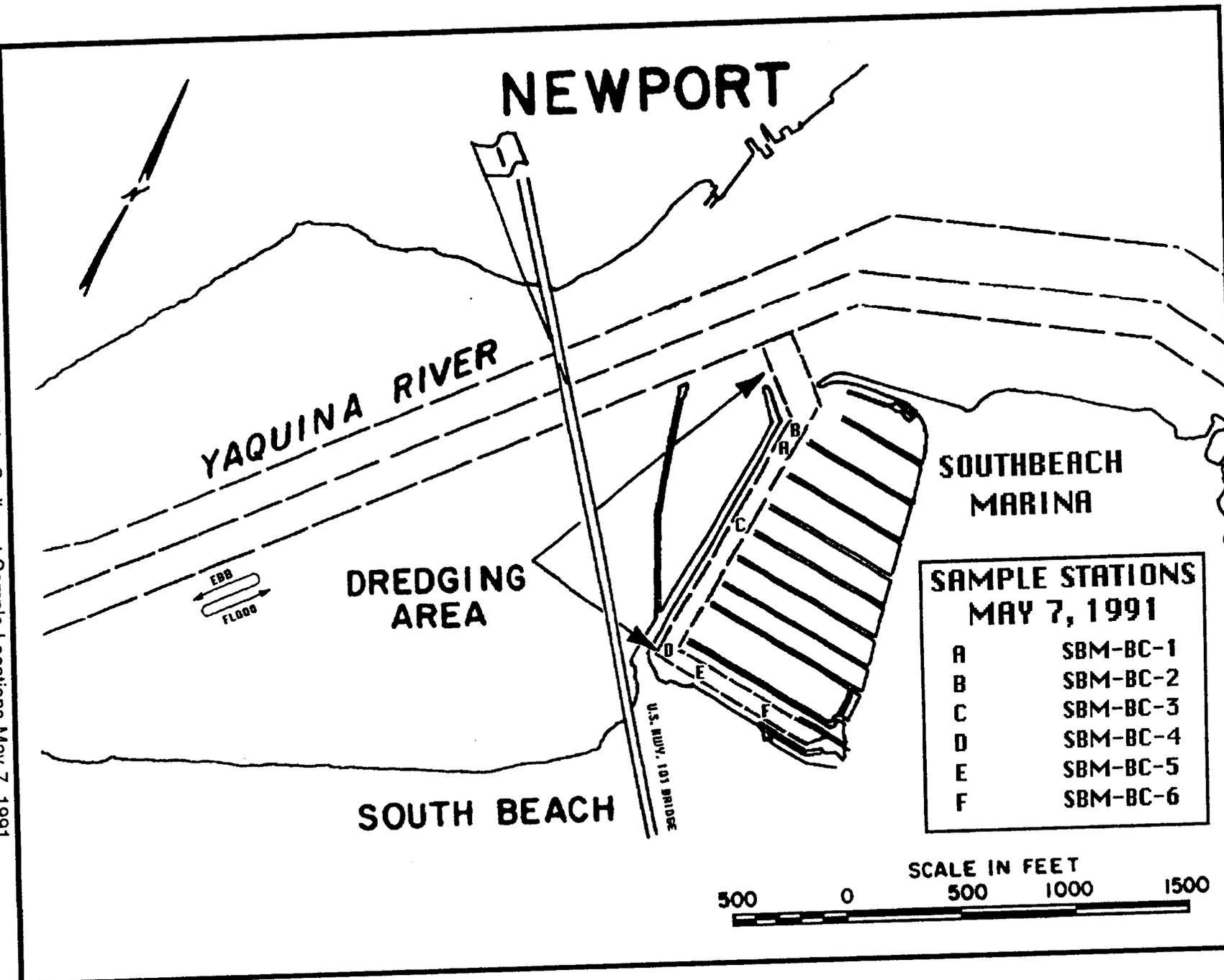
3. Yaquina Bay is the fifth largest estuary in Oregon lying 115 miles south of the mouth of the Columbia River. It is fed by the Yaquina River and its tributaries which drain an area of 253 square miles.

4. Previous sediment evaluation studies of the main Yaquina Bay channel were conducted in June 1980, July 1986 and July 1990 as part of the regularly scheduled sediment evaluation program. In addition as part of an EPA, Region 10 funded sediment characterization study in July 1990, samples were collected and analyzed from non-federal project areas but also included the subject study area. One of these samples contained levels of TBT, phenol and 4-methylphenol above established levels of concern. The present study was designed to further evaluated the material from this area through additional physical, chemical and biological analysis.

Methods

5. On May 7, 1991 six sediment samples were taken with a stainless steel, modified 0.096 m² Gray-O'Hare box core at various locations along the length of the proposed project channel. Sediment samples for physical analysis (dredge analysis) were placed in ziplock plastic bags. Sediment samples for chemical analysis were collected by coring the material collected in the box corer with 2-1/4 inch by 24 inch long acid-rinsed cellulose butyrate acetate core tubes. Chemical samples were placed on ice and delivered to NPD Materials Laboratory for further processing and shipping to the analytical laboratories. Chemical analyses were conducted by Columbia Analytical Services, Kelso, Washington while the physical properties were measured by the NPD Laboratory.

Figure 1 : Yaquina Bay South Beach Marina Sediment Sample Locations May 7, 1991.



6. All six sediment samples were analyzed physically. Three sediment samples (SBM-BC-1, 2 and 3) were analyzed chemically for TBT and phenols. As a blind duplicate sample SBM-BC-1 was split into two separate subsamples and labeled SBM-BC-1 and SBM-BC-10 for an actual total of 4 chemical analyses. Sediment samples SBM-BC-1 and 2 were from the shoal where the high values for TBT, phenol and 4-methylphenol were collected in the joint USACE/EPA 1991 sediment characterization study. This entrance shoal area was the prime focus of this evaluation as the material in the remainder of the project is considered suitable for unconfined inwater disposal without further evaluations required.

7. Sediment samples for the biological testing were collected at the same time by Northwestern Aquatic Sciences from the same box core sample as the samples for the physical and chemical analyses. Under contract, these samples were collected by Dr. Richard S. Caldwell, placed on ice and delivered to the biological laboratory located in Newport, Oregon. Biological testing included 10 day and 20 day Neanthes sp. bioassays, two 48 hour oyster larva (Crassostrea gigas) bioassays and a 10 day amphipod (Rhepoxynius sp.) bioassay for a total of five separate tests.

8. The bioassays were conducted on three sediment samples (SBM-BC-1, 2 and 3), a reference (SBM-BC-7) and a control. The reference was collected from a quiet water area near River Mile 2.1, an area which had been sampled and analyzed previously under the joint USACE/EPA 1991 sediment characterization study (sample YQ-EPA-9). The control sediment was collected at the time and location where the amphipods for the amphipod bioassays were collected. This location is along the sandy beach on the main bay just upstream of the South Beach Marina entrance.

9. Results of the current study and previous collected data were examined in order to make recommendations regarding disposal options for the material. This evaluation is intended to meet the requirements of the Clean Water Act of 1977 and the Marine Protection, Research, and Sanctuaries act of 1972 (Ocean Dumping Act). Section 404 (b) the Clean Water Act requires that an evaluation be prepared to address the proposed discharge of dredged material (return water from upland site) into water of the United States. State Water Quality certification must also be obtained as required under Section 401 of the Act. The Ocean Dumping Act requires that prior to dredging and transportation of dredged material on the ocean the material must be evaluated to determine that the proposed operation will not unreasonably degrade or endanger human health, welfare, or amenities of the marine environment, ecological systems, or economic potentialities.

Results/Discussion

10. The physical and chemical raw data are presented in attachment 1. The physical analyses show the material to be composed of silty sand and sandy silt as summarized in Table 1. Median grain size ranged from 0.09 mm to 0.15 mm with a mean of 0.12 mm. Percent fines, the percent of material by weight passing the #230 sieve, ranged from 15.9% to 65.4% with a mean of 33.9%. Volatile solids ranged from 2.2% to 9.4% with a mean of 5.52%. The mean values in the earlier study samples (USACE/EPA 1991) from the South Beach Marina were median grain size 0.12 mm, percent sand 64.5%, percent fines 35.5% and percent volatile solids 8.1% for comparison.

Table 1.

Grain size, sediment distribution and volatile solids in South Beach Marina sediments.

sample number	median grain size	size distribution			volatile solids
		sand	fines	clay	
	mm	%	%	%	%
SBM-BC-1(10)	0.11	83.3	16.7	5.6	5.7
SBM-BC-2	0.09	34.6	65.4	2.4	9.4
SBM-BC-3	0.10	60.8	39.2	7.1	8.4
SBM-BC-4	0.15	84.1	15.9	5.2	2.2
SBM-BC-5	0.10	55.3	44.7	10.2	4.7
SBM-BC-6	0.14	78.5	21.5	6.5	2.7
SBM-BC-7(ref)	0.10	41.3	58.7	10.4	11.8
mean	0.12	66.1	33.9	6.17	5.52

11. The chemical data is presented in attachment 2 and is summarized in Table 2. Analyses were restricted to those chemicals of concern which exceeded the established levels of concern (TBT, phenol and 4-methylphenol) in the earlier study (USACE/EPA 1991) and total organic carbon (TOC). In addition the analyses were restricted to the area of interest near the entrance to the marina and those sediments for which the bioassays were conducted. A total of 4 separate sets of analyses were run. Sample SBM-BC-1 was split in the NPD Materials Laboratory and SBM-BC-10 was run as a blind duplicate. All analyses indicate that chemical contamination is below the established levels of concern for all analytes tested. In the USACE/EPA 1991 study TBT was measured at 278.0 ppb and 8.4 ppb, phenol was measured at 480 ppb and 120 ppb and 4-methylphenol was measured at 170 ppb in one sample. Concern generated by these values prompted the further studies presented here.

Table 2.

Concentrations of TOC, TBT and phenols in South Beach Marina sediments.

sample #	SBM-BC-1	SBM-BC-10	SBM-BC-2	SBM-BC-3
	$\mu\text{g/kg}$ (ppb) Dry Weight Basis			
Tetrabutaltin	- 10	- 12	- 15	- 12
Tributyltin Chloride	- 10	12	- 15	- 12
Didutyltin Dichloride	10	25	- 15	- 12

Butylltin Trichloride - 1 0 - 1 2 - 1 5 - 1 2
 Table 2. (continued)

sample #	SBM-BC-1	SBM-BC-10	SBM-BC-2	SBM-BC-3
	µg/kg (ppb) Dry Weight Basis			
PHENOLS				
phenol	50	50	- 40	- 40
4-methylphenol	70	- 40	60	- 40
total phenols	120	50	60	ND
TOC (%)	2.24*	2.14	4.30	2.56

- Negative values are detection levels.

* Reported value for TOC is average of sample result and duplicate sample result
 ((2.27+2.21)+2=2.24).

ND: None Detected.

12. All internal quality control (QC), including method blanks, relative percent difference of laboratory duplicates and surrogate and matrix spike recoveries, were within QC limits and acceptable for the chemical analyses performed. Quality assurance (QA) comparison of all values for SBM-BC-1 and SBM-BC-10 analyses are within acceptable limits of variability. All data are considered acceptable.

13. The results of the bioassays are presented in attachment 3. The solid phase tests revealed no significant differences between control, reference and South Beach Marina sediments in the test endpoints. There was no significant difference in the percent survival of the amphipod Rhepoxynius abronius (10 day) and the polychaete worm Neanthes sp. (10 day) tests. The suspended particulate phase bioassay was performed using a 48-hr oyster larva (Crassostrea gigas) test as described in ASTM Standard E 724-89 Standard Guide for Conducting Static Acute Toxicity Tests Starting with Four Species of Saltwater Bivalve Molluscs. The 100% suspended particulate phase for South Beach Marina sample SBM-BC-2 caused a significant increase in the percent abnormal and dead response compared with the control. Percent mortality, however was not significantly affected. These three sets of tests were conducted as per the requirements of the protocols described in the Evaluation of Dredged Material Proposed for Ocean Disposal, February 1991, the new "Green Book". Based on these biological tests and the results of the physical and chemical tests the material to be dredged as part of the South Beach Marina project are suitable for unconfined inwater disposal.

14. Two additional sets of tests were conducted using the oyster larva (Crassostrea gigas) and the polychaete worm Neanthes sp. for the comparison of testing protocol between those prescribed in the "Green Book" and those described in EPA, 1990 and Johns, et al., 1990.

Johns, et al., 1990, Protocol for Juvenile Neanthes Sediment Bioassays, is a 20 day Neanthes bioassay which measures survival as well as growth. EPA,1990, Recommended Protocols for Conducting Laboratory Bioassays on Puget Sound Sediments, Final Report TC-3991-04, is a 48-hr oyster larval test in which larva are exposed to 20 grams of sediment in 1 L of water. Results for the 20 day polychaete bioassays show no significant mortality of polychaetes in any of the control, test or reference sediments. The total Neanthes biomass and mean biomass per Neanthes worm was not significantly different between the sediments indicating no effects on growth of the worms. For solid phase tests on oyster larvae (Crassostrea) mean abnormal larvae did not exceed 4.4% in any of the six test treatments. Percent mortality and the combined measure, percent abnormal and dead, were significantly elevated in two of the South Beach Marina sediments (SBM-BC-1 and SBM-BC-2) and in the Yaquina Bay Control sediment relative to the reference station (SBM-BC-7R). Neither of the two elevated South Beach Marina sediment responses was significantly higher than the response to the Yaquina Bay Control sediment. More comparative tests are scheduled using a variety of sediments from various locations in Oregon, Washington and Alaska. This further testing may provided further information regarding the acceptability of this 48-hr oyster larval test protocol.

