

**TOXICOLOGICAL EVALUATION OF
PROPOSED DREDGED SEDIMENTS:
SAUGUS RIVER, SAUGUS, MASSACHUSETTS**

Contract Number DACW33-92-M-1080

Prepared For

**Department of the Army
U.S. Army Corps of Engineers
New England Division
424 Trapello Road
Waltham, Massachusetts 02254-9149**

By

**EnviroSystems, Incorporated
1 Lafayette Road
Hampton, New Hampshire 03842**

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Reference ACE3561

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**TOXICOLOGICAL EVALUATION OF
PROPOSED DREDGED SEDIMENTS:
SAUGUS RIVER, SAUGUS, MASSACHUSETTS**

Contract Number DACW17-87-C-0026

1.0 INTRODUCTION

As part of a comprehensive plan to reduce adverse environmental impacts of ocean dumping, Section 103 of the Marine Protection, Research and Sanctuaries Act of 1972 specifies that all sediments to be discharged into ocean waters must be evaluated to define their potential impact on existing benthic and pelagic communities. The Environmental Protection Agency has determined that the most effective means to make such an assessment is through the use of bioassay tests which provide a relatively direct estimate of potential impact.

This project called for evaluation of proposed dredge spoils and disposal of the spoil material at an approved offshore disposal site. The evaluation followed procedures established by the EPA and Corps of Engineers for testing of dredge material, presented in *Evaluation of Dredged Material Proposed for Ocean Disposal* (1991) and *Guidance for Performing Tests On Dredged Material To Be Disposed Of In Open Waters* (1989).

2.0 METHODS AND MATERIALS

2.1 SAMPLE COLLECTION AND PRESERVATION

Sediment samples for toxicological analysis were collected by the U.S. Army Corps of Engineers, New England Division, at three sites within the project area. The samples were collected on June 22, 1992 between 1140 and 1415 hours. Samples were identified as being from Station Numbers "C", "D", and "G". Reference sediment was collected by the Corps of Engineers on June 24, 1992. The sample was identified as "Reference Location Sample B". Coordinates of the Reference site were 42° 22.70' North by 70° 30.30' West. All samples were placed in new 5 gallon plastic buckets and the top tightly sealed. The buckets were delivered to EnviroSystems' laboratory on June 25, 1992.

Control sediments were collected on July 8, and again on July 26, 1992 in the Hampton, New Hampshire estuary. The first sediment was a fine grained sand and silt mix. The second sample was required as there was unacceptable control mortality in the initial assay. The second sample contained a higher percentage of fine material and a higher percentage of organic material. The estuary receives no industrial waste inputs and sediments collected at this site have been used as "Control Sediments" for over 10 years. At EnviroSystems laboratory all samples were given sample identification numbers and stored, refrigerated at 2-4°C until required.

Saugus River Dredged Sediment Evaluation
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2.1 BIOASSAY

2.1.1 General Considerations

General protocol used in the assay, including glassware preparation, animal holding and experimental conditions used in the program followed guidelines defined by the EPA/CE Technical Committee in *Evaluation of Dredged Material Proposed for Ocean Disposal* (1991), and *Guidance for Performing Tests On Dredged Material To Be Disposed Of In Open Waters* (1989). The solid phase bioassay was set up on July 7, with test animals added to the aquaria systems and dredged material added on July 8, 1992. The assay was re-set on July 28, 1992 as control survival in the original assay failed to meet acceptability criteria.

2.1.2 Sediment Preparation

Dredge spoil, reference and control sediments were all sieved (1 mm) to remove macroinvertebrates, stones and shell prior to use in the assays. Control sediments were obtained from the Hampton estuary. The control sediment was treated in the same manner as the dredge spoil samples.

2.1.3 Solid Phase Assays

Solid phase assays were conducted using the amphipod, *Ampellicsa abdita*. Prior to use, test organisms were held for two days under conditions of temperature, salinity and photoperiod similar to those to be used in the assay. Amphipods selected for use in the assay were obtained from a commercial supply source, Aquatic Research Organisms, of Hampton, New Hampshire. Amphipods were approximately 2 to 4 mm in length at the start of the assay.

The assays were started by placing a 30 mm layer of control sediment in a 1400 mL beaker. Similar volumes of Reference Sediment and proposed dredge spoil samples were also placed in 1400 mL beakers. Each treatment utilized five (5) true replicates. All beakers were modified for continuous flow through operation. After the sediments were added to the beakers they were allowed to settle for a period of 24 hours during which time water flow was stopped. Thirty amphipods were added to the test chambers after the initial 24 hour period. At the end of the assay sediments were siphoned into a 0.5 mm screen and gently washed with seawater to remove sediments. All material retained by the screen was placed in a container and set aside for microscopic evaluation. Aliquots of the sediments were placed in a small volume of water and placed under a dissecting microscope. The sediments were sorted and all amphipods transferred from the sample to a vial of final counting.

Water temperature established for the assay was $20 \pm 2^{\circ}\text{C}$. Salinity regime was established at 30-33‰ (ppt) while a 24-light/0-dark photoperiod was used. Dissolved oxygen levels were maintained at a minimum level of 4.0 mg/l. If observed values were lower, aeration was either started in the test chamber or increased. Water flow rates were also set higher, 5 mL per minute, to achieve adequate dissolved oxygen levels. This resulted in providing approximately 6 volume additions per day to the test chambers.

2.5 STATISTICAL ANALYSIS

Statistical procedures used for evaluating differences in survival between reference and treatments (animals exposed to spoil or reference sediments) followed protocol suggested by the EPA (1991). This includes analysis of variance tests for evaluating differences in mean survival. Data were also evaluated to establish if the data were homogenous and normally distributed. Data analysis used the "TOX STAT" programs developed by the University of Wyoming.

3.0 RESULTS

3.1 Solid Phase Bioassay - July 8, 1992 Assay

Evaluation of survival in the laboratory control was 67%, less than the minimum acceptable limit of 80%. Survival in the remaining treatments was variable, ranging from a high of 80% in the reference sediment to a low of 24% observed in sediments from Site D. Evaluation of the sediments and amphipods at the end of this assay showed little evidence of tube production in the control. Production of the mucus and sediments tubes in the reference sediments was higher than observed in the control sediment. Tube production was almost non existent in the Saugus River samples.

3.2 Solid Phase Bioassay - July 28, 1992 Assay

Review of survival data from the second assay showed 86.67% survival in the lab control and 81.33% in the Reference sediment. Both values exceeded the minimum survival levels established by the protocol. Survival in the Saugus River sediments varied from 23.33% for Site D to 68.0% for Site C. Survival for Site G was 34.67%. Survival data are summarized in Table 1.