15. This sediment evaluation report was prepared by Mark D. Siipola, CENPP-PE-HR, Ph# (503) 632-6463.

ATTACHMENT 1



DEPARTMENT OF THE ARMY
NORTH PACIFIC DIVISION MATERIALS LABORATORY
CORPS OF ENGINEERS
1491 N.W. GRAHAM AVENUE
TROUTDALE, OREGON 97060-9503

CENPD-EN-G-L (1110-1-8100c)

1 Jul 91

MEMORANDUM FOR Commander, Portland District, ATTN: CENPP-PE-HR (Britton)

SUBJECT: W.O.91-S-370, Report of Soil Test Results

Project: YAQUINA SOUTH BEACH MARINA
Intended Use: ---
Source of Material: Yaquina Bay
Submitted by: CENPP-PE-HR (Jim Britton)
Date Sampled: 7 May Date Received: 8 May 91
Method of Test or Specification: ASTM, EM1110-2-1906
Reference: a) DD Form 448, MIPR No. E86-91-0056, Amendment 3, dated 17 May 91
b) Sample Transmittal dated 7 May 91 covering submittal of seven sediment samples and required tests.

1. Enclosed are seven Gradation Analysis summary sheets and one dredge test analysis summary sheet covering resuspended density, void ratio, volatile solids, specific gravity and roundness grading for samples tested.
2. This completes all physical analyses requested.

Enclosures

Timothy J. Seeman
TIMOTHY J. SEEMAN
Director

Copy Furnished: CENPD-PE-GT

CENPD-PE-GT-L (91-SHM-370)

YAQUINA SOUTH BEACH MARINA
Results of Dredge Test Analysis

<u>CENPP Sample No.</u>	<u>Resuspended Density,gms/L</u>	<u>Void Ratio</u>	<u>Volatile Solids,%</u>	<u>Specific Gravity</u>	<u>Particle Roundness Grading</u>
SBM-BC-1	1476	2.336	5.7	2.59	angular-sub angular
SBM-BC-2	1348	3.297	9.4	2.50	sub angular-sub rounded
SBM-BC-3	1361	3.289	8.4	2.55	sub angular-sub rounded
SBM-BC-4	1628	1.684	2.2	2.69	sub rounded-rounded
SBM-BC-5	1403	3.037	4.7	2.63	sub angular-sub rounded
SBM-BC-6	1587	1.892	2.7	2.70	sub angular-sub rounded
SBM-BC-7	*	*	11.8	*	*

* NOTE: No test requested

Received : 8 May 1991

* * * Corps of Engineers - North Pacific Division Materials Laboratory * * *
 YAQUINA SOUTH BEACH (91-SHM-370)

Boring: -- Sample: SBM BC-1 Depth: -- Lab No.: 39701

Sieve Analysis			Hydrometer Analysis				
Sieve	Cumulative Grams Retained	Percent Passing	Sample Weight (g)	Temp (C)	Hydrometer Reading	Diameter in mm	Start Time
5 In.	0.00	100.0	44.3	20.0	6.3	0.0524	0000
2.5 In.	0.00	100.0		20.0	4.8	0.0305	
1.25 In.	0.00	100.0		20.0	4.3	0.0167	
5/8 In.	0.00	100.0		20.0	2.7	0.0069	
5/16 In.	0.00	100.0		20.0	2.0	0.0049	
No. 5	0.00	100.0					
No. 10	0.00	100.0					
Pan	44.30	0.0					
No. 18	0.00	100.0					
No. 35	0.50	98.9					
No. 60	1.80	95.9					
No. 120	14.80	66.6					
No. 230	36.90	16.7					
Pan	44.30	0.0					

*2.5% fines
F = 0.11*

D85: 0.18 D60: 0.12 D50: 0.10 D30: .078 D15: .051 D10: .014 mm
 Cu: 8.59 Cc: 3.93

Liquid Limit: NP Plasticity Index: NP
 Fines Type Used for Classification: ML, SILT

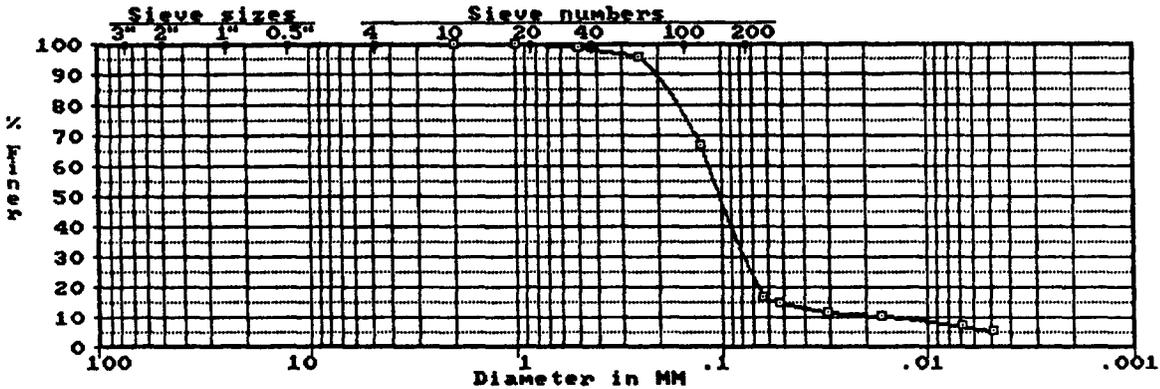
Gravel: 0.0% Sand: 72.9% Fines: 27.1%

ASTM D 2487 Classification

SM Silty SAND

Comments

- VOLATILE SOLIDS - 5.7%



YAQUINA SOUTH BEACH (91-SHM-370)

Boring: -- Sample: SBM BC-2 Depth: -- Lab No.: 39702

Sieve Analysis			Hydrometer Analysis				
Sieve	Cumulative Grams Retained	Percent Passing	Sample Weight: 181.1 gr.	Temp (C)	Hydrometer Reading	Diameter in mm	Percent Finer
5 In.	0.00	100.0	1	20.0	9.5	0.0514	5.5
2.5 In.	0.00	100.0	3	20.0	7.0	0.0301	4.1
1.25 In.	0.00	100.0	10	20.0	6.0	0.0166	3.6
5/8 In.	0.00	100.0	100	20.0	4.0	0.0068	2.5
5/16 In.	0.00	100.0	200	20.0	3.8	0.0048	2.4
No. 5	0.00	100.0					
No. 10	0.00	100.0					
Pan	181.10	0.0					
No. 18	0.20	99.9					
No. 35	2.90	98.4					
No. 60	6.30	96.5					
No. 120	37.20	79.5					
No. 230	62.60	65.4					
Pan	181.10	0.0					

X = 0.09

D85: 0.15 D60: .062 D50: .060 D30: .056 D15: .053 D10: .052 mm
Cu: 1.18 Cc: 0.97

Liquid Limit: NP Plasticity Index: NP
Fines Type Used for Classification: ML, SILT

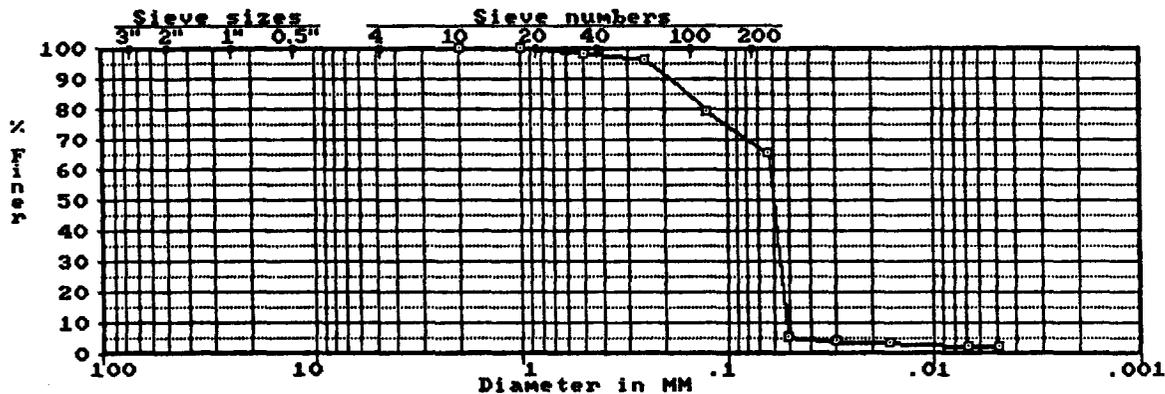
Gravel: 0.0% Sand: 31.0% Fines: 69.0%

ASTM D 2487 Classification

ML Sandy SILT

Comments

VOLATILE SOLIDS = 9.4%



* * * Corps of Engineers - North Pacific Division Laboratory * * *
 YAQUINA SOUTH BEACH (91-SHM-370)

Boring: -- Sample: SBM-BG-3 Depth: -- Lab No.: 39703

----- Sieve Analysis -----			----- Hydrometer Analysis -----				
Sieve	Cumulative Grams Retained	Percent Passing	Sample Time	Weight: 90.3 gr. Temp (C)	Hydrometer Reading	Start Time: 0000 Diameter in mm	Percent Finer
5 In.	0.00	100.0	1	20.0	31.3	0.0448	34.9
2.5 In.	0.00	100.0	3	20.0	21.3	0.0277	23.9
1.25 In.	0.00	100.0	10	20.0	14.3	0.0158	16.2
5/8 In.	0.00	100.0	100	20.0	7.6	0.0067	8.9
5/16 In.	0.00	100.0	200	20.0	6.0	0.0048	7.1
No. 5	0.00	100.0					
No. 10	0.00	100.0					
Pan	90.30	0.0					
No. 18	0.10	99.9					
No. 35	0.70	99.2					
No. 60	8.60	90.5					
No. 120	32.70	63.8					
No. 230	54.90	39.2					
Pan	90.30	0.0					

$\bar{x} = 0.10$

 D85: 0.21 D60: 0.11 D50: .089 D30: .036 D15: .014 D10: .0080 mm
 Cu: 14.3 Cc: 1.42

Liquid Limit: NP Plasticity Index: NP
 Fines Type Used for Classification: ML, SILT

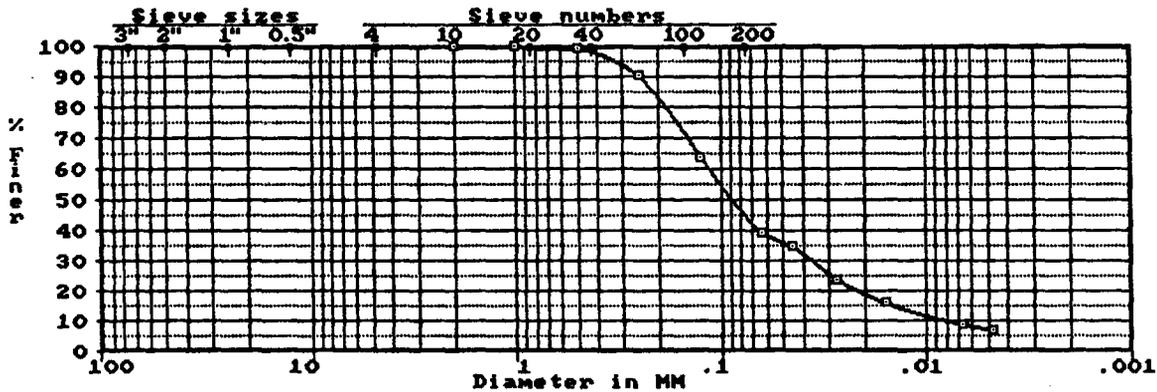
Gravel: 0.0% Sand: 55.6% Fines: 44.4%

----- ASTM D 2487 Classification -----

SM Silty SAND

----- Comments -----

- VOLATILE SOLIDS - 8.4%



* * * Corps of Engineers - North Pacific Division Laboratory * * *
 YAQUINA SOUTH BEACH (91-SHM-370)

Boring: -- Sample: SBM-BC-5 Depth: -- Lab No.: 39705

Sieve Analysis			Hydrometer Analysis				
Sieve	Cumulative Grams Retained	Percent Passing	Sample Weight	Temp (C)	Hydrometer Reading	Diameter in mm	Percent Finer
			75.6 gr.				Start Time: 0000
5 In.	0.00	100.0	1	20.0	30.0	0.0452	39.9
2.5 In.	0.00	100.0	3	20.0	23.5	0.0273	31.4
1.25 In.	0.00	100.0	10	20.0	16.5	0.0156	22.3
5/8 In.	0.00	100.0	100	20.0	9.0	0.0067	12.4
5/16 In.	0.00	100.0	200	20.0	7.3	0.0048	10.2
No. 5	0.00	100.0					
No. 10	0.00	100.0					
Pan	75.60	0.0					
No. 18	0.10	99.9					
No. 35	0.20	99.7					
No. 60	2.40	96.8					
No. 120	32.50	57.0					
No. 230	41.80	44.7					
Pan	75.60	0.0					

X = 0.10

D85: 0.20 D60: 0.13 D50: .094 D30: .025 D15: .0088 mm

Liquid Limit: NP Plasticity Index: NP
 Fines Type Used for Classification: ML, SILT

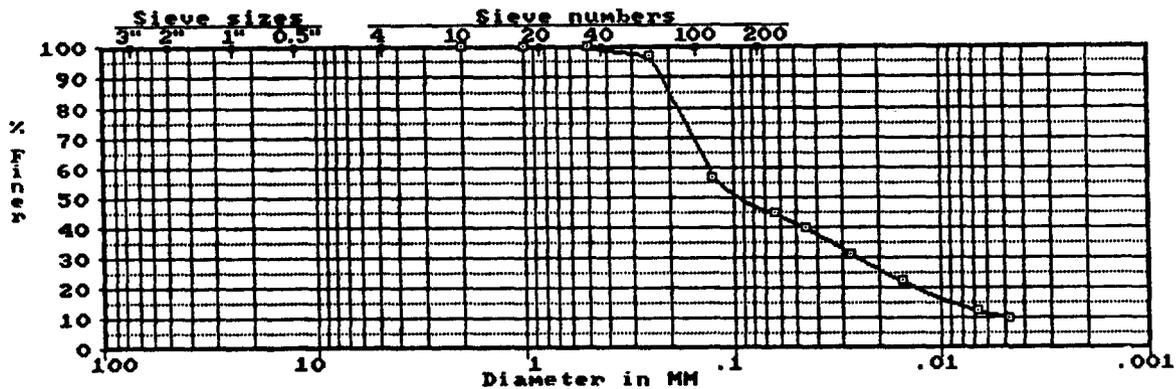
Gravel: 0.0% Sand: 53.6% Fines: 46.4%

----- ASTM D 2487 Classification -----

SM Silty SAND

----- Comments -----

- VOLATILE SOLIDS = 4.7%



*** Corps of Engineers - North Pacific Division Laboratory ***

YAQUINA SOUTH BEACH (91-SHM-370)

Boring: -- Sample: SBM-BC-6 Depth: -- Lab No.: 39706

Sieve Analysis			Hydrometer Analysis				
Sieve	Cumulative Grams Retained	Percent Passing	Sample Weight	Temp (C)	Hydrometer Reading	Diameter in mm	Percent Finer
5 In.	0.00	100.0	106.7 gr.	20.0	21.8	0.0478	20.7
2.5 In.	0.00	100.0		20.0	17.8	0.0283	17.0
1.25 In.	0.00	100.0		20.0	13.8	0.0159	13.3
5/8 In.	0.00	100.0		20.0	8.6	0.0067	8.4
5/16 In.	0.00	100.0		20.0	6.5	0.0048	6.5
No. 5	0.00	100.0	Time				
No. 10	0.00	100.0					
Pan	106.70	0.0					
No. 18	0.00	100.0					
No. 35	0.30	99.7					
No. 60	5.90	94.5					
No. 120	75.60	29.1					
No. 230	83.80	21.5					
Pan	106.70	0.0					

$\bar{x} = 0.14$

D85: 0.23 D60: 0.17 D50: 0.16 D30: 0.13 D15: .021 D10: .0089 mm
Cu: 19.4 Cc: 10.3

Liquid Limit: NP Plasticity Index: NP
Fines Type Used for Classification: ML, SILT

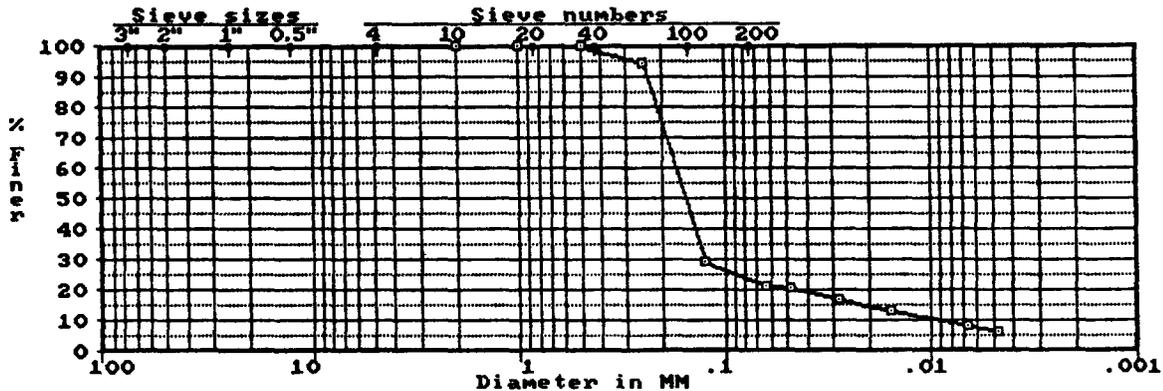
Gravel: 0.0% Sand: 76.6% Fines: 23.4%

ASTM D 2487 Classification

SM Silty SAND

Comments

VOLATILE SOLIDS = 2.7%



* * * Corps of Engineers - North Pacific Division Laboratory * * *
 YAQUINA SOUTH BEACH (91-SHM-370)

Boring: -- Sample: SBM-BC-7 Depth: -- Lab No.: 39707

----- Sieve Analysis -----			----- Hydrometer Analysis -----				
Cumulative			Sample Weight: 74.6 gr.	Start Time: 0000			
Sieve	Grams Retained	Percent Passing	Time	Temp (C)	Hydrometer Reading	Diameter in mm	Percent Finer
5 In.	0.00	100.0	1	20.0	38.6	0.0423	51.9
2.5 In.	0.00	100.0	3	20.0	29.1	0.0263	39.3
1.25 In.	0.00	100.0	10	20.0	20.6	0.0152	28.0
5/8 In.	0.00	100.0	100	20.0	8.2	0.0067	11.5
5/16 In.	0.00	100.0	200	20.0	7.3	0.0048	10.4
No. 5	0.00	100.0					
No. 10	0.00	100.0					
Pan	74.60	0.0					
No. 18	0.00	100.0					
No. 35	0.30	99.6					
No. 60	2.20	97.1					
No. 120	5.70	92.4					
No. 230	30.80	58.7					
Pan	74.60	0.0					

F = 0.10

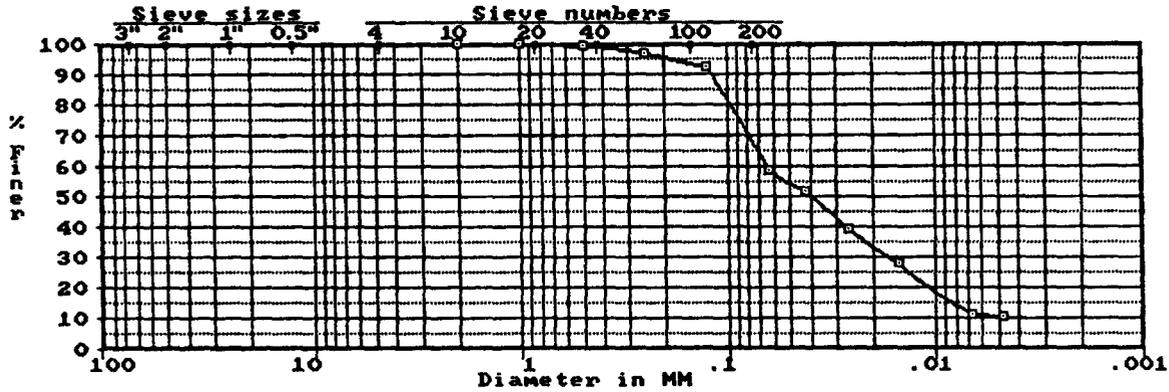
 D85: 0.11 D60: .065 D50: .039 D30: .017 D15: .0084 mm

Liquid Limit: NP Plasticity Index: NP
 Fines Type Used for Classification: ML, SILT

Gravel: 0.0% Sand: 32.7% Fines: 67.3%

----- ASTM D 2487 Classification -----

ML Sandy SILT



ATTACHMENT 2



DEPARTMENT OF THE ARMY
NORTH PACIFIC DIVISION MATERIALS LABORATORY
CORPS OF ENGINEERS
1491 N.W. GRAHAM AVENUE
TROUTDALE, OREGON 97060-9503

CENPD-PE-GT-L (1110-1-8100c)

18 Jun 91

MEMORANDUM FOR Commander, Portland District, ATTN: CENPP-PE-HR

SUBJECT: W.O.91-SM-387, Report of Soil Test Results

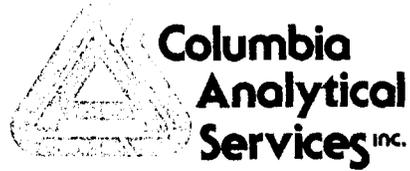
Project: SOUTH BEACH MARINA
Intended Use: Evaluate site
Source of Material: Reference Chain of Custody form
Submitted by: CENPP-PE-HR (Jim Britton)
Date Sampled: 7 May 91 Date Received: 9 May 91
Method of Test or Specification: Reference Enclosure 1
Reference: DD Form 448, MIPR No. E86-91-0056, Change 3, dated 17 May 91

1. Enclosed are results of analyses and quality assurance data for environmental samples collected from the above site. Included is report No. K912533 from Columbia Analytical Services, Inc.
2. All internal quality control (QC), including method blanks, relative percent difference of laboratory duplicates and surrogate and matrix spike recoveries, were within QC limits and acceptable. All data are acceptable.
3. This completes all work requested.

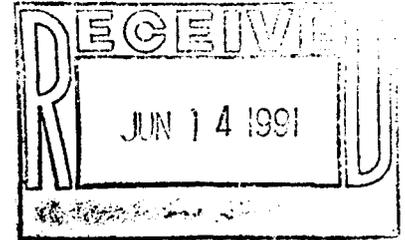
Enclosures

Timothy J. Seeman
TIMOTHY J. SEEMAN
Director

Copy Furnished: CENPD-PE-GT
CEMRD-EP-EC
CEMP-RT



June 12, 1991



Tim Seeman
U.S. Army Corps of Engineers
CENPD Materials Laboratory
1491 NW Graham Avenue
Troutdale, OR 97060-9503

Re: **South Beach Marina/Project #91-Sm-387**

Dear Tim:

Enclosed are the results of the samples submitted to our lab on May 9, 1991. For your reference, our service request number for this work is K912533.

CAS employed an NOAA procedure utilizing GC/MS Sims Techniques to analyze for organotins. We were not able to obtain a 10 $\mu\text{g}/\text{Kg}$ dry weight basis detection limit due to the relatively high moisture content of the samples. CAS is in the process of further refining the technique to obtain lower detection limits. The high moisture content also resulted in elevated detection limits for the phenolic compounds.

All analyses were performed in accordance with the laboratory's quality assurance program.

Please call if you have any questions.

Respectfully submitted,

Columbia Analytical Services, Inc.

David L. Edelman
David L. Edelman
Vice-President

DLE/so

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client: U.S. Army Corps of Engineers
Project: South Beach Marina/#91-Sm-387
Sample Matrix: Sediment

Date Received: 05/09/91
Date Analyzed: 05/13/91
Work Order #: K912533

Solids, Total
EPA Method 160.3
%
As Received Basis

Sample Name	Lab Code	Result
SBM-BC-1	K2533-1	64.9
SBM-BC-2	K2533-2	45.3
SBM-BC-3	K2533-3	55.3
SBM-BC-10	K2533-4	53.4

Approved by Dave Edelmann Date 6/13/91

00001

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client: U.S. Army Corps of Engineers
Project: South Beach Marina/#91-Sm-387
Sample Matrix: Sediment

Date Received: 05/09/91
Date Analyzed: 05/21/91
Work Order #: K912533

Total Organic Carbon (TOC)
EPA Method Modified 415.1
%
Dry Weight Basis

Sample Name	Lab Code	MRL	Result
SBM-BC-1	K2533-1	0.05	2.27
SBM-BC-2	K2533-2	0.05	4.30
SBM-BC-3	K2533-3	0.05	2.56
SBM-BC-10	K2533-4	0.05	2.14
Method Blank	K2533-MB	0.05	ND

MRL Method Reporting Limit
ND None Detected at or above the method reporting limit

Approved by Dave Edelman Date 6/13/91

00002

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client: U.S. Army Corps of Engineers
Project: South Beach Marina/#91-Sm-387
Sample Matrix: Sediment

Date Received: 05/09/91
Date Extracted: 06/03/91
Date Analyzed: 06/07/91
Work Order #: K912533

Organotins
NOAA*
 $\mu\text{g/Kg}$ (ppb)
Dry Weight Basis

Sample Name:
Lab Code:

SBM-BC-1
K2533-1

Method Blank
K2533-MB

Analyte	MRL		
Tetrabutyltin	10	ND	ND
Tributyltin Chloride	10	ND	ND
Dibutyltin Dichloride	10	10	ND
Butyltin Trichloride	10	ND	ND

* By GC/MS Sims Procedure, Nov. 1988, by Krone, et al.
MRL Method Reporting Limit
ND None Detected at or above the method reporting limit

Approved by Dave Edeh... Date 6/13/91

00003

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client: U.S. Army Corps of Engineers
Project: South Beach Marina/#91-Sm-387
Sample Matrix: Sediment

Date Received: 05/09/91
Date Extracted: 06/03/91
Date Analyzed: 06/07/91
Work Order #: K912533

Organotins
NOAA*
 $\mu\text{g/Kg}$ (ppb)
Dry Weight Basis

Sample Name:
Lab Code:

SBM-BC-2
K2533-2

Analyte	MRL**	
Tetrabutyltin	15	ND
Tributyltin Chloride	15	ND
Dibutyltin Dichloride	15	ND
Butyltin Trichloride	15	ND

* By GC/MS Sims Procedure, Nov. 1988, by Krone, et al.

MRL Method Reporting Limit

** Elevated MRLs because of the low percent solids in the sample as received.

ND None Detected at or above the method reporting limit

Approved by Dave Eshelman Date 6/13/91

00004

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client: U.S. Army Corps of Engineers
Project: South Beach Marina/#91-Sm-387
Sample Matrix: Sediment

Date Received: 05/09/91
Date Extracted: 06/03/91
Date Analyzed: 06/07/91
Work Order #: K912533

Organotins
NOAA*
 $\mu\text{g/Kg}$ (ppb)
Dry Weight Basis

Sample Name:
Lab Code:

SBM-BC-3
K2533-3

SBM-BC-10
K2533-4

Analyte	MRL**		
Tetrabutyltin	12	ND	ND
Tributyltin Chloride	12	ND	12
Dibutyltin Dichloride	12	ND	25
Butyltin Trichloride	12	ND	ND

* By GC/MS Sims Procedure, Nov. 1988, by Krone, et al.

MRL Method Reporting Limit

** Elevated MRLs because of the low percent solids in the sample as received.

ND None Detected at or above the method reporting limit

Approved by Dave Edelman Date 6/13/91

00005

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client: U.S. Army Corps of Engineers
 Project: South Beach Marina/#91-Sm-387
 Sample Matrix: Sediment

Date Received: 05/09/91
 Date Extracted: 05/18/91
 Date Analyzed: 06/04/91
 Work Order #: K912533

Phenols
 EPA Methods 3540/Modified 8270
 µg/Kg (ppb)
 Dry Weight Basis

	Sample Name: Lab Code:	SBM-BC-1 K2533-1	SBM-BC-2 K2533-2	SBM-BC-3 K2533-3
Analyte	MRL*			
Phenol	40	50	ND	ND
2-Methylphenol	40	ND	ND	ND
4-Methylphenol	40	70	60	ND
2,4-Dimethylphenol	40	ND	ND	ND
Pentachlorophenol	100	ND	ND	ND

MRL Method Reporting Limit
 * Elevated MRLs because of the low percent solids in the sample as received.
 ND None Detected at or above the method reporting limit

Approved by Dave Schell Date 6/13/91

00006

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client: U.S. Army Corps of Engineers
Project: South Beach Marina/#91-Sm-387
Sample Matrix: Sediment

Date Received: 05/09/91
Date Extracted: 05/18/91
Date Analyzed: 06/04/91
Work Order #: K912533

Phenols
EPA Methods 3540/Modified 8270
 $\mu\text{g}/\text{Kg}$ (ppb)
Dry Weight Basis

Sample Name:
Lab Code:

SBM-BC-10
K2533-4

Analyte	MRL*	
Phenol	40	50
2-Methylphenol	40	ND
4-Methylphenol	40	ND
2,4-Dimethylphenol	40	ND
Pentachlorophenol	100	ND

MRL Method Reporting Limit

* Elevated MRLs because of the low percent solids in the sample as received.