A qualitative evaluation of the sediments at the termination of the assay showed considerable differences in the activity of the amphipods during the assay in terms of construction of mucus tubes. The tubes, where the animals live, are constructed of mucus and organic material in the sediments. Low levels of tube building activity may indicate stress or a lack of suitable materials. The lack of burrows exposes the animals to the sediments and increases the chances for predation. Evaluation of the control sediments at the end of the assay showed a high level of tube building activity. In comparison, the Reference sediment showed significant evidence of tube building, but less than observed in the lab control. Sediments from the Saugus River sample sites exhibited very little tube building activity. During recovery of the amphipods the number of tubes encountered was approximately one tenth of that observed in the lab control sample. General observations made during the recovery of the amphipods from the Saugus River samples showed the material remaining in the screen contained very little organic material and very few tubes. Also, the majority of the sediments remaining in the screen were observed to be quartz or quartz-like sand grains. The sand grains were noted to be angular rather than rounded.

Statistical analysis of the survival data showed that the data was normally distributed and that variances were homogenous. This allowed use of standard analysis of variance techniques to evaluate differences in mean survival between the controls and treatments. Results, summarized in Table 2 and presented in detail in Appendix B, showed there was no difference in amphipod survival for organisms exposed to lab control and Reference site sediments. Comparison of survival, Tukey's Method of

Multiple Comparison, in the three Saugus River samples with the Reference sediment showed significantly reduced survival at the "D" and "G" sites as compared to the Reference site. Survival at the "C" site was not significantly different from the Reference site.

4.0 DISCUSSION

5.0 LITERATURE CITED

U.S. EPA and Army Corps of Engineers. 1991. *Evaluation of Dredged Material Proposed for Ocean Disposal*. U.S. Army Engineers Waterways Experimental Station, Vicksburg. EPA-503/8-91/001.

U.S. EPA and Army Corps of Engineers, New England Division. 1989. *Guidance for Performing Tests On Dredged Material To Be Disposed Of In Open Waters*. EPA Region I and N.E. Division Corps of Engineers, Boston, Massachusetts, 30 pages.

TABLE 2. Summary of Water Quality Data for the Amphipod, *Ampelisca abdita*, Exposed to Proposed Dredged Material from the Saugus River. Saugus River Dredged Sediment Evaluation. U.S. Army Corps of Engineers. August 1992.

DAY	DATE	PARAMETER	CONTROL	REF SITE	SITE C	SITE D	SITE G
0	07/28	SALINITY	31	31	31.0	31	31
		pH	7.64	7.66	7.73	7.66	7.69
		D.O.	8.0	7.9	7.5	7.8	7.9
		TEMPERATURE	19.2	19.2	19.2	19.2	19.2
1	07/29	SALINITY	31	31	31	31	31
		pH	7.65	7.66	7.70	7.66	7.68
		D.O.	7.9	7.8	7.6	7.7	7.7
		TEMPERATURE	19.3	19.3	19.3	19.3	19.3
2	07/30	SALINITY	32	32	32	32	32
		pH	7.64	7.70	7.70	7.65	7.66
		D.O.	6.4	6.3	6.3	6.3	6.3
		TEMPERATURE	19.3	19.3	19.3	19.3	19.3
3	07/31	SALINITY	31	31	31	31	31
		pH	7.63	7.66	7.71	7.64	7.61
		D.O.	6.4	6.4	6.4	6.6	6.4
		TEMPERATURE	19.6	19.6	19.6	19.6	19.6
4	08/01	SALINITY	32	32	32	32	32
		pH	7.59	7.72	7.72	7.71	7.68
		D.O.	6.5	6.4	6.4	6.5	6.5
		TEMPERATURE	19.3	19.3	19.3	19.3	19.3
5	08/02	SALINITY	32	33	33	33	33
		pH	7.66	7.74	7.81	7.80	7.75
		D.O.	6.9	6.7	6.6	6.7	6.8
		TEMPERATURE	20.0	19.0	19.0	19.0	19.0
6	08/03	SALINITY	32	33	33	33	33
		pH	7.70	7.74	7.78	7.81	7.78
		D.O.	6.6	6.7	6.8	5.4	5.8
		TEMPERATURE	19.8	19.3	19.5	19.5	19.3
7	08/04	SALINITY	33	33	33	33	33
		pH	7.67	7.69	7.81	7.96	7.84
		D.O.	6.3	5.6	6.7	5.8	6.2
		TEMPERATURE	20.0	20.0	20.0	20.0	20.0
8	08/05	SALINITY	32	32	33	33	33
		pH	7.72	7.80	7.85	7.96	7.85
		D.O.	6.2	6.0	6.2	6.3	6.2
		TEMPERATURE	20.0	20.0	19.5	19.5	19.0
9	08/06	SALINITY	30	33	33	33	33
		pH	7.66	7.76	7.79	7.78	7.89
		D.O.	6.2	6.6	6.8	6.9	5.7
		TEMPERATURE	20.0	20.0	20.0	20.0	19.5
10	08/07	SALINITY	32	34	33	33	34
		pH	7.59	7.61	7.73	7.76	8.00
		D.O.	5.8	5.0	6.6	6.8	5.6
		TEMPERATURE	20.0	19.8	19.9	20.0	19.6

**APPENDIX A
RAW DATA**

Documentation Form

Project/Study No. _____ Study Director _____

Project Title Saugus SludgeEntered by _____ Date 7/29-

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Animals added 7/28/92

The following information is () miscellaneous documentation
 () a deviation from the protocol
 () a deviation from SOP _____

	Rep1-5	Control	Ref.	C	D	G
Sal.	30.5	30.5	31	31	31	31
pH	7.65	7.66	7.70	7.66	7.68	7.68
DO	7.9	7.8	7.6	7.7	7.7	7.7
Temp	19.3	19.3	19.3	19.3	19.3	19.3

7/29
1240
LH
day 1

Sal.	31.5	31.5	31.5	31.5	31.5
pH	7.64	7.70	7.70	7.65	7.66
DO	6.4	6.3	6.3	6.3	6.3
Temp	19.3	19.3	19.3	19.3	19.3

7/30
LH
1035
day 2

Sal.	31	31	31	31	31
pH	7.63	7.66	7.71	7.64	7.61
DO	6.4	6.4	6.4	6.6	6.4
Temp	19.6	19.6	19.6	19.6	19.6

7/31
day 3
LH
1225

Sal.	32	32	32	32	32
pH	7.59	7.72	7.72	7.71	7.68
DO	6.5	6.4	6.4	6.5	6.5
Temp	19.3	19.3	19.3	19.3	19.3

8/1
day 4
1200
LH

Approved by _____ Date _____

Documentation Form

Project/Study No. _____ Study Director _____

Project Title Saugus SludgeEntered by _____ Date 7/28

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The following information is () miscellaneous documentation
 () a deviation from the protocol
 () a deviation from SOP _____

Day 5
8/2
OK
1200

Rep 1-5	Control	Ref	C	D	Cor
Sal	32.63 ~~32.63~~	33	33	33	33
pH	7.66	7.74	7.81	7.80	7.75
DO	6.9	6.7	6.6	6.7	6.7
Temp	20	19	19	19	9

Day 6
8/3
GAC
1015

Sal	32	32.5	33	33	33
pH	7.70	7.74	7.78	7.81	7.78
DO	6.6	6.7	6.8	5.4	5.8
Temp	19.8	19.3	19.5	19.5	19.3

Day 7
8/4
OK
1140

Sal	33	33	33	34	34
pH	7.67	7.69	7.81	7.96	7.95
DO	6.3	6.6	6.7	5.8	6.2
Temp	20	20	20	20	20

Day 8
8/5
OK
1105

Sal	32	32	33	33	33
pH	7.72	7.80	7.85	7.96	7.85
DO	6.2	6.0	6.2	6.3	6.2
TEMP	20	20	19.5	19.5	19

Approved by _____ Date _____

Documentation Form

Project/Study No. _____ Study Director _____

Project Title Sanguis Study

Entered by _____ Date _____

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The following information is () miscellaneous documentation
() a deviation from the protocol
() a deviation from SOP _____

Day 9
8/6
DL

Reps 1-5	Control	Ref	C	D	G
Sal	30	33	33	33	33
pH	7.66	7.76	7.79	7.78	7.89
DO	6.2	6.6	6.8	6.9	5.7
Temp	20	20	20	20	19.5

Day 10
8/7
JH

Sal	32	34	33	33	34
pH	7.59	7.61	7.73	7.76	8.00
DO	5.8	5.0	6.6	6.8	5.6
Temp	20	19.8	19.9	20	19.6

Approved by _____ Date _____

3561 Saugus Sediment Evaluation
File: Sediment Transform: NO TRANSFORMATION

Hartley test for homogeneity of variance

Calculated H statistic (max Var/min Var) = 7.07
Closest, conservative, Table H statistic = 59.0 (alpha = 0.01)

Used for Table H ==> R (# groups) = 5, df (# reps-1) = 4
Actual values ==> R (# groups) = 5, df (# avg reps-1) = 4.00

Data PASS homogeneity test. Continue analysis.

NOTE: This test requires equal replicate sizes. If they are unequal but do not differ greatly, the Hartley test may still be used as an approximate test (average df are used).

3561 Saugus Sediment Evaluation
File: Sediment Transform: NO TRANSFORMATION

Bartlett's test for homogeneity of variance

Calculated B statistic = 5.88
Table Chi-square value = 13.28 (alpha = 0.01)
Table Chi-square value = 9.49 (alpha = 0.05)

Average df used in calculation ==> df (avg n - 1) = 4.00
Used for Chi-square table value ==> df (#groups-1) = 4

Data PASS homogeneity test at 0.01 level. Continue analysis.

NOTE: If groups have unequal replicate sizes the average replicate size is used to calculate the B statistic (see above).

3561 Sauquus Sediment Evaluation
File: Sediment Transform: NO TRANSFORMATION

Chi-square test for normality: actual and expected frequencies

INTERVAL	<-1.5	-1.5 to <-0.5	-0.5 to 0.5	>0.5 to 1.5	>1.5
EXPECTED	1.675	6.050	9.550	6.050	1.675
OBSERVED	1	8	7	7	2

Calculated Chi-Square goodness of fit test statistic = 1.7937
Table Chi-Square value (alpha = 0.01) = 13.277

Data PASS normality test. Continue analysis.

3561 Sauquus Sediment Evaluation
File: Sediment Transform: NO TRANSFORMATION

Shapiro Wilks test for normality

D = 185.600

W = 0.980

Critical W (P = 0.05) (n = 25) = 0.918
Critical W (P = 0.01) (n = 25) = 0.888

Data PASS normality test at P=0.01 level. Continue analysis.

ion

orm: NO TRANSFORMATION

S ON TRANSFORMED DATA TABLE 1 of 2

MTN	MAX	MEAN
21.000	30.000	26.000
23.000	27.000	24.400
15.000	26.000	20.400
4.000	8.000	7.000
8.000	14.000	10.400

on

rm: NO TRANSFORMATION

ON TRANSFORMED DATA TABLE 2 of 2

ANCE	SD	SEM
5.500	3.937	1.761
2.800	1.673	0.748
9.800	4.450	1.990
3.000	1.732	0.775
5.300	2.302	1.030

Saugus River Dredge Sediment Evaluation
File: none Transform: NO TRANSFORMATION

Chi-square test for normality: actual and expected frequencies

INTERVAL	<-1.5	-1.5 to <-0.5	-0.5 to 0.5	>0.5 to 1.5	>1.5
EXPECTED	1.340	4.840	7.640	4.840	1.340
OBSERVED	1	6	6	5	2

Calculated Chi-Square goodness of fit test statistic = 1.0467
Table Chi-Square value (alpha = 0.01) = 13.277

Data PASS normality test. Continue analysis.

Saugus River Dredge Sediment Evaluation
File: none Transform: NO TRANSFORMATION

Shapiro Wilks test for normality

D = 123.600

W = 0.983

Critical W (P = 0.05) (n = 20) = 0.905

Critical W (P = 0.01) (n = 20) = 0.868

Data PASS normality test at P=0.01 level. Continue analysis.

Saugus River Dredge Sediment Evaluation
File: none Transform: NO TRANSFORMATION

Hartley test for homogeneity of variance

Calculated H statistic (max Var/min Var) = 7.07
Closest, conservative, Table H statistic = 49.0 (alpha = 0.01)

Used for Table H ==> R (# groups) = 4, df (# reps-1) = 4
Actual values ==> R (# groups) = 4, df (# avg reps-1) = 4.00

Data PASS homogeneity test. Continue analysis.

NOTE: This test requires equal replicate sizes. If they are unequal but do not differ greatly, the Hartley test may still be used as an approximate test (average df are used).

Saugus River Dredge Sediment Evaluation
File: none Transform: NO TRANSFORMATION

Bartlett's test for homogeneity of variance

Calculated B statistic = 5.06
Table Chi-square value = 11.34 (alpha = 0.01)
Table Chi-square value = 7.81 (alpha = 0.05)

Average df used in calculation ==> df (avg n - 1) = 4.00
Used for Chi-square table value ==> df (#groups-1) = 3

Data PASS homogeneity test at 0.01 level. Continue analysis.

NOTE: If groups have unequal replicate sizes the average replicate size is used to calculate the B statistic (see above).

Grain size distribution curve showing Percent Finer versus Grain Size (mm). The curve is plotted on a semi-logarithmic scale, with the x-axis (Grain Size) ranging from 200 mm to 0.001 mm and the y-axis (Percent Finer) ranging from 0 to 100. The curve shows a well-graded soil with a peak at 0.075 mm (70% finer) and a tail extending to 0.001 mm (8% finer).