ND None Detected at or above the method reporting limit

Approved by Dave Eshelby Date 6/13/91

00007

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client: U.S. Army Corps of Engineers
Project: South Beach Marina/#91-Sm-387
Sample Matrix: Sediment

Date Received: 05/09/91
Date Extracted: 05/18/91
Date Analyzed: 06/04/91
Work Order #: K912533

Phenols
EPA Methods 3540/Modified 8270
 $\mu\text{g/Kg}$ (ppb)
Dry Weight Basis

Sample Name:
Lab Code:

Method Blank
K2533-MB

Analyte	MRL	
Phenol	20	ND
2-Methylphenol	20	ND
4-Methylphenol	20	ND
2,4-Dimethylphenol	20	ND
Pentachlorophenol	50	ND

MRL Method Reporting Limit

ND None Detected at or above the method reporting limit

Approved by Dave Schick Date 6/13/91

00008

APPENDIX A
LABORATORY QC RESULTS

00009

COLUMBIA ANALYTICAL SERVICES, INC.

Client: U.S. Army Corps of Engineers
Project: South Beach Marina/#91-Sm-387
Sample Matrix: Sediment

Date Received: 05/09/91
Date Analyzed: 05/21/91
Work Order #: K912533

QA/QC Report
Duplicate Summary
Total Organic Carbon (TOC)
EPA Method Modified 415.1
%
Dry Weight Basis

Sample Name	Lab Code	MRL	Sample Result	Duplicate Sample Result	Average	Relative Percent Difference
SBM-BC-1	K2533-1	0.05	2.27	2.21	2.24	3

MRL Method Reporting Limit

Approved by Dave Edelman Date 6/13/91

00010

COLUMBIA ANALYTICAL SERVICES, INC.

Client: U.S. Army Corps of Engineers
Project: South Beach Marina/#91-Sm-387
Sample Matrix: Sediment

Date Received: 05/09/91
Date Extracted: 06/03/91
Date Analyzed: 06/07/91
Work Order #: K912533

QA/QC Report
Surrogate Recovery Summary
Organotins
NOAA*

Sample Name	Lab Code	Percent Recovery Tri-n-propyltin Chloride
SBM-BC-1	K2533-1	116
SBM-BC-2	K2533-2	156
SBM-BC-2	K2533-2MS	126
SBM-BC-3	K2533-3	118
SBM-BC-10	K2533-4	146
Method Blank	K2533-MB	43.3

* By GC/MS Sims Procedure, Nov. 1988, by Krone, et al.

Approved by Dave Edelman Date 6/13/91

00011

COLUMBIA ANALYTICAL SERVICES, INC.

Client: U.S. Army Corps of Engineers
Project: South Beach Marina/#91-Sm-387
Sample Matrix: Sediment

Date Received: 05/09/91
Date Extracted: 06/03/91
Date Analyzed: 06/07/91
Work Order #: K912533

QA/QC Report
Matrix Spike Summary
Organotins
NOAA*
 $\mu\text{g/Kg}$ (ppb)
Dry Weight Basis

Sample Name: SBM-BC-2
Lab Code: K2533-2

Analyte	Spike Level	Sample Result	Spiked Sample Result	Percent Recovery
Tetrabutyltin	164	ND	103	62.8
Tributyltin Chloride	149	ND	155	104
Dibutyltin Chloride	149	ND	212	142
Butyltin Chloride	149	ND	137	76.5

* By GC/MS Sims Procedure, Nov. 1988, by Krone, et al.
ND None Detected at or above the method reporting limit

Approved by Dave Edwards Date 6/13/91

00012

COLUMBIA ANALYTICAL SERVICES, INC.

Client: U.S. Army Corps of Engineers
Project: South Beach Marina/#91-Sm-387
Sample Matrix: Sediment

Date Received: 05/09/91
Date Extracted: 05/18/91
Date Analyzed: 06/04/91
Work Order #: K912533

QA/QC Report
Surrogate Recovery Summary
Phenols
EPA Methods 3540/Modified 8270

Sample Name	Lab Code	P e r c e n t R e c o v e r y		
		2-Fluorophenol	Phenol-d ₆	2,4,6-Tribromophenol
SMB-BC-1	K2533-1	64.9	65.6	153
SMB-BC-2	K2533-2	67.6	70.1	108
SMB-BC-3	K2533-3	31.0	54.7	126
SMB-BC-10	K2533-4	22.0	39.7	114
Method Blank	K2533-MB	28.2	32.6	52.7

Approved by Dave Schell Date 6/13/91

00013

APPENDIX B
CHAIN OF CUSTODY INFORMATION

00014

K2533

Columbia Analytical Ser, Inc.
 1317 South 13th Street
 Kelso, WA 98626

CHAIN OF CUSTODY RECORD

PROJECT					NO. CONTAINERS	TOC TBT P/rev/s *	REMARKS OR SAMPLE LOCATION	PRESERVATION			
South Beach Marina								ICED	SPECIFY CHEMICALS ADDED AND FINAL pH IF KNOWN		
SAMPLERS: (Signature)					NO. CONTAINERS	TOC	TBT	P/rev/s *	REMARKS OR SAMPLE LOCATION	ICED	SPECIFY CHEMICALS ADDED AND FINAL pH IF KNOWN
SAMPLE NUMBER	DATE	TIME	COMP.	GRAB							
SBM-BC-1	5/7/91				2	X	X	X			
SBM-BC-2	5/7/91				2	X	X	X			
SBM-BC-3	5/7/91				2	X	X	X			
SBM-BC-10	5/7/91				2	X	X	X			
Relinquished by: (Signature) ①	Date / Time	Received by: (Signature)	Relinquished by: (Signature) ④	Date / Time	Shipped via:						
Jim Britton	5/8/91 0945	Panda Swan									
Relinquished by: (Signature) ②	Date / Time	Received by: (Signature)	Received for Laboratory by: (Signature)	Date / Time	Shipping Ticket No.						
Panda Swan	5/8/91 1A00			5/9/91 0930	0685152893						
Relinquished by: (Signature) ③	Date / Time	Received by: (Signature)	Remarks *								
			* Please use your "Modified 8270" with low detection limits for ocean sediment samples								

00015

COOLER RECEIPT FORM

Project: South Beach Marina

Cooler received on 5,9,91 and opened on 5,9,91 by Lance Jordins

- 1) Were custody seals on outside of cooler?----- YES NO
 If yes, how many and where? Front + Side
 Were signature and date correct?----- YES NO
- 2) Were custody papers taped to lid inside cooler?----- YES NO
- 3) Were custody papers properly filled out (ink, signed, etc.)?----- YES NO
- 4) Did you sign custody papers in the appropriate place?----- YES NO
- 5) Did you attach shipper's packing slip to this form?----- YES NO
- 6) What kind of packing material was used? Vermiculite
- 7) Was sufficient ice used (if appropriate)?----- YES NO
- 8) Were all bottles sealed in separate plastic bags?----- YES NO
- 9) Did all bottles arrive in good condition (unbroken)?----- YES NO
 Were all bottle labels complete (No., date, signed, anal., pres, etc)? YES NO
- 11) Did all bottle labels and tags agree with custody papers?----- YES NO
- 12) Were correct bottles used for the tests indicated?----- YES NO
- 13) Were VOA vials checked for absence of air bubbles, & noted if so? YES NO
- 14) Was a sufficient amount of sample sent in each bottle?----- YES NO

Explain any discrepancies---> No VOA Vials Sent

ATTACHMENT 3

NORTHWESTERN AQUATIC SCIENCES

A Division of NAS Associates, Inc.

P.O. Box 1437, Newport, Oregon 97365 (503) 265-7225



July 7, 1991

Mr. Mark Siipola
U.S. Army Corps of Engineers
Portland District
P.O. Box 2946
Portland, OR 97208-2946

Dear Mark:

In the interest in providing you immediately with the data you need to proceed with the South Beach dredging project, I am enclosing draft test reports for the five bioassay tests that we recently performed for you. These are presented in our standard report format and you may consider the test results, which are presented in tabular format and briefly summarized, to be definitive. I will be out of the office for the next 10 days, but on return I will assemble these into the comprehensive report required by the contract terms.

Sincerely,

A handwritten signature in black ink, appearing to read "Richard S. Caldwell". The signature is written in a cursive style and is positioned above the typed name.

Richard S. Caldwell, Ph.D.
Director

Encl.

DRAFT TEST REPORT

TEST IDENTIFICATION

Test No.: 409-1

Title: Toxicity of marine sediments using a 10-day amphipod, Rhepoxynius abronius, sediment bioassay.

Protocol No.: NAS-409-RA4, May 10, 1991. Based on Tetra Tech, Inc. and E.V.S. Consultants, Inc. 1986. Recommended protocols for conducting laboratory bioassays on Puget Sound sediments. Final Rept. No. TC-3991-04, Prepared for U.S. EPA, Region 10 - Office of Puget Sound, Seattle, WA, 55 pp.

STUDY MANAGEMENT

Study Sponsor: U.S. Army Corps of Engineers, Portland District, P.O. Box 2946, Portland, OR 97208-2946.

Sponsor's Study Monitor: Mr. Mark Siipola

Testing Laboratory: Northwestern Aquatic Sciences, P.O. Box 1437, Newport, OR 97365

Test Location: Newport laboratory

Laboratory's Study Personnel: R.S. Caldwell, Ph.D., Proj. Man./Study Dir.; D.R. Buhler, Ph.D., QA Officer; L.K. Garrison, B.A., Aq. Biol.; S.A. Manwaring, B.S., Aq. Biol., and G.A. Buhler, B.S., Aq. Toxicol.

Study Schedule:

Test Beginning: 5-15-91, 1:00 p.m.

Test Ending: 5-25-91, 1:00 a.m.

Disposition of Study Records: All specimens, raw data, reports and other study records are stored according to Good Laboratory Practice regulations at: Northwestern Aquatic Sciences, Yaquina Bay Rd., P.O. Box 1437, Newport, OR 97365.

Good Laboratory Practices: The test was conducted following the principles of Good Laboratory Practices (GLP) as defined in the EPA/TSCA Good Laboratory Practice regulations effective December 29, 1983 (40 CFR Part 792).

TEST MATERIAL

Description:

Sample No. 5158D (Station SBM-BC-1. Collected 5-7-91)

Sample No. 5159D (Station SBM-BC-2. Collected 5-7-91)

Sample No. 5160D (Station SBM-BC-3. Collected 5-7-91)

Sample No. 5161D (Station SBM-BC-7R. Collected 5-7-91)

Yaquina Bay (negative) Control Sediment (Collected 5-11-91)

Comments: The negative control sediment was taken from the lower portion of Yaquina Bay, OR at the edge of the shipping channel adjacent to the South Beach Marina. This sediment is the collection site sediment for the amphipod, Rhepoxynius abronius and is a fine to medium size clean sand (mean grain size 0.16 mm).

TEST WATER

Source: Yaquina Bay, OR

Date of Collection: 5-14-91

Pretreatment: Sand and cartridge filtered; diluted to 28 ppt

TEST ORGANISMS

Species: Rhepoxynius abronius, marine amphipod

Age: Adult

Source: Field collected on 5-11-91 from Yaquina Bay, OR
 Acclimation: Temp, $15.8 \pm 0.2^{\circ}\text{C}$; DO, 6.3 ± 0.1 mg/L; pH, 7.9 ± 0.1 ;
 Salinity, 30.2 ± 0.3 ppt.

TEST PROCEDURES AND CONDITIONS

Test Chambers: 1 L borosilicate glass beakers.

Test Volumes: 2.0 cm sediment layer; seawater added to a total volume of 950 ml/beaker.

Replicates/Treatment: 5

Organisms/Treatment: 100

Water Volume Changes per 24 hr: None.

Effects Criteria: 1) survival after 10 days, and 2) daily emergence of amphipods from the test sediments. Death is defined as no visible appendage movement or response to tactile stimulation. Missing amphipods were considered to be dead.

Water Quality and Other Test Conditions: Temperature, $15.2 \pm 0.6^{\circ}\text{C}$; dissolved oxygen, 8.2 ± 0.2 mg/L; pH, 8.2 ± 0.2 ; salinity, 28.7 ± 0.8 ppt. Photoperiod, continuous illumination.

DATA ANALYSIS METHODS

ANOVA and Dunnett's tests were used to compare the numbers of amphipod emergence events and amphipod survival between control and test sediments. No data transformations were employed. The statistical software employed for these calculations was Crunch Statistical Package (Crunch Software Corp.).

PROTOCOL DEVIATIONS

None

TEST RESULTS

A detailed tabulation of sediment emergence and survival of amphipods during the 10-day test is given in Table 1. The means and standard deviations of the responses for each sediment are summarized in Table 2. Daily water quality conditions in one replicate of each treatment are given in Table 3.

There were no significant differences at the end of the 10-day test between any of the control, reference or test sediments for either sediment emergence or survival.

CONCLUSION

The test sediments were not toxic to the marine amphipod, Rhepoxynius abronius.

STUDY APPROVAL

Richard S. Caldwell 7/15/91
 Study Director Date

Table 1. Daily sediment emergence and 10-day survival of *R. abronius* in each replicate container exposed to sediments.

Sample description	Daily & total sediment emergence ¹											Number of surviving amphipods
	1	2	3	4	5	6	7	8	9	10	Total	
<u>Yaquina Bay Control</u>												
1	0	0	0	2	2	2	2	0	0	0	8	17
2	0	0	0	0	0	0	0	0	0	0	0	20
3	0	0	0	0	1	0	0	0	0	0	1	20
4	0	0	0	0	0	0	0	0	0	0	0	20
5	0	0	0	1	0	0	0	0	0	0	1	20
<u>5158D (SBM-BC-1)</u>												
1	0	0	0	2	0	0	0	0	0	0	2	19
2	0	0	0	0	0	0	0	0	0	0	0	20
3	0	0	0	0	0	0	0	0	0	0	0	20
4	0	0	0	0	1	0	0	0	0	0	1	19
5	0	0	0	0	0	0	0	0	0	1	1	20
<u>5159D (SBM-BC-2)</u>												
1	0	0	0	1	0	0	0	0	0	0	1	20
2	0	0	0	0	0	0	0	0	0	0	0	20
3	0	0	0	1	0	0	0	0	0	1	2	19
4	0	0	0	0	1	1	0	0	0	0	2	18
5	0	0	0	1	0	0	0	0	0	0	1	19
<u>5160D (SBM-BC-3)</u>												
1	0	0	0	0	0	0	0	0	0	0	0	20
2	0	0	0	2	1	0	0	0	0	0	3	19
3	0	0	0	0	0	0	1	0	0	0	1	20
4	0	0	0	0	0	0	0	0	0	0	0	19
5	0	0	0	0	0	1	0	0	0	0	1	20
<u>5161D (SBM-BC-7R)</u>												
1	0	0	0	0	0	0	0	0	0	0	0	20
2	0	0	0	0	0	0	0	1	0	1	2	19
3	0	0	0	0	0	0	0	0	0	1	1	20
4	1	0	0	2	1	1	1	0	0	0	6	20
5	0	0	0	0	0	0	0	0	1	0	1	20

¹Daily emergence counts include all amphipods observed on or above the sediment surface whether living or dead.

Table 2. Means and standard deviations (n=5) of sediment emergence and 10-day survival of *R. abronius* exposed to sediments.

Sample description	Sediment emergence events (Number/test container)	10-Day survival (Number/test container)
Yaquina Bay Control	2.0 ± 3.4	19.4 ± 1.3
5158D (SBM-BC-1)	0.8 ± 0.8	19.6 ± 0.5
5159D (SBM-BC-2)	1.2 ± 0.8	19.2 ± 0.8
5160D (SBM-BC-3)	1.0 ± 1.2	19.6 ± 0.5
5161D (SBM-BC-7R)	2.0 ± 2.3	19.8 ± 0.4

* Results significantly different ($P < 0.05$) from the control.

Table 3. Water quality raw data for *Rhepoxynius abronius* 10-day test. Data are measurements on one replicate from each treatment per day.

Day	Temp (°C)	DO (mg/L)	Sal (ppt)	pH	S= (mg/L)	NH ₃ -N (mg/L)
<u>Yaquina Bay Control</u>						
0	15.2	8.2	28.5	8.0	<0.02	0.30
1	15.2	7.9	29.0	8.0	---	---
2	15.8	8.1	28.5	8.1	---	---
3	15.9	8.1	28.5	8.1	---	---
4	14.3	8.2	29.0	8.1	---	0.49
5	14.2	8.5	28.0	8.0	---	---
6	15.6	8.1	28.5	8.1	---	---
7	14.4	8.2	29.0	8.1	---	---
8	16.0	8.4	28.0	8.0	---	---
9	14.4	8.9	28.0	8.1	---	---
10	15.3	8.1	28.0	8.1	<0.02	0.08
<u>5158D (SBM-BC-1)</u>						
0	15.3	8.0	28.5	8.0	<0.02	2.30
1	15.6	8.0	28.5	8.0	---	---
2	15.6	8.0	28.5	8.1	---	---
3	16.0	8.0	28.5	8.1	---	---
4	14.4	8.0	30.0	8.1	---	4.70
5	14.2	8.5	28.5	8.0	---	---
6	15.5	8.0	28.5	8.1	---	---
7	15.1	8.1	29.0	8.1	---	---
8	16.0	8.4	28.5	8.3	---	---
9	14.3	8.8	29.0	8.4	---	---
10	15.1	8.2	29.0	8.5	<0.02	3.50
<u>5159D (SBM-BC-2)</u>						
0	15.1	8.1	28.0	8.0	<0.02	3.40
1	15.8	8.1	28.0	8.0	---	---
2	15.8	8.2	28.0	8.1	---	---
3	15.9	8.1	28.5	8.2	---	---
4	14.1	8.2	29.5	8.3	---	9.40
5	14.2	8.4	28.5	8.3	---	---
6	15.7	8.1	28.0	8.3	---	---
7	15.4	8.2	29.0	8.3	---	---
8	15.9	8.4	28.0	8.3	---	---
9	14.4	8.9	28.5	8.5	---	---
10	15.2	8.5	29.0	8.6	<0.02	11.00

Table 3. Continued.

Day	Temp (°C)	DO (mg/L)	Sal (ppt)	pH	S= (mg/L)	NH ₃ -N (mg/L)
<u>5160D (SBM-BC-3)</u>						
0	15.4	8.0	28.0	7.9	<0.02	0.36
1	15.1	7.8	29.0	7.9	---	---
2	15.9	8.0	28.0	7.9	---	---
3	15.9	7.9	28.0	7.9	---	---
4	14.2	7.9	28.0	8.1	---	1.10
5	14.4	8.4	28.0	8.2	---	---
6	15.7	8.0	28.0	8.3	---	---
7	14.5	8.0	28.0	8.4	---	---
8	15.9	8.4	28.5	8.5	---	---
9	14.7	8.5	28.0	8.6	---	---
10	15.4	8.4	28.0	8.6	<0.02	1.20
<u>5161D (SBM-BC-7R)</u>						
0	15.3	8.3	29.0	8.0	<0.02	1.30
1	15.5	7.9	29.5	8.1	---	---
2	15.5	8.1	31.0	8.0	---	---
3	16.0	8.0	32.0	8.1	---	---
4	14.3	8.4	29.5	8.2	---	3.20
5	14.1	8.6	29.0	8.2	---	---
6	15.5	8.1	29.0	8.3	---	---
7	15.0	8.2	28.0	8.5	---	---
8	15.9	8.4	28.5	8.5	---	---
9	14.3	8.7	30.0	8.6	---	---
10	15.1	8.1	30.0	8.7	<0.02	0.56

DRAFT TEST REPORT

TEST IDENTIFICATION

Test No.: 409-2

Title: Toxicity of marine sediments using a 10-day juvenile Neanthes sediment bioassay.

Protocol No.: NAS-409-NA5, May 10, 1991. Based on Johns, et al. 1990. Protocol for juvenile Neanthes sediment bioassay. Prepared for U.S. Env. Prot. Agency, Region 10 - Office of Puget Sound, Seattle, WA, 17 pp., and USEPA and USCOE. 1990. Draft ecological evaluation of proposed discharge of dredged material into ocean waters. EPA-503-8-90/002.

STUDY MANAGEMENT

Study Sponsor: U.S. Army Corps of Engineers, Portland District, P.O. Box 2946, Portland, OR 97208-2946.

Sponsor's Study Monitor: Mr. Mark Siipola

Testing Laboratory: Northwestern Aquatic Sciences, P.O. Box 1437, Newport, OR 97365

Test Location: Newport laboratory

Laboratory's Study Personnel: R.S. Caldwell, Ph.D., Proj. Man./Study Dir.; D.R. Buhler, Ph.D., QA Officer; L.K. Garrison, B.A., Aq. Biol.; S.A. Manwaring, B.S., Aq. Biol., and G.A. Buhler, B.S., Aq. Toxicol.

Study Schedule:

Test Beginning: 5-16-91, 1:00 p.m.

Test Ending: 5-26-91, 10:00 a.m.

Disposition of Study Records: All specimens, raw data, reports and other study records are stored according to Good Laboratory Practice regulations at: Northwestern Aquatic Sciences, Yaquina Bay Rd., P.O. Box 1437, Newport, OR 97365.

Good Laboratory Practices: The test was conducted following the principles of Good Laboratory Practices (GLP) as defined in the EPA/TSCA Good Laboratory Practice regulations effective December 29, 1983 (40 CFR Part 792).

TEST MATERIAL

Description:

Sample No. 5158D (Station SBM-BC-1. Collected 5-7-91)

Sample No. 5159D (Station SBM-BC-2. Collected 5-7-91)

Sample No. 5160D (Station SBM-BC-3. Collected 5-7-91)

Sample No. 5161D (Station SBM-BC-7R. Collected 5-7-91)

Yaquina Bay (negative) Control Sediment (Collected 5-11-91)

Comments: The negative control sediment was taken from the lower portion of Yaquina Bay, OR at the edge of the shipping channel adjacent to the South Beach Marina. This sediment is the collection site sediment for the amphipod, Rhepoxynius abronius and is a fine to medium size clean sand (mean grain size 0.16 mm).

TEST WATER

Source: Yaquina Bay, OR

Salinity: 31.0 ppt

Date of Collection: 5-15-91

Pretreatment: Sand and cartridge filtered

TEST ORGANISMS

Test No. 409-2

Species: *Neanthes* sp.

Age: 2-3 week post-emergence juveniles

Source: Laboratory cultures at California State University, Long Beach, CA

Acclimation: Temperature, $19.6 \pm 0.1^\circ\text{C}$; Dissolved oxygen, 5.7 ± 0.3 mg/L; pH, 7.3 ± 0.2 ; and salinity, 32.0 ± 4.4 ppt for four days prior to testing.

TEST PROCEDURES AND CONDITIONS

Test Chambers: 1 L borosilicate glass beakers.

Test Volumes: 2.0 cm sediment layer; sea water added to a total volume of 1000 ml.

Replicates/Treatment: 5

Organisms/Treatment: 50

Water Volume Changes: One third of the seawater in each beaker was replaced on days 4 and 7.

Effects Criteria: The effect criterion was survival after 10 days.

Water Quality and Other Test Conditions: Temperature, $20.0 \pm 0.1^\circ\text{C}$; salinity, 31.6 ± 0.8 ppt; dissolved oxygen, 7.1 ± 0.1 mg/L; pH, 8.2 ± 0.2 ; and Photoperiod, continuous illumination.

DATA ANALYSIS METHODS

ANOVA and Dunnett's tests were used to compare survival between control, test, and reference sediment samples. An arcsine transformation was performed on the survival data prior to statistical analysis. The statistical software employed for these calculations was CRUNCH statistical package (Crunch Software Corp.).

PROTOCOL DEVIATIONS

None

TEST RESULTS

A detailed tabulation of survival of polychaetes during the 10-day test is given in Table 1. The means and standard deviations of the responses for each sediment are also summarized in Table 1. Table 2 lists the water quality conditions in the test containers during the test.

Out of 250 worms used in the test, only two mortalities were observed, both in South Beach Marina sediments. These mortalities were not significantly different compared with the reference sediment.

CONCLUSION

The test sediments are not toxic to the polychaete, *Neanthes* sp., relative to the reference sediment.

STUDY APPROVAL

<u>Richard S. Caldwell</u>	<u>7/8/91</u>
Study Director	Date

Table 1. Survival of polychaetes, *Neanthes* sp., exposed for 10 days to marine sediments.

Station Description & replicate	Number of worms			Percent survival	Mean \pm S.D.
	Exposed	Dead	Surviving		
<u>Yaquina Bay Control</u>					
1	10	0	10	100.0	100.0 \pm 0.0
2	10	0	10	100.0	
3	10	0	10	100.0	
4	10	0	10	100.0	
5	10	0	10	100.0	
<u>5158D (SBM-BC-1)</u>					
1	10	0	10	100.0	100.0 \pm 0.0
2	10	0	10	100.0	
3	10	0	10	100.0	
4	10	0	10	100.0	
5	10	0	10	100.0	
<u>5159D (SBM-BC-2)</u>					
1	10	1	9	90.0	98.0 \pm 4.5
2	10	0	10	100.0	
3	10	0	10	100.0	
4	10	0	10	100.0	
5	10	0	10	100.0	
<u>5160D (SBM-BC-3)</u>					
1	10	0	10	100.0	98.0 \pm 4.5
2	10	0	10	100.0	
3	10	0	10	100.0	
4	10	1	9	90.0	
5	10	0	10	100.0	
<u>5161D (SBM-BC-7R)</u>					
1	10	0	10	100.0	100.0 \pm 0.0
2	10	0	10	100.0	
3	10	0	10	100.0	
4	10	0	10	100.0	
5	10	0	10	100.0	

* Means significantly different ($P < 0.05$) from the reference (SBM-BC-7R) sediment.

Table 2. Water quality raw data for *Neanthes* sp. 10-day test. Data are measurements on one replicate from each treatment per day.

Day	Temp (°C)	DO (mg/L)	Sal (ppt)	pH	S= (mg/L)	NH ₃ -N (mg/L)
<u>Yaquina Bay Control</u>						
0	20.0	7.1	31.5	8.1	<0.02	0.09
1	20.0	7.2	31.0	8.0	---	---
2	19.9	7.1	31.5	8.0	---	---
3	20.0	7.4	33.0	8.2	---	0.09
4	20.0	7.1	33.0	8.0	---	---
5	20.0	7.2	32.0	8.0	---	---
6	20.2	7.2	31.5	7.9	---	---
7	19.9	7.2	32.5	8.0	---	---
8	19.9	7.1	32.0	8.0	---	---
9	19.8	6.9	31.0	8.1	---	---
10	20.2	7.2	31.5	8.1	<0.02	0.05
<u>5158D (SBM-BC-1)</u>						
0	20.0	7.2	31.5	8.1	<0.02	2.80
1	20.0	7.1	31.5	8.0	---	---
2	19.9	7.0	31.5	8.0	---	---
3	20.0	7.2	33.5	8.2	---	4.60
4	19.9	7.0	32.5	8.0	---	---
5	20.0	7.0	31.0	8.1	---	---
6	20.1	7.2	31.0	8.2	---	---
7	19.8	7.0	31.5	8.4	---	---
8	19.8	7.0	31.0	8.5	---	---
9	19.9	7.0	31.0	8.7	---	---
10	20.2	6.7	31.5	8.6	<0.02	0.12
<u>5159D (SBM-BC-2)</u>						
0	20.1	7.0	31.0	8.1	<0.02	5.00
1	20.0	7.2	31.5	8.1	---	---
2	19.9	7.0	31.5	8.1	---	---
3	19.8	7.1	32.5	8.3	---	9.60
4	20.1	7.0	32.0	8.1	---	---
5	20.1	7.1	32.0	8.0	---	---
6	20.1	7.2	31.0	8.1	---	---
7	20.0	6.9	31.5	8.2	---	---
8	20.0	7.0	31.0	8.2	---	---
9	19.9	7.0	30.5	8.0	---	---
10	20.3	6.7	31.0	8.4	<0.02	0.09

Table . Continued.