Grain Size (mm)	Percent Finer (%)
200	100
100	100
60	100
40	100
30	100
25	100
20	100
15	100
12.5	100
10	100
7.5	100
6	100
4.75	100
3.75	100
3	100
2.5	100
2	100
1.5	100
1.18	100
0.85	100
0.75	98
0.6	95
0.425	90
0.3	85
0.25	80
0.2	75
0.15	70
0.125	65
0.106	60
0.085	55
0.075	50
0.06	45
0.05	40
0.0425	35
0.0375	30
0.03	25
0.025	20
0.02	18
0.015	15
0.0125	14
0.0106	13
0.0085	12
0.0075	11
0.006	10
0.005	9
0.00425	8
0.00375	8
0.003	8
0.0025	8
0.002	8
0.0015	8
0.00125	8
0.00106	8
0.00085	8
0.00075	8
0.0006	8
0.0005	8
0.000425	8
0.000375	8
0.0003	8
0.00025	8
0.0002	8
0.00015	8
0.000125	8
0.000106	8
0.000085	8
0.000075	8
0.00006	8
0.00005	8
0.0000425	8
0.0000375	8
0.00003	8
0.000025	8
0.00002	8
0.000015	8
0.0000125	8
0.0000106	8
0.0000085	8
0.0000075	8
0.000006	8
0.000005	8
0.00000425	8
0.00000375	8
0.000003	8
0.0000025	8
0.000002	8
0.0000015	8
0.00000125	8
0.00000106	8
0.00000085	8
0.00000075	8
0.0000006	8
0.0000005	8
0.000000425	8
0.000000375	8
0.0000003	8
0.00000025	8
0.0000002	8
0.00000015	8
0.000000125	8
0.000000106	8
0.000000085	8
0.000000075	8
0.00000006	8
0.00000005	8
0.0000000425	8
0.0000000375	8
0.00000003	8
0.000000025	8
0.00000002	8
0.000000015	8
0.0000000125	8
0.0000000106	8
0.0000000085	8
0.0000000075	8
0.000000006	8
0.000000005	8
0.00000000425	8
0.00000000375	8
0.000000003	8
0.0000000025	8
0.000000002	8
0.0000000015	8
0.00000000125	8
0.00000000106	8
0.00000000085	8
0.00000000075	8
0.0000000006	8
0.0000000005	8
0.000000000425	8
0.000000000375	8
0.0000000003	8
0.00000000025	8
0.0000000002	8
0.00000000015	8
0.000000000125	8
0.000000000106	8
0.000000000085	8
0.000000000075	8
0.00000000006	8
0.00000000005	8
0.0000000000425	8
0.0000000000375	8
0.00000000003	8
0.000000000025	8
0.00000000002	8
0.000000000015	8
0.0000000000125	8
0.0000000000106	8
0.0000000000085	8
0.0000000000075	8
0.000000000006	8
0.000000000005	8
0.00000000000425	8
0.00000	

[illegible]

Project No.: 100-573-3 Project: SAUGUS RIVER, MASS. o Location: SAMPLE LOCATION "G"	Remarks: SILTY SAND COLOR: DK. BROWN TO GREY
Date: 8-14-92 GRAIN SIZE DISTRIBUTION TEST REPORT CORPS OF ENGINEERS - NEW ENGLAND	Fig. No. 3

Fig. No. 3

GRAIN SIZE DISTRIBUTION TEST DATA

Test No.: 3

Date: 8-14-92
 Project No.: 100-573-3
 Project: SAUGUS RIVER , MASS.

Sample Data

Location of Sample: SAMPLE LOCATION "G"
 Sample Description: SURFACE "GRAB" SAMPLE
 USCS Class: SM Liquid limit:
 AASHTO Class: Plasticity index:

Notes

Remarks: SILTY SAND COLOR: DK. BROWN TO GREY

Fig. No.: 3

Mechanical Analysis Data

Initial
 Dry sample and tare= 46.30
 Tare = 0.00
 Dry sample weight = 46.30
 Sieve tare method

Sieve	Weight retained	Sieve tare	Percent finer
# 4	0.00	0.00	100.0
# 10	0.80	0.00	98.3
# 20	1.60	0.00	94.8
# 40	3.50	0.00	87.3
# 70	6.90	0.00	72.4
# 100	4.50	0.00	62.6
# 200	6.00	0.00	49.7

Hydrometer Analysis Data

Separation sieve is number 10
 Percent -# 10 based on complete sample= 98.3
 Weight of hydrometer sample: 46.3
 Calculated biased weight= 47.1
 Table of composite correction values:
 Temp, deg C: 23.0 24.0 25.0 26.0 27.0
 Comp. corr: - 2.4 - 2.2 - 1.9 - 1.7 - 1.6
 Meniscus correction only= 0.5
 Specific gravity of solids= 2.68
 Specific gravity correction factor= 0.993
 Hydrometer type: 151H Effective depth L= 16.294964 - 0.2645 x Rm

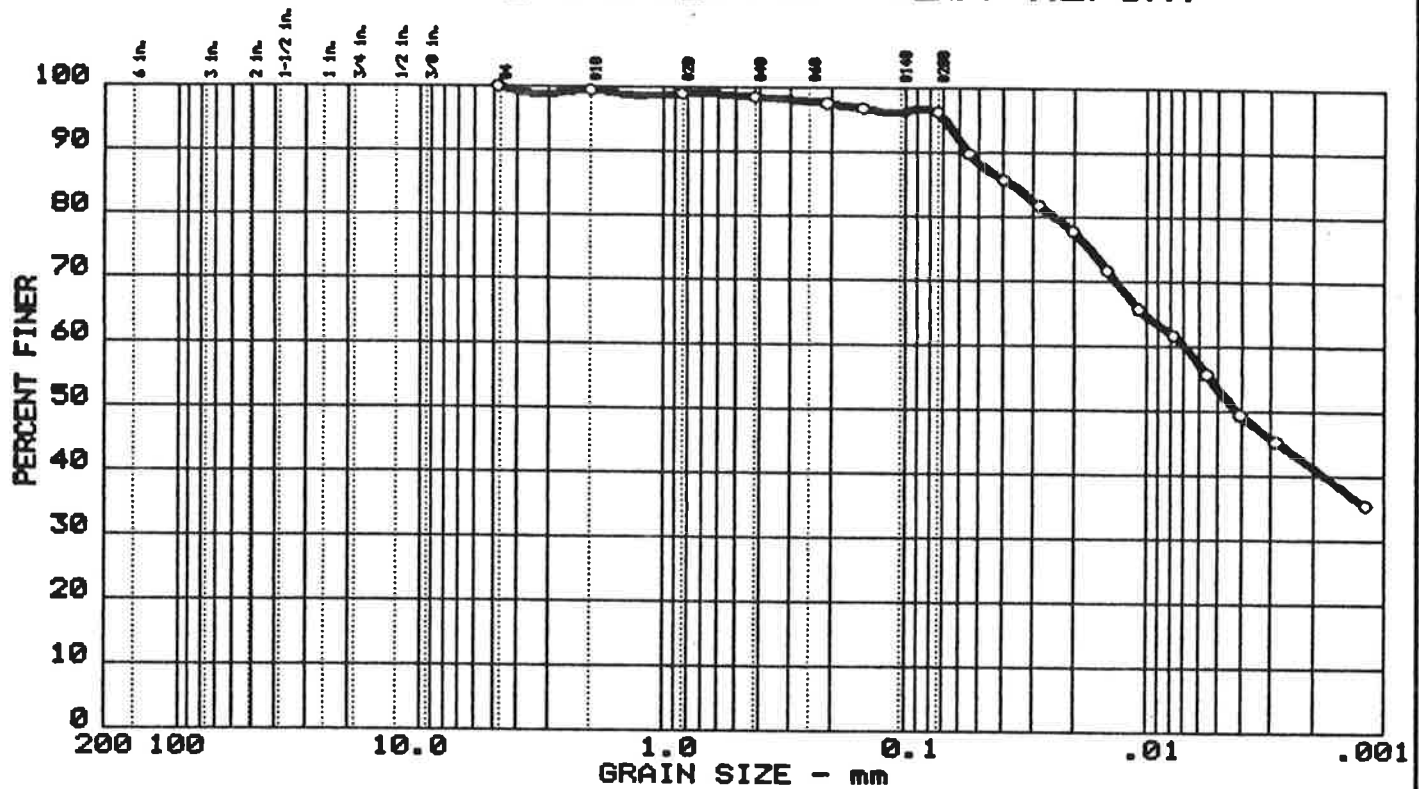
Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
0.5	26.8	1.0240	1.0224	0.0124	24.5	9.8	0.0550	89.8
1.0	26.8	1.0230	1.0214	0.0124	23.5	10.1	0.0394	85.7
2.0	26.8	1.0220	1.0204	0.0124	22.5	10.3	0.0282	81.7
4.0	26.8	1.0210	1.0194	0.0124	21.5	10.6	0.0202	77.7
8.0	26.9	1.0195	1.0179	0.0124	20.0	11.0	0.0146	71.7
15.0	26.9	1.0180	1.0164	0.0124	18.5	11.4	0.0108	65.7
30.0	26.9	1.0170	1.0154	0.0124	17.5	11.7	0.0077	61.7
60.0	26.7	1.0155	1.0139	0.0124	16.0	12.1	0.0056	55.6
120.0	26.1	1.0140	1.0123	0.0125	14.5	12.5	0.0040	49.4
240.0	26.0	1.0130	1.0113	0.0125	13.5	12.7	0.0029	45.3
1440.0	26.3	1.0105	1.0088	0.0125	11.0	13.4	0.0012	35.4

Fractional Components

% + 3 in. = 0.0 % GRAVEL = 0.0 % SAND = 3.8
 % SILT = 42.8 % CLAY = 53.3

D75= 0.02 D60= 0.007 D50= 0.004

GRAIN SIZE DISTRIBUTION TEST REPORT



Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
4	0.0	0.0	3.8	42.8	53.3

LL	PI	D75	D60	D50	D30	D25	D10	Cc	Cu
				0.00					

MATERIAL DESCRIPTION	USCS	AASHTO
o SURFACE "GRAB" SAMPLE	CL-ML	

Project No.: 100-573-4 Project: SAUGUS RIVER, MASS. o Location: SAMPLE LOCATION "REF."	Remarks: SILTY CLAY COLOR: MED. TO DK. BROWN
Date: 8-14-92 GRAIN SIZE DISTRIBUTION TEST REPORT CORPS OF ENGINEERS - NEW ENGLAND	Fig. No. 4

GRAIN SIZE DISTRIBUTION TEST DATA

Test No.: 4

Date: 8-14-92
Project No.: 100-573-4
Project: SAUGUS RIVER, MASS.

Sample Data

Location of Sample: SAMPLE LOCATION "REF."
Sample Description: SURFACE "GRAB" SAMPLE
USCS Class: CL-ML Liquid limit:
AASHTO Class: Plasticity index:

Notes

Remarks: SILTY CLAY COLOR: MED. TO DK. BROWN

Fig. No.: 4

Mechanical Analysis Data

Initial
Dry sample and tare= 39.40
Tare = 0.00
Dry sample weight = 39.40
Sieve tare method

Sieve	Weight retained	Sieve tare	Percent finer
# 4	0.00	0.00	100.0
# 10	0.20	0.00	99.5
# 20	0.20	0.00	99.0
# 40	0.20	0.00	98.5
# 70	0.40	0.00	97.5
# 100	0.30	0.00	96.7
# 200	0.20	0.00	96.2

Hydrometer Analysis Data

Separation sieve is number 10
Percent -# 10 based on complete sample= 99.5
Weight of hydrometer sample: 39.4
Calculated biased weight= 39.6
Table of composite correction values:
Temp, deg C: 23.0 24.0 25.0 26.0 27.0
Comp. corr: - 2.4 - 2.2 - 1.9 - 1.7 - 1.6
Meniscus correction only= 0.5
Specific gravity of solids= 2.7
Specific gravity correction factor= 0.989
Hydrometer type: 151H Effective depth L= 16.294964 - 0.2645 x Rm

Saugus River Dredge Sediment Evaluation
 File: none Transform: NO TRANSFORMATION

KRUSKAL-WALLIS ANOVA BY RANKS - TABLE 1 OF 2 (p=0.05)

GROUP	IDENTIFICATION	TRANSFORMED MEAN	MEAN CALCULATED IN ORIGINAL UNITS	RANK SUM
1	Reference Site	24.400	24.400	85.000
2	Site C	20.400	20.400	70.000
3	Site D	7.000	7.000	16.500
4	Site G	10.400	10.400	38.500

Calculated H Value = 16.485 Critical H Value Table = 7.810
 Since Calc H > Crit H REJECT Ho: All groups are equal.

Saugus River Dredge Sediment Evaluation
 File: none Transform: NO TRANSFORMATION

DUNNS MULTIPLE COMPARISON - KRUSKAL-WALLIS - TABLE 2 OF 2 (p=0.05)

GROUP	IDENTIFICATION	TRANSFORMED MEAN	ORIGINAL MEAN	GROUP 0 0 0 0 3 4 2 1
3	Site D	7.000	7.000	\
4	Site G	10.400	10.400	. \
2	Site C	20.400	20.400	* . \
1	Reference Site	24.400	24.400	* . . \