Day	Temp (°C)	DO (mg/L)	Sal (ppt)	pH	S= (mg/L)	NH3-N (mg/L)
<u>5160D (SBM-BC-3)</u>						
0	19.9	7.1	32.0	8.2	<0.02	0.76
1	20.1	7.2	32.0	8.1	---	---
2	20.0	7.0	31.5	8.2	---	---
3	19.9	7.2	33.0	8.6	---	1.30
4	20.1	7.0	33.5	8.5	---	---
5	20.1	7.0	31.0	8.5	---	---
6	20.1	7.2	31.0	8.4	---	---
7	20.0	7.0	32.0	8.5	---	---
8	20.0	7.0	31.5	8.4	---	---
9	19.9	7.1	31.0	8.3	---	---
10	20.3	6.8	31.5	8.5	<0.02	0.07
<u>5161D (SBM-BC-7R)</u>						
0	20.1	7.1	31.0	8.0	<0.02	1.90
1	20.0	7.2	31.0	8.0	---	---
2	19.9	7.0	31.5	8.1	---	---
3	20.0	6.8	33.5	8.5	---	3.50
4	20.0	7.0	33.0	8.5	---	---
5	20.0	7.0	31.0	8.7	---	---
6	20.1	7.2	31.0	8.7	---	---
7	19.9	6.9	32.0	8.7	---	---
8	20.0	7.0	31.0	8.5	---	---
9	19.9	7.0	30.0	8.4	---	---
10	20.2	6.8	30.5	8.6	<0.02	0.65

DRAFT TEST REPORT

TEST IDENTIFICATION

Test No.: 409-5

Title: Toxicity of marine sediment suspended particulate phases (SPP) using a 48-hr oyster, *Crassostrea gigas*, embryo bioassay.

Protocol No.: NAS-409-CG3, May 10, 1991. Based on ASTM Standard E 724-89, Standard Guide for Conducting Static Acute Toxicity Tests Starting with Embryos of Four Species of Saltwater Bivalve Molluscs, and USEPA and USCOE. 1990. Draft ecological evaluation of proposed discharge of dredged material into ocean waters. EPA-503-8-90/002.

STUDY MANAGEMENT

Study Sponsor: U.S. Army Corps of Engineers, Portland District, P.O. Box 2946, Portland, OR 97208-2946.

Sponsor's Study Monitor: Mr. Mark Siipola

Testing Laboratory: Northwestern Aquatic Sciences, P.O. Box 1437, Newport, OR 97365

Test Location: Newport laboratory

Laboratory's Study Personnel: R.S. Caldwell, Ph.D., Proj. Man./Study Dir.; D.R. Buhler, Ph.D., QA Officer; L.K. Garrison, B.A., Aq. Biol.; S.A. Manwaring, B.S., Aq. Biol., and G.A. Buhler, B.S., Aq. Toxicol.

Study Schedule:

Test Beginning: 5-15-91, 10:30 p.m.

Test Ending: 5-17-91, 10:00 p.m.

Disposition of Study Records: All specimens, raw data, reports and other study records are stored according to Good Laboratory Practice regulations at: Northwestern Aquatic Sciences, Yaquina Bay Rd., P.O. Box 1437, Newport, OR 97365.

Good Laboratory Practices: The test was conducted following the principles of Good Laboratory Practices (GLP) as defined in the EPA/TSCA Good Laboratory Practice regulations effective December 29, 1983 (40 CFR Part 792).

TEST MATERIAL

Description:

Sample No. 5158D (Station SBM-BC-1. Collected 5-7-91)

Sample No. 5159D (Station SBM-BC-2. Collected 5-7-91)

Sample No. 5160D (Station SBM-BC-3. Collected 5-7-91)

Sample No. 5161D (Station SBM-BC-7R. Collected 5-7-91)

DILUTION WATER

Source: Yaquina Bay, Oregon.

Salinity: 30.0 ppt

Date of Collection: 5-15-91

Pretreatment: Filtered.

TEST ORGANISMS

Species: Pacific oyster (*Crassostrea gigas*)

Age: 2.0 hours post-fertilization.

Source: Oregon Oyster Co., Newport, OR

Conditioning: Purchased adults on 3-27-91; conditioned at ca. 18-20°C.

Holding during the preceeding two weeks averaged: Temperature, 18.8 ± 0.5°C; DO, 7.0 ± 0.5 mg/L; pH, 7.8 ± 0.1; and salinity, 30.2 ± 0.4 ppt.

Source of Gametes: 3 females and 3 males.

TEST PROCEDURES AND CONDITIONS

Test Chambers: 250 ml glass beakers containing 100 ml of test solutions.

Test Concentrations: 100%, 50%, 10%, and 0% (control).

Replicates/Treatment: 53

Initial Concentration of Test Organisms: 27.9/ml.

Volume of Subsamples Taken for Counting: 5 ml

Water Volume Changes per 24 hr: None (non-renewal static test).

Effects Criteria: The effect criteria used were: 1) failure of embryos to survive and produce completely developed shells; and 2) mortality.

Data collected were: 1) the initial embryo density; 2) the number of abnormal larvae observed; and 3) the number of normal (live with completely developed shells) larvae observed.

Water Quality and Other Test Conditions: Temperature, $20.1 \pm 0.1^\circ\text{C}$; dissolved oxygen, 7.2 ± 0.1 mg/L; salinity, 30.6 ± 0.6 ppt; pH, 8.0 ± 0.1 ; and photoperiod 16:8 hr, L:D.

DATA ANALYSIS METHODS

The percent abnormal and dead, and the percent mortality were calculated for each treatment replicate using the formula $A=100(N-B)/N$ as described in the ASTM method (ASTM 1989). The means were obtained for each treatment level and the latter were then corrected for control response using Abbott's formula, as follows: $E=100(A-M)/(100-M)$.

The EC50 and LC50 were calculated using the EPA TOXDAT Multi-Method program (EPA 600/4-85/013). NOEC and LOEC values were computed using ANOVA and Dunnett's test on arcsine transformed percent mortality and percent abnormal/dead data. The statistical software employed for these calculations was Crunch Statistical Package (Crunch Software Corp.).

PROTOCOL DEVIATIONS

None

TEST RESULTS

Detailed tabulations of the test results are given in Table 1. The biological effects, shown as the NOEC, LOEC, and EC50/LC50 for abnormal/dead and mortality are summarized below each sediment data set. Water quality conditions in the test containers at the beginning and end of the test are given in Table 2.

The 100% suspended particulate phase for South Beach Marina sample SBM-BC-2 caused a significant increase in the percent abnormal and dead response compared with the control. Percent mortality, however, was not significantly affected. No effects were observed as a result of exposure to the suspended particulate phases of any of the other sediment samples.

STUDY APPROVAL

Richard S. Caldwell

Study Director

7/8/91

Date

Table 1. Test response of oyster, *Crassostrea gigas*, embryos exposed to suspended particulate phases (SPP) of marine sediments.

Suspended phase concentration (%SPP)	Larvae counted			Abnormal/Dead*			Mortality*			
	Repl.	Norm.	Abn.	Total	%	Mean %	Adjust.%	%	Mean %	Adjust.%
Sample No. 5158D	SBM-BC-1									
100	1	136	3	139	2.9			0.7		
	2	135	2	137	3.6			2.1		
	3	147	3	150	-5.0			-7.1		
	4	160	6	166	-14.3			-18.6		
	5	150	7	157	-7.1	-4.0	-9.6	-12.1	-7.0	-10.8
50	1	129	7	136	7.9			2.9		
	2	154	6	160	-10.0			-14.3		
	3	118	6	124	15.7			11.4		
	4	152	2	154	-8.6			-10.0		
	5	143	2	145	-2.1	0.6	-4.7	-3.6	-2.7	-6.3
10	1	158	4	162	-12.9			-15.7		
	2	140	1	141	0.0			-0.7		
	3	169	3	172	-20.7			-22.9		
	4	141	4	145	-0.7			-3.6		
	5	143	6	149	-2.1	-7.3	-13.1	-6.4	-9.9	-13.8
Control	1	105	2	107	25.0			23.6		
	2	146	4	150	-4.3			-7.0		
	3	113	2	115	19.3			17.9		
	4	164	3	167	-17.1			-19.3		
	5	143	4	147	-2.1			-5.0		
	6	126	0	126	10.0	5.1	--	10.0	3.4	--

* Based on an average initial count of 140 embryos per 5 ml subsample.
 ** Result significantly different (P=0.05) from the control.

	Abnormal/Dead	Mortality
NOEC (%)	100	100
LOEC (%)	--	--
EC50/LC50 (%)	>100	>100
(95% C.I.)	--	--
Method of Calc.	by inspection	by inspection

Table 1. Continued.

Suspended phase concentration (%SPP)	Larvae counted				Abnormal/Dead*			Mortality*		
	Repl.	Norm.	Abn.	Total	%	Mean %	Adjust.%	%	Mean %	Adjust.%
Sample No. 5159D	<i>SBM-BC-2</i>									
100	1	24	102	126	82.9			10.0		
	2	24	78	102	82.9			27.1		
	3	18	123	141	87.1			-0.7		
	4	28	100	128	80.0			8.6		
	5	16	82	98	88.6	84.3**	83.4	30.0	15.0	12.0
50	1	156	3	159	-11.4			-13.6		
	2	144	2	146	-2.9			-4.3		
	3	144	6	150	-2.9			-7.1		
	4	143	3	146	-2.1			-4.3		
	5	102	1	103	27.1	1.6	-3.7	26.4	-0.6	-4.1
10	1	136	2	138	2.9			1.4		
	2	161	3	164	-15.0			-17.1		
	3	133	2	135	5.0			3.6		
	4	127	3	130	9.3			7.1		
	5	147	2	149	-5.0	-0.6	-6.0	-6.4	-2.3	-5.9
Control	1	105	2	107	25.0			23.6		
	2	146	4	150	-4.3			-7.0		
	3	113	2	115	19.3			17.9		
	4	164	3	167	-17.1			-19.3		
	5	143	4	147	-2.1			-5.0		
	6	126	0	126	10.0	5.1	--	10.0	3.4	--

* Based on an average initial count of 140 embryos per 5 ml subsample.
 ** Result significantly different (P=0.05) from the control.

	Abnormal/Dead	Mortality
NOEC (%)	50	100
LOEC (%)	100	--
EC50/LC50 (%)	79.6	>100
(95% C.I.)	(50 - 100)	--
Method of Calc.	binomial	by inspection

Table 1. Continued.

Suspended phase concentration (%SPP)	Larvae counted				Abnormal/Dead*			Mortality*		
	Repl.	Norm.	Abn.	Total	%	Mean %	Adjust.%	%	Mean %	Adjust.%
Sample No. 5160D	<i>SPM-BC-3</i>									
100	1	148	2	150	-5.7			-7.1		
	2	133	2	135	5.0			3.6		
	3	172	3	175	-22.9			-25.0		
	4	161	5	166	-15.0			-18.6		
	5	131	7	138	6.4	-6.4	-12.1	1.4	-9.1	-12.9
50	1	134	1	135	4.3			3.6		
	2	158	3	161	-12.9			-15.0		
	3	126	1	127	10.0			9.3		
	4	143	0	143	-2.1			-2.1		
	5	136	2	138	2.9	0.4	-5.0	1.4	-0.6	-4.1
10	1	133	4	137	5.0			2.1		
	2	145	1	146	-3.6			-4.3		
	3	145	0	145	-3.6			-3.6		
	4	125	2	127	10.7			9.3		
	5	121	5	126	13.6	4.4	-0.7	10.0	2.7	-0.7
Control	1	105	2	107	25.0			23.6		
	2	146	4	150	-4.3			-7.0		
	3	113	2	115	19.3			17.9		
	4	164	3	167	-17.1			-19.3		
	5	143	4	147	-2.1			-5.0		
	6	126	0	126	10.0	5.1	--	10.0	3.4	--

* Based on an average initial count of 140 embryos per 5 ml subsample.
 ** Result significantly different (P=0.05) from the control.

	Abnormal/Dead	Mortality
NOEC (%)	100	100
LOEC (%)	--	--
EC50/LC50 (%) (95% C.I.)	>100	>100
Method of Calc.	by inspection	by inspection

Table 1. Continued.

Suspended phase concentration (%SPP)	Larvae counted				Abnormal/Dead*			Mortality*		
	Repl.	Norm.	Abn.	Total	%	Mean %	Adjust.%	%	Mean %	Adjust.%
Sample No. 51610	<i>CHL 20 9R (1.000)</i>									
100	1	158	9	167	-12.9			-19.3		
	2	144	9	153	-2.9			-9.3		
	3	138	11	149	1.4			-6.4		
	4	121	5	126	13.6			10.0		
	5	119	9	128	15.0	2.8	-2.4	8.6	-3.3	-6.9
50	1	135	1	136	3.6			2.9		
	2	119	4	123	15.0			12.1		
	3	152	5	157	-8.6			-12.1		
	4	162	4	166	-15.7			-18.6		
	5	140	2	142	0.0	-1.1	-6.5	-1.4	-3.4	-7.0
10	1	138	1	139	1.4			0.7		
	2	133	0	133	5.0			5.0		
	3	140	0	140	0.0			0.0		
	4	129	2	131	7.9			6.4		
	5	125	4	129	10.7	5.0	-0.1	7.9	4.0	0.6
Control	1	105	2	107	25.0			23.6		
	2	146	4	150	-4.3			-7.0		
	3	113	2	115	19.3			17.9		
	4	164	3	167	-17.1			-19.3		
	5	143	4	147	-2.1			-5.0		
	6	126	0	126	10.0	5.1	--	10.0	3.4	--

* Based on an average initial count of 140 embryos per 5 ml subsample.
 ** Result significantly different (P=0.05) from the control.