* = significant difference (p=0.05)
 Table q value (0.05,4) = 2.639

. = no significant difference
 SE = 3.722

1992 Retesting
Data Package

CENED-ED-GL-M

SAIR

RECORD OF TRANSMITTAL

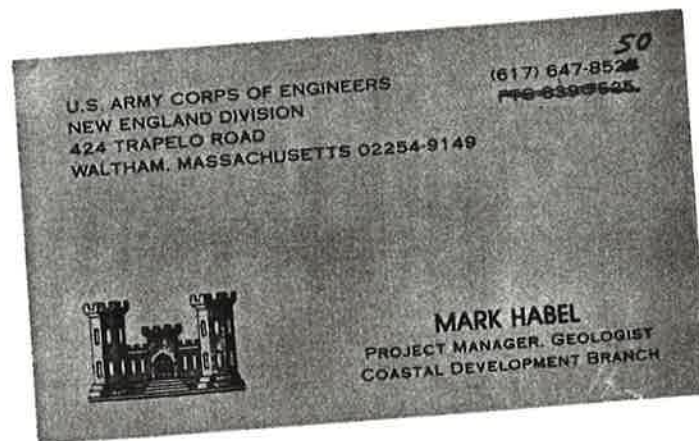
DATE: 30 December 1992

TO: Coastal Engineering and Survey Branch, ATTN:
CENED-ED-DE (Mr. Meader)

SUBJECT: Transmittal of Addendum for Saugus River, MA

1. Enclosed is a summary report for the subject project.
2. The grain size curves and complete ten day amphipod bioassay report were previously submitted.
3. If you have any questions concerning this report, please direct them to Mr. Forrest Knowles at extension 7793.

Received
from
MARK Habel
5/93



Report of Environmental Sampling and Testing

Saugus River, Saugus Ma

A. Sampling:

The sampling efforts were performed by NED Materials Laboratory personnel on June 22, 1992 at nine locations within Saugus River (C1, C2, C3; D1, D2, D3, ;G1, G2, G3-Figure EA-2) and on June 24, 1992 at the Massachusetts Bay Disposal Site reference location.

The samples from within the river and the reference location consisted of surface grabs. Sediment cores were attempted at all nine locations within the river but the bottom was too hard. A Ponar grab sampler was used to collect the samples. Positioning of the work boat was accomplished through a combination of sextant readings taken from permanent shore locations, visual sightings, and water depths. Water depths were determined by a lead line. The work boat used at the reference location was positioned using lat/lon coordinates provided by Dr. Fredette, Regulatory Division.

The grabs from within the river with the same letter designation (C1, C2, C3) were composited in precleaned high density polyethylene pails. The four composites were designated "C", "D", and "G" and consisted of five gallons each. Five gallons of sediment from the reference location was also placed in a precleaned high density polyethylene pail. The sample container precleaning, sample handling, and preservation techniques employed during collection and transportation all conformed to the EPA/CE testing protocol "Guidance for Performing Tests on Dredged Material to be disposed of in Open Water", September, 1989.

Upon receipt at the Materials Laboratory, the Saugus River composites and reference sediment were placed in a refrigerator at 34-40 degrees F. They remained in storage until taken out to be thoroughly mixed and portions removed for physical testing and chemical analysis (if necessary). The remaining material was returned to the refrigerator and stored until removal for shipping to a contractor for the 10 day amphipod tests. (See QA review for biological testing)

B. Testing:

1. Physical Testing:

The sediment composites and reference material were analyzed where applicable for:

TEST	PROCEDURE
Mechanical Analysis	EM1110-2-1906, Appendix V with

Hydrometer:

references to ASTM C136 and ASTM
D422

Visual Classification

ASTM, D2488

The results of the physical tests indicate that the sediment at the three composite locations is a mixture of dark grey to black medium to fine sand and silt/clay(see enclosed table). At "C" and "D" the fines range from 18 to 20%. At "G" the material is evenly divided between silt/clay(50%) and sand. The sand portion in all three composites consists mainly of fine sand(38-60%) with medium sand ranging from 11-21%). No measurable gravel was found. Coarse sand amounted to only traces. The sediment from the reference site was predominantly medium to dark brown silty clay with a small quantity of fine sand and no measurable coarse material or medium sand. This is similar to previous material taken from this reference area.

The sediment taken in 1992 was compared to previous material collected in 1982 and 1984 that was from locations closest to the present work ("C" and "D", 1982 ; "G", 1984). They were single stations. The earlier results are considerably finer(51-82%). The samples apparently are from localized areas of silt as all three replicates for each 1992 sample location were mostly sand. We moved away from the map positions and found the same type of material. Also, it has been at least nine years since sampling was performed by NED in these areas. Perhaps the river bottom has been altered by tidal action, storms, runoff, etc. during that time period.

2. Bioassay:

A full report of this work was previously submitted. The following is the QA review:

Quality Assurance Review
Project: Saugus River Bioassay
Date: December 28, 1992

A. Sample Handling:

The samples were collected by NED Materials Laboratory personnel using standardized procedures. Appropriate sample containers and preservation techniques were used. Proper chain of custody procedures were followed.

B. Laboratory Analysis:

1. Holding Time:

The 6 week maximum holding time between sample collection and start of bioassay was met for both the July 8 and July 28 testing.

2. Control Sample Survival:

The testing that commenced on July 8, 1992 resulted in a control

sample amphipod survival average of 67% which is significantly below the minimum of 90%. Very little tube building was in evidence for any of the samples. The cause for the departure was determined to be a bad batch of organisms. The test was repeated with the control organism survival average of 86.7% with considerable tube building which is slightly under the minimum of 90% but not exceeding it as stated in the laboratory report. This departure is acceptable according to Dr. Thomas Fredette, Regulatory Division as control organism survivals slightly below 90% are a common occurrence based upon the experience of the Corps and other agencies.

3. Methodology:

Test procedures conforming to the EPA/CE protocol, "Guidance for Performing Tests on Dredged Material to be Disposed of in Open Waters", September, 1989 were used (known hereafter as "the Protocol"). The exceptions were that NED prefers a flow through laboratory setup rather than the static system described in the Protocol and five control tanks were used instead of three.

4. Daily Observations:

The water temperature range and DO requirements were met throughout the 10 day test. The test water salinity ranged from 30 to 34 o/oo which is higher than the range of 28-32 o/oo stated in the Protocol. The pH ranged from 7.6 to 8.0 which is less than the 7.8 to 8.2 range in the Protocol. None of the departures are significant.