	Abnormal/Dead	Mortality
NOEC (%)	100	100
LOEC (%)	---	---
EC50/LC50 (%) (95% C.I.)	>100	>100
Method of Calc.	by inspection	by inspection

Table 3. Water quality raw data for *Crassostrea gigas* test. Data are measurements on one replicate from each treatment at the beginning and end of the test.

SPP Conc (%)	Day	Temp (°C)	DO (mg/L)	Sal (ppt)	pH	S= (mg/L)	NH3-N (mg/L)
<u>Seawater Control</u>							
100	0	19.9	7.2	30.5	7.9	<0.02	0.03
100	2	20.1	7.2	31.0	8.0	<0.02	0.06
<u>5158D (SBM-BC-1)</u>							
100	0	19.9	7.4	30.5	7.7	<0.02	3.9
50	0	20.0	7.3	30.5	7.8	---	---
10	0	20.0	7.3	30.0	7.9	---	---
100	2	20.2	7.0	32.0	8.1	<0.02	4.0
50	2	20.2	7.1	31.5	8.0	<0.02	1.7
10	2	20.1	7.2	31.5	7.9	<0.02	0.40
<u>5159D (SBM-BC-2)</u>							
100	0	19.9	7.3	30.0	7.8	<0.02	6.4
50	0	19.9	7.2	30.5	7.9	---	---
10	0	19.9	7.3	30.0	7.9	---	---
100	2	20.2	6.9	30.5	8.2	<0.02	5.8
50	2	20.2	7.0	30.0	8.1	<0.02	5.2
10	2	20.2	7.0	30.0	8.0	<0.02	0.72
<u>5160D (SBM-BC-3)</u>							
100	0	20.0	7.3	30.0	7.8	<0.02	1.5
50	0	19.9	7.2	30.5	7.9	---	---
10	0	19.9	7.2	30.0	7.9	---	---
100	2	20.2	7.2	31.5	8.1	<0.02	1.3
50	2	20.2	7.2	30.5	8.0	<0.02	0.58
10	2	20.2	7.1	30.0	8.0	<0.02	0.32
<u>5161D (SBM-BC-7R)</u>							
100	0	19.9	7.4	30.5	7.9	<0.02	4.5
50	0	19.9	7.3	30.5	7.9	---	---
10	0	20.0	7.3	30.5	7.9	---	---
100	2	20.2	7.2	32.0	8.2	<0.02	3.7
50	2	20.2	7.2	31.0	8.2	<0.02	1.9
10	2	20.2	7.2	30.5	8.0	<0.02	0.50

DRAFT TEST REPORT

TEST IDENTIFICATION

Test No.: 409-4

Title: Toxicity of marine sediments using a 48-hr oyster, Crassostrea gigas, embryo sediment bioassay.

Protocol No.: NAS-409-CG4, May 10, 1991. Based on ASTM Standard E 724-89, Standard Guide for Conducting Static Acute Toxicity Tests Starting with Embryos of Four Species of Saltwater Bivalve Molluscs, and USEPA. 1990. Recommended protocols for conducting laboratory bioassays on Puget Sound sediments. Final Rept No. TC-3991-04, prepared by Tetra Tech, Inc. and E.V.S. Consultants, Inc., updated by PTI for U.S. Env. Prot. Agency, Region 10 - Office of Puget Sound, Seattle, WA, 55 pp.

STUDY MANAGEMENT

Study Sponsor: U.S. Army Corps of Engineers, Portland District, P.O. Box 2946, Portland, OR 97208-2946.

Sponsor's Study Monitor: Mr. Mark Siipola

Testing Laboratory: Northwestern Aquatic Sciences, P.O. Box 1437, Newport, OR 97365

Test Location: Newport laboratory

Laboratory's Study Personnel: R.S. Caldwell, Ph.D., Proj. Man./Study Dir.; D.R. Buhler, Ph.D., QA Officer; L.K. Garrison, B.A., Aq. Biol.; S.A. Manwaring, B.S., Aq. Biol., and G.A. Buhler, B.S., Aq. Toxicol.

Study Schedule:

Test Beginning: 5-15-91, 9:30 p.m.

Test Ending: 5-17-91, 8:00 p.m.

Disposition of Study Records: All specimens, raw data, reports and other study records are stored according to Good Laboratory Practice regulations at: Northwestern Aquatic Sciences, Yaquina Bay Rd., P.O. Box 1437, Newport, OR 97365.

Good Laboratory Practices: The test was conducted following the principles of Good Laboratory Practices (GLP) as defined in the EPA/TSCA Good Laboratory Practice regulations effective December 29, 1983 (40 CFR Part 792).

TEST MATERIAL

Description:

Sample No. 5158D (Station SBM-BC-1. Collected 5-7-91)

Sample No. 5159D (Station SBM-BC-2. Collected 5-7-91)

Sample No. 5160D (Station SBM-BC-3. Collected 5-7-91)

Sample No. 5161D (Station SBM-BC-7R. Collected 5-7-91)

Yaquina Bay (negative) Control Sediment (Collected 5-11-91)

Comments: The negative control sediment was taken from the lower portion of Yaquina Bay, OR at the edge of the shipping channel adjacent to the South Beach Marina. This sediment is the collection site sediment for the amphipod, Rhepoxynius abronius and is a fine to medium size clean sand (mean grain size 0.16 mm).

TEST WATER

Source: Yaquina Bay, OR

Date of Collection: 5-15-91

Pretreatment: Sand and cartridge filtered; diluted to 28 ppt

TEST ORGANISMS

Species: Pacific oyster, *Crassostrea gigas*

Age: 1.0 hours post-fertilization

Source: Oregon Oyster Co., Newport, OR 97365

Conditioning: Purchased adults on 3-27-91; Conditioned at ca. 18-20°C.

Holding during the preceeding three weeks averaged: temperature, 18.8 ± 0.5°C; DO, 7.0 ± 0.5 mg/L; pH, 7.8 ± 0.1; and salinity, 30.2 ± 0.4 ppt.

Source of Gametes: 3 females and 3 males

TEST PROCEDURES AND CONDITIONS

Test Chambers: 1 L glass jars.

Test Volumes: 1 L of test water containing 20 g of test sediment.

Replicates/Treatment: 5

Initial Concentration of Test Organisms: 30.0/ml

Volume of Subsamples Taken for Counting: 10 ml

Water Volume Changes per 24 hr: None (non-renewal static test).

Effects Criteria: The effect criteria used were based on the 1989 ASTM procedures and were: 1) failure of embryos to produce completely developed shells; and 2) mortality. Data collected were: 1) the initial embryo density (based on five 0-time samples); 2) the number of abnormal larvae observed; and 3) the number of normal (live with completely developed shells) larvae observed. The results were expressed as: 1) percent abnormal; 2) percent abnormal and dead; and 3) percent mortality.

Water Quality and Other Test Conditions: Temperature, 20.0 ± 0.0°C; salinity, 29.1 ± 0.3 ppt; dissolved oxygen, 6.3 ± 1.0 mg/L; pH, 7.8 ± 0.2; and Photoperiod 16:8 hr, L:D.

DATA ANALYSIS METHODS

The percent abnormal for each treatment replicate was calculated using the formula $A=100(C/B)$. The percent abnormal and dead, and the percent mortality were calculated for each treatment replicate using the formula $A=100(N-B)/N$ as described in the ASTM method (ASTM 1989), and the means and standard deviation were calculated for each treatment level.

ANOVA and Dunnett's tests were used to compare the mean responses between control, test, and reference sediment samples. An arcsine transformation was performed on all test data prior to the statistical analysis. The statistical software employed for these calculations was Crunch Statistical Package (Crunch Software Corp.)

PROTOCOL DEVIATIONS

None

TEST RESULTS

The numbers of normal and abnormal embryos counted, and the percent abnormal, the percent abnormal and dead, and the percent mortality in each test replicate are given in Table 1. Means and standard deviations for the latter are given in Table 2. Water quality conditions in the test containers at the beginning and end of the test are given in Table 3.

The percent of abnormal larvae did not exceed 4.4% in any of the six test treatments (Table 2). However, percent mortality and the combined measure, percent abnormal and dead, were significantly elevated in two of the South

Beach Marina sediments (SBM-BC-1 and SBM-BC-2) and in the Yaquina Bay Control sediment relative to the reference station (SBM-BC-7R). Neither of the two elevated South Beach Marina sediment responses was significantly higher than the response to the Yaquina Bay Control sediment.

CONCLUSION

Two South Beach Marina sediments (SBM-BC-1 and SBM-BC-2) were toxic to oyster larvae relative to the response in the reference sediment (SBM-BC-7R), but not relative to the Yaquina Bay Control sediment.

STUDY APPROVAL

Richard S. Caldwell 7/8/91
Study Director Date

Table 1. Test response of oyster, *Crassostrea gigas*, embryos exposed to sediments.

Sample description	Larvae counted			Percent abnormal	Percent* abnormal/dead	Percent* mortality
	Normal	Abnormal	Total			
<u>Sea Water Control</u>						
1	222	6	228	2.6	26.0	24.0
2	249	0	249	0.0	17.0	17.0
3	269	1	270	0.4	10.3	10.0
4	214	0	214	0.0	28.7	28.7
5	252	1	253	0.4	16.0	15.7
<u>Yaquina Bay Control</u>						
1	255	7	262	2.7	15.0	12.7
2	252	6	258	2.3	16.0	14.0
3	169	7	176	4.0	43.7	41.3
4	163	10	173	5.8	45.7	42.3
5	211	1	212	0.5	29.7	29.3
<u>5158D (SBM-BC-1)</u>						
1	214	1	215	0.5	28.7	28.3
2	209	4	213	1.9	30.3	29.0
3	197	3	200	1.5	39.3	33.3
4	234	4	238	1.7	22.0	20.7
5	259	7	266	2.6	13.7	11.3
<u>5159D (SBM-BC-2)</u>						
1	237	4	241	1.7	21.0	19.7
2	180	15	195	7.7	40.0	35.0
3	113	7	120	5.8	62.3	60.0
4	197	6	203	3.0	34.3	32.3
5	95	4	99	4.0	68.3	67.0
<u>5160D (SBM-BC-3)</u>						
1	282	2	284	0.7	6.0	5.3
2	300	2	302	0.7	0.0	-0.7
3	283	2	285	0.7	5.7	5.0
4	262	1	263	0.4	12.7	12.3
5	258	2	260	0.8	14.0	13.3
<u>5161D (SBM-BC-7R)</u>						
1	301	3	304	1.0	-0.3	-1.3
2	249	5	254	2.0	17.0	15.3
3	281	6	287	2.1	6.3	4.3
4	254	5	259	1.9	15.3	13.7
5	285	5	290	1.7	5.0	3.3

* Based on an average initial count of 300 embryos per 10 ml subsample.

Table 2. Means and standard deviations (n=5) of responses of oyster, *Crassostrea gigas*, embryos exposed to sediments.

Sample description	Percent abnormal	Percent [*] abnormal/dead	Percent [*] mortality
Sea Water Control	0.7 ± 1.1	19.6 ± 7.6	19.1 ± 7.3
Yaquina Bay Control	3.1 ± 2.0	30.0 ± 14.6**	27.9 ± 14.2**
5158D (SBM-BC-1)	1.6 ± 0.8	25.8 ± 8.1**	24.5 ± 8.7**
5159D (SBM-BC-2)	4.4 ± 2.4	45.2 ± 19.7**	42.8 ± 19.9**
5160D (SBM-BC-3)	0.7 ± 0.2	7.7 ± 5.7	7.0 ± 5.8
5161D (SBM-BC-7R)	1.7 ± 0.4	8.7 ± 7.3	7.1 ± 7.1

* Based on an average initial count of 300 embryos per 10 ml subsample.

** Means significantly different (P<0.05) from the reference (SBM-BC-7R) sediment.

Table 3. Water quality raw data for *Crassostrea gigas* test. Data are measurements on one replicate from each treatment at the beginning and end of the test.

Day	Temp (°C)	DO (mg/L)	Sal (ppt)	pH	S= (mg/L)	NH ₃ -N (mg/L)
<u>Seawater Control</u>						
0	20.0	7.5	29.0	8.0	<0.02	0.04
2	20.0	7.3	29.0	7.8	<0.02	0.07
<u>Yaquina Bay Control</u>						
0	20.1	7.6	29.0	8.0	<0.02	0.05
2	20.0	6.5	29.0	7.8	<0.02	0.05
<u>5158D (SBM-BC-1)</u>						
0	20.1	6.6	29.0	7.9	<0.02	0.28
2	20.1	5.2	29.0	7.6	<0.02	0.41
<u>5159D (SBM-BC-2)</u>						
0	20.1	6.4	29.5	7.9	<0.02	0.34
2	20.1	5.1	28.5	7.6	<0.02	0.82
<u>5160D (SBM-BC-3)</u>						
0	20.0	6.6	29.5	8.0	<0.02	0.10
2	20.1	5.1	29.0	7.6	<0.02	0.14
<u>5161D (SBM-BC-7R)</u>						
0	20.0	6.7	29.5	8.0	<0.02	0.05
2	20.0	4.6	29.0	7.6	<0.02	0.37

DRAFT TEST REPORT

TEST IDENTIFICATION

Test No.: 409-3

Title: Toxicity of marine sediments using a 20-day juvenile Neanthes sediment bioassay.

Protocol No.: NAS-409-NA4, May 10, 1991. Based on Johns, et al. 1990.

Protocol for juvenile Neanthes sediment bioassay. Prepared for U.S. Env. Prot. Agency, Region 10 - Office of Puget Sound, Seattle, WA, 17 pp.