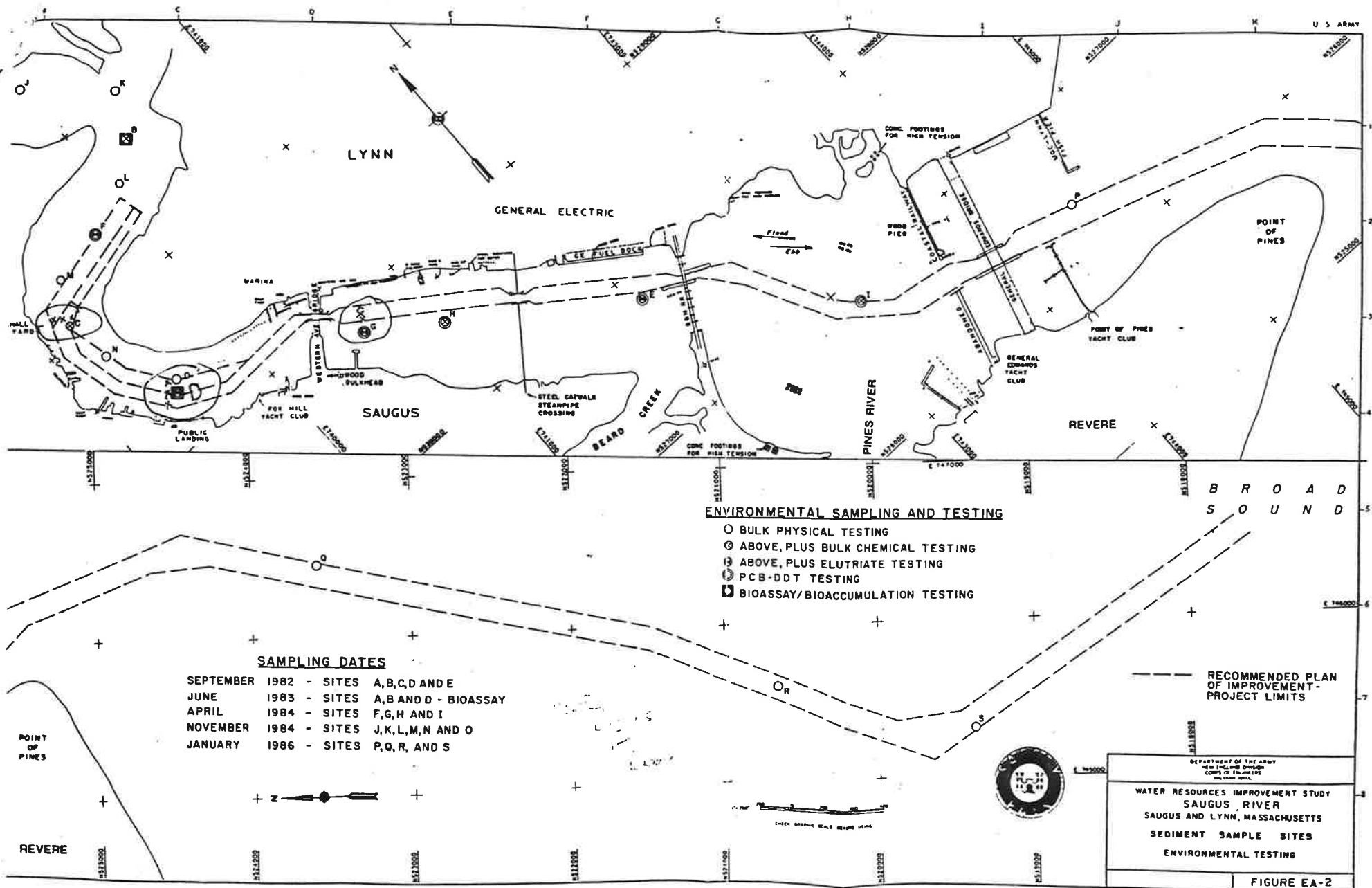
5. Results:

The survival average for the reference sediment was 81.33%. This is acceptable as there was evidence of considerable tube building by the organisms which indicates a healthy environment. The amphipod survival averages in the samples ranged from 23.6% ("D") to 68.0% ("C"). Location "C" was not statistically different from the reference. Locations "D" and "G" were considerably lower than the reference in survival averages. According to the laboratory report the reason for the high mortalities was due to the presence of considerable quantities of sand in the sediment samples in which the particles were sharp and would be harmful to the organisms. However, this reason is in doubt as the least amount of sand (5%) was found in the sample from location "G" which had only a 34.7% average organism survival. The best survival average was the sample from location "C" which consisted of about 80% sand. Perhaps there are other factors that contributed to the mortalities.

6. Assessment of Data:

The 10 day amphipod bioassay for Saugus River appears to have been conducted properly. The data generated appear reasonable and internally consistent.


Forrest E. Knowles, Jr.
Quality Assurance Officer
Laboratory Testing Operations



BOTTOM SEDIMENT SAMPLE TEST RESULTS - PHYSICAL TESTING

02BB22	SAUGUS RIVER	YEAR - 1992	STATE - MA	TIDAL SYS - MES	QUAD - LYNN
LAB SERIAL NO.	100-573-1	100-573-2	100-573-3	100-573-4	
EXPLORATION NO.	C	D	G	REF	
SAMPLE NO.	COMP(C1,C2,C3)	COMP(D1,O2,D3)	COMP(G1,G2,G3)	2	
SAMPLE DEPTH (FT)	SURFACE	SURFACE	SURFACE	SURFACE	
LATITUDE	42 27.05-07N	42 26.90-04N	42 26.85-86N	42 22.70N	
LONGITUDE	70 58.87-70W	70 58.63-64W	70 58.36-39W	70 30.30W	
SOUNDING	5.0-11.4'	3.0-10.5'	8.5-11.0'	300'	
REDUCED SOUNDING(MLW)	0.2-6.8'	0.8-8.3'	7.1-9.6'		
DATE - HOUR	6/22:1345-1415	6/22:1240-1320	6/22:1140-1230	6/24/92	
WEATHER	0	0	0	21	
SEA STATE	0	0	0	3	
VISUAL CLASSIFICATION BY LABORATORY	DARK GREY TO BLACK SILTY SAND (SM)	DARK GREY TO BLACK SILTY SAND (SM)	DARK BROWN TO GREY SILTY SAND (SM)	MEDIUM TO DARK BROWN SILTY CLAY (CL-ML)	
SOIL CLASS/DOMIN	SM	SM	SM	CL-ML	
GRAIN SIZE CURVE-MED	0.1700	0.1600	0.0700	0.0040	
GRAIN SIZE CURVE-Q1	0.3800	0.3500	0.2300	0.0170	
GRAIN SIZE CURVE-Q3	0.1009	0.0878	0.0230	<0.001	
NORMAL/BIMODAL	N	N	N	N	
WATER CONTENT, %	68.7	84.1	54.6	99.0	
% GRAVEL (RETAINED #4 US STD SIEVE)	<1	<1	<1	<1	
% COARSE SAND (PASS #4 US STD SIEVE RETAINED #10 SIEVE)	2	1	1	<1	
% MEDIUM SAND (PASS #10 SIEVE RETAINED #40 SIEVE)	20	21	11	<1	
% FINE SAND (PASS #40 SIEVE RETAINED #200 US STD SIEVE)	60	57	38	4	
% FINES (SILT/CLAY) PASS #200 SIEVE	18	21	50	96	