STUDY MANAGEMENT

Study Sponsor: U.S. Army Corps of Engineers, Portland District, P.O. Box 2946, Portland, OR 97208-2946.

Sponsor's Study Monitor: Mr. Mark Siipola

Testing Laboratory: Northwestern Aquatic Sciences, P.O. Box 1437, Newport, OR 97365

Test Location: Newport laboratory

Laboratory's Study Personnel: R.S. Caldwell, Ph.D., Proj. Man./Study Dir.; D.R. Buhler, Ph.D., QA Officer; L.K. Garrison, B.A., Aq. Biol.; S.A. Manwaring, B.S., Aq. Biol., and G.A. Buhler, B.S., Aq. Toxicol.

Study Schedule:

Test Beginning: 5-15-91, 4:00 p.m.

Test Ending: 6-4-91, 4:00 p.m.

Disposition of Study Records: All specimens, raw data, reports and other study records are stored according to Good Laboratory Practice regulations at: Northwestern Aquatic Sciences, Yaquina Bay Rd., P.O. Box 1437, Newport, OR 97365.

Good Laboratory Practices: The test was conducted following the principles of Good Laboratory Practices (GLP) as defined in the EPA/TSCA Good Laboratory Practice regulations effective December 29, 1983 (40 CFR Part 792).

TEST MATERIAL

Description:

Sample No. 5158D (Station SBM-BC-1. Collected 5-7-91)

Sample No. 5159D (Station SBM-BC-2. Collected 5-7-91)

Sample No. 5160D (Station SBM-BC-3. Collected 5-7-91)

Sample No. 5161D (Station SBM-BC-7R. Collected 5-7-91)

Yaquina Bay (negative) Control Sediment (Collected 5-11-91)

Comments: The negative control sediment was taken from the lower portion of Yaquina Bay, OR at the edge of the shipping channel adjacent to the South Beach Marina. This sediment is the collection site sediment for the amphipod, Rhepoxynius abronius and is a fine to medium size clean sand (mean grain size 0.16 mm).

TEST WATER

Source: Yaquina Bay, OR

Date of Collection: 5-14-91

Pretreatment: Sand and cartridge filtered

TEST ORGANISMS

Species: Neanthes sp.

Age: 2-3 week post-emergence juveniles

Source: Laboratory cultures at California State University, Long Beach, CA

Acclimation: Temperature, $19.6 \pm 0.1^\circ\text{C}$; Dissolved oxygen, 5.7 ± 0.3 mg/L; pH, 7.3 ± 0.2 ; and salinity, 32.0 ± 4.4 ppt for four days prior to testing.

TEST PROCEDURES AND CONDITIONS

Test Chambers: 1 L borosilicate glass beakers.

Test Volumes: 2.0 cm sediment layer; sea water added to a total volume of 1000 ml.

Replicates/Treatment: 5

Organisms/Treatment: 25

Water Volume Changes: One third of the seawater in each beaker was replaced every third day.

Effects Criteria: The effect criteria used were: 1) survival after 20 days, 2) total biomass (dry weight), and 3) average individual biomass (total biomass/number of surviving worms).

Water Quality and Other Test Conditions: Temperature, $20.1 \pm 0.2^\circ\text{C}$; salinity, 29.6 ± 1.4 ppt; dissolved oxygen, 6.9 ± 0.3 mg/L; pH, 8.2 ± 0.2 ; and Photoperiod, continuous illumination.

DATA ANALYSIS METHODS

ANOVA and Dunnett's tests were used to compare survival and growth between control, test, and reference sediment samples. An arcsine transformation was performed on the survival data prior to statistical analysis. The statistical software employed for these calculations was CRUNCH statistical package (Crunch Software Corp.).

PROTOCOL DEVIATIONS

None

TEST RESULTS

A detailed tabulation of survival of polychaetes during the 20-day test is given in Table 1. The means and standard deviations of the responses for each sediment are also summarized in Table 1. The tabulation of growth (as biomass) of polychaetes during the test, as well as the means and standard deviations, are given in Table 2. Table 3 lists the water quality conditions in the test containers during the test.

No significant mortality of polychaetes was observed in any of the control, test or reference sediments (Table 1). Only one death was observed and that was in the reference (SBM-BC-7R) sediment. Furthermore, growth of polychaetes, expressed either as total biomass or average biomass per worm, in the South Beach Marina test sediments was not significantly different than in the reference (SBM-BC-7R) sediment (Table 2).

CONCLUSION

The test sediments are not toxic to the polychaete, Neanthes sp., relative to the reference sediment.

STUDY APPROVAL

Richard S. Caldwell

Study Director

7/8/91

Date

Table 1. Survival of polychaetes, *Neanthes* sp., exposed for 20 days to marine sediments.

Station Description & replicate	Number of worms			Percent survival	Mean \pm S.D.
	Exposed	Dead	Surviving		
<u>Yaquina Bay Control</u>					
1	5	0	5	100.0	
2	5	0	5	100.0	
3	5	0	5	100.0	
4	5	0	5	100.0	
5	5	0	5	100.0	100.0 \pm 0.0
<u>5158D (SBM-BC-1)</u>					
1	5	0	5	100.0	
2	5	0	5	100.0	
3	5	0	5	100.0	
4	5	0	5	100.0	
5	5	0	5	100.0	100.0 \pm 0.0
<u>5159D (SBM-BC-2)</u>					
1	5	0	5	100.0	
2	5	0	5	100.0	
3	5	0	5	100.0	
4	5	0	5	100.0	
5	5	0	5	100.0	100.0 \pm 0.0
<u>5160D (SBM-BC-3)</u>					
1	5	0	5	100.0	
2	5	0	5	100.0	
3	5	0	5	100.0	
4	5	0	5	100.0	
5	5	0	5	100.0	100.0 \pm 0.0
<u>5161D (SBM-BC-7R)</u>					
1	5	0	5	100.0	
2	5	0	5	100.0	
3	5	1	4	80.0	
4	5	0	5	100.0	
5	5	0	5	100.0	96.0 \pm 8.9

* Means significantly different ($P < 0.05$) from the reference (SBM-BC-7R) sediment.

Table 2. Growth of polychaetes, *Neanthes* sp., exposed for 20 days to marine sediments.

Station Description & replicate	Total biomass (mg)		Average biomass/worm (mg)	
	Each repl.	Mean \pm S.D.	Each repl.	Mean \pm S.D.
<u>Yaquina Bay Control</u>				
1	84.8		17.0	
2	80.7		16.1	
3	64.7		12.9	
4	62.9		12.6	
5	79.3	74.5 \pm 10.0	15.9	14.9 \pm 2.0
<u>5158D (SBM-BC-1)</u>				
1	53.3		10.7	
2	100.2		20.0	
3	51.0		10.2	
4	59.2		11.8	
5	66.7	66.1 \pm 20.0	13.3	13.2 \pm 4.0
<u>5159D (SBM-BC-2)</u>				
1	56.8		11.4	
2	42.8		8.6	
3	75.7		15.1	
4	94.3		18.8	
5	49.0	63.7 \pm 21.1	9.8	12.7 \pm 4.2
<u>5160D (SBM-BC-3)</u>				
1	53.5		10.7	
2	68.8		13.8	
3	57.9		11.6	
4	56.1		11.2	
5	68.5	61.0 \pm 7.2	13.7	12.2 \pm 1.4
<u>5161D (SBM-BC-7R)</u>				
1	90.7		18.1	
2	94.4		18.9	
3	92.4		23.1	
4	57.7		11.5	
5	38.9	74.8 \pm 25.1	7.8	15.9 \pm 6.1

* Means significantly different ($P < 0.05$) from the reference (SBM-BC-7R) sediment.

Table 3. Water quality raw data for *Neanthes* sp. 20-day test. Data are measurements on one replicate from each treatment per day.

Day	Temp (°C)	DO (mg/L)	Sal (ppt)	pH	S= (mg/L)	NH3-N (mg/L)
<u>Yaquina Bay Control</u>						
0	19.9	7.0	30.5	7.9	<0.02	0.35
1	20.1	7.2	30.5	8.1	--	--
2	19.9	7.2	30.5	8.1	--	--
3	19.9	7.0	31.0	8.0	--	0.70
4	19.8	7.0	32.0	8.1	--	--
5	20.0	7.1	31.5	8.0	--	--
6	20.0	7.0	27.5	8.0	--	--
7	20.2	7.1	27.5	7.7	--	--
8	19.9	7.1	28.0	7.9	--	--
9	19.8	6.9	28.5	7.7	--	--
10	19.8	6.8	28.0	8.1	--	--
11	20.2	7.2	28.5	8.2	--	--
12	19.8	7.1	28.0	8.1	--	--
13	20.2	7.3	29.0	8.2	--	--
14	20.4	7.3	30.0	8.1	--	--
15	20.0	7.0	31.0	8.1	--	--
16	20.2	7.0	28.5	8.1	--	--
17	20.2	7.0	28.5	8.2	--	--
18	20.2	7.0	29.0	8.1	--	--
19	20.3	6.6	29.0	8.0	--	--
20	19.7	7.4	29.0	8.0	<0.02	<0.05
<u>5158D (SBM-BC-1)</u>						
0	19.8	7.1	31.0	7.9	<0.02	3.30
1	20.0	7.1	31.0	8.1	--	--
2	19.8	7.2	30.5	8.1	--	--
3	19.9	7.2	31.0	8.1	--	5.70
4	19.9	7.2	32.0	8.1	--	--
5	20.0	7.0	31.5	8.1	--	--
6	20.1	6.9	28.0	8.1	--	--
7	20.2	7.1	28.0	8.1	--	--
8	20.0	6.7	29.0	8.4	--	--
9	20.1	6.8	30.0	8.5	--	--
10	19.9	6.9	30.0	8.7	--	--
11	20.4	7.0	30.0	8.6	--	--
12	20.0	7.1	28.5	8.4	--	--
13	20.4	7.0	30.5	8.4	--	--
14	20.5	7.0	31.0	8.3	--	--
15	20.1	6.6	32.0	8.2	--	--
16	20.4	6.6	28.5	8.2	--	--
17	20.3	6.8	28.5	8.3	--	--
18	20.3	6.7	28.5	8.3	--	--
19	20.3	6.2	28.0	8.1	--	--
20	20.0	6.7	28.5	7.8	<0.02	0.29

Table 3. Continued.

Day	Temp (°C)	DO (mg/L)	Sal (ppt)	pH	S= (mg/L)	NH3-N (mg/L)
<u>5159D (SBM-BC-2)</u>						
0	20.0	6.8	31.5	7.8	<0.02	5.60
1	20.2	6.9	30.5	8.0	---	---
2	20.0	7.0	30.5	8.0	---	---
3	20.0	6.5	31.5	8.0	---	13.00
4	20.0	7.1	31.5	8.2	---	---
5	20.0	6.9	31.5	8.0	---	---
6	20.1	6.8	27.0	8.1	---	---
7	20.2	6.8	27.5	8.0	---	---
8	20.0	6.9	28.0	8.2	---	---
9	20.0	6.6	29.0	8.2	---	---
10	20.0	6.8	30.0	8.4	---	---
11	20.3	6.8	29.5	8.4	---	---
12	20.2	7.1	28.5	8.4	---	---
13	20.4	7.0	30.0	8.4	---	---
14	20.3	7.0	30.5	8.4	---	---
15	20.1	6.8	31.0	8.3	---	---
16	20.4	7.0	28.5	8.3	---	---
17	20.3	7.1	29.0	8.4	---	---
18	20.3	7.0	29.0	8.4	---	---
19	20.4	6.6	28.0	8.2	---	---
20	20.0	8.2	28.5	8.3	<0.02	<0.05
<u>5160D (SBM-BC-3)</u>						
0	19.8	7.0	31.0	7.9	<0.02	0.95
1	20.1	7.2	30.5	8.1	---	---
2	20.0	7.2	31.0	8.0	---	---
3	20.0	6.8	31.0	8.2	---	2.00
4	19.9	7.1	32.0	8.5	---	---
5	20.0	6.7	31.5	8.5	---	---
6	20.1	6.8	27.5	8.4	---	---
7	20.2	7.0	28.0	8.0	---	---
8	20.0	6.9	28.0	8.2	---	---
9	19.9	6.9	29.0	8.1	---	---
10	19.9	6.6	29.0	8.3	---	---
11	20.2	7.2	29.0	8.4	---	---
12	20.0	7.1	28.5	8.4	---	---
13	20.3	7.1	30.0	8.5	---	---
14	20.2	7.2	31.0	8.4	---	---
15	20.1	7.0	33.0	8.4	---	---
16	20.2	7.1	28.0	8.4	---	---
17	20.3	6.7	28.0	8.5	---	---
18	20.3	7.1	29.0	8.4	---	---
19	20.4	6.7	29.0	8.4	---	---
20	19.9	7.4	28.5	8.4	<0.02	<0.05

Table 3. Continued.

Day	Temp (°C)	DO (mg/L)	Sal (ppt)	pH	S= (mg/L)	NH ₃ -N (mg/L)
5161D (SEM-BC-7R)						
0	19.9	6.9	31.0	7.9	<0.02	1.80
1	20.0	7.0	31.5	8.0	---	---
2	20.0	7.1	31.0	7.9	---	---
3	20.0	6.5	31.0	8.1	---	3.60
4	20.0	6.4	32.0	8.4	---	---
5	20.1	6.5	31.5	8.6	---	---
6	20.1	6.5	28.0	8.5	---	---
7	20.2	6.3	28.0	8.3	---	---
8	20.0	6.9	28.0	8.5	---	---
9	20.2	6.4	29.0	8.5	---	---
10	20.0	6.5	29.5	8.6	---	---
11	20.3	6.9	29.0	8.6	---	---
12	20.1	6.8	28.5	8.5	---	---
13	20.3	6.9	30.0	8.4	---	---
14	20.4	6.8	30.5	8.4	---	---
15	20.2	6.8	31.0	8.3	---	---
16	20.4	6.7	28.0	8.3	---	---
17	20.3	6.9	29.0	8.4	---	---
18	20.3	6.9	29.5	8.3	---	---
19	20.4	7.0	28.5	8.3	---	---
20	20.0	7.1	29.0	8.3	<0.02	0.09