6/22/1992
sampling date

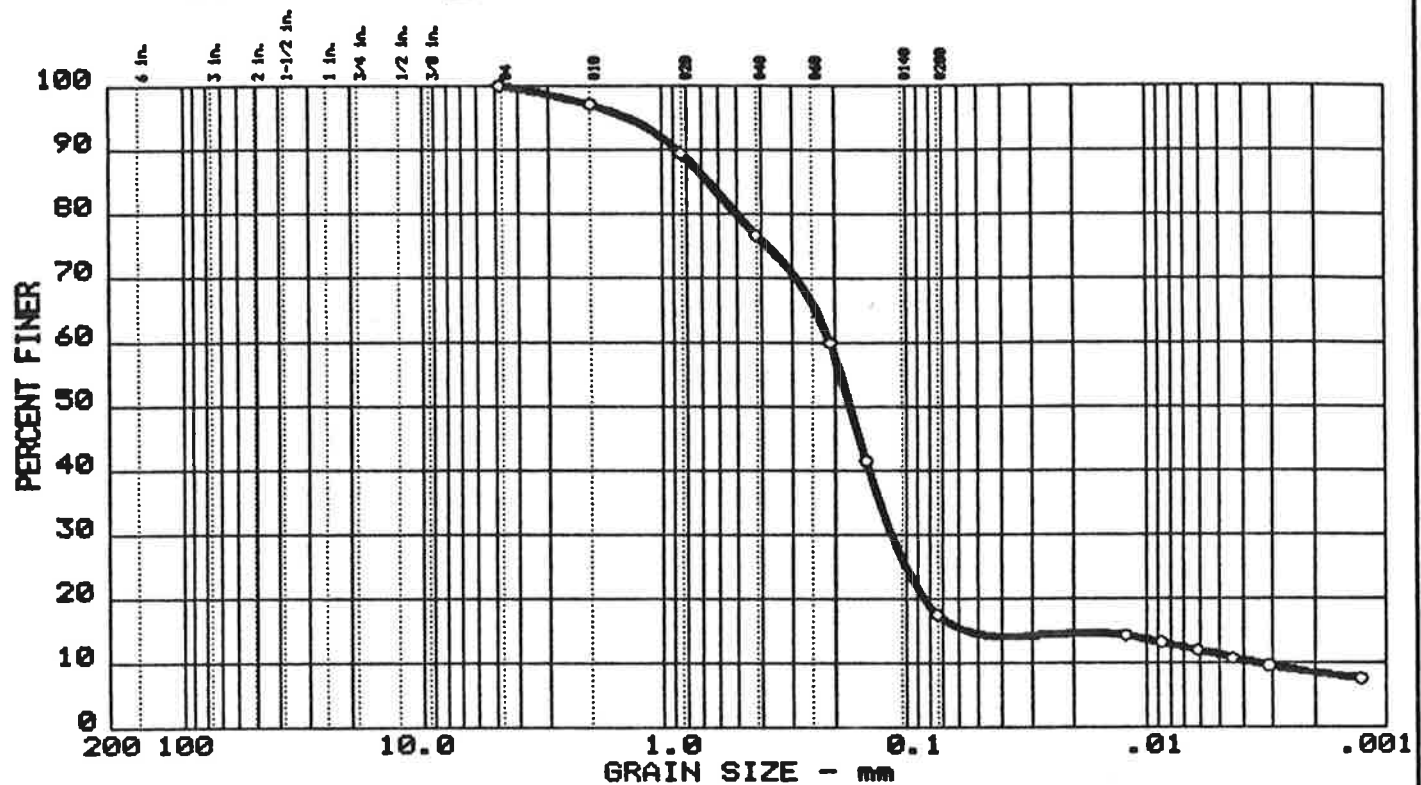
Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
15.0	26.2	1.0080	1.0063	0.0126	8.5	14.0	0.0122	14.3
15.0	26.2	1.0080	1.0063	0.0126	8.5	14.0	0.0122	14.3
30.0	26.1	1.0075	1.0058	0.0126	8.0	14.2	0.0087	13.2
60.0	26.0	1.0070	1.0053	0.0126	7.5	14.3	0.0062	12.0
120.0	25.8	1.0065	1.0048	0.0126	7.0	14.4	0.0044	10.8
240.0	25.8	1.0060	1.0043	0.0126	6.5	14.6	0.0031	9.6
1440.0	26.3	1.0050	1.0033	0.0126	5.5	14.8	0.0013	7.5

Fractional Components

% + 3 in. = 0.0 % GRAVEL = 0.0 % SAND = 82.5
 % SILT = 6.3 % CLAY = 11.3

D75= 0.38 D60= 0.210 D50= 0.173
 D30= 0.1159 D25= 0.10093 D10= 0.00346
 Cc = 18.4927 Cu = 60.6736

GRAIN SIZE DISTRIBUTION TEST REPORT



Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
1	0.0	0.0	82.5	6.3	11.3

LL	PI	D ₇₅	D ₆₀	D ₅₀	D ₃₀	D ₂₅	D ₁₀	C _c	C _u
		0.38	0.21	0.17	0.116	0.1009	0.0035	18.49	60.7

MATERIAL DESCRIPTION	USCS	AASHTO
o SURFACE "GRAB" SAMPLE	SM	

Project No.: 100-573-1
 Project: SAUGUS RIVER, MASS.
 o Location: SAMPLE LOCATION "C"

Date: 8-14-92

GRAIN SIZE DISTRIBUTION TEST REPORT
 CORPS OF ENGINEERS - NEW ENGLAND

Remarks:
 SILTY SAND
 COLOR: DK. GREY TO BLACK

Fig. No. 1

GRAIN SIZE DISTRIBUTION TEST DATA

Test No.: 1

Date: 8-14-92
Project No.: 100-573-1
Project: SAUGUS RIVER , MASS.

Sample Data

Location of Sample: SAMPLE LOCATION "C"
Sample Description: SURFACE "GRAB" SAMPLE
USCS Class: SM Liquid limit:
AASHTO Class: Plasticity index:

Notes

Remarks: SILTY SAND COLOR: DK. GREY TO BLACK

Fig. No.: 1

Mechanical Analysis Data

Initial
Dry sample and tare= 68.40
Tare = 0.00
Dry sample weight = 68.40
Sieve tare method

Sieve	Weight retained	Sieve tare	Percent finer
# 4	0.00	0.00	100.0
# 10	2.00	0.00	97.1
# 20	5.20	0.00	89.5
# 40	8.70	0.00	76.8
# 70	11.50	0.00	59.9
# 100	12.60	0.00	41.5
# 200	16.40	0.00	17.5

Hydrometer Analysis Data

Separation sieve is number 10
Percent -# 10 based on complete sample= 97.1
Weight of hydrometer sample: 68.4
Calculated biased weight= 70.5
Table of composite correction values:
Temp, deg C: 23.0 24.0 25.0 26.0 27.0
Comp. corr: - 2.4 - 2.2 - 1.9 - 1.7 - 1.6
Meniscus correction only= 0.5
Specific gravity of solids= 2.68
Specific gravity correction factor= 0.993
Hydrometer type: 151H Effective depth L= 16.294964 - 0.2645 x Rm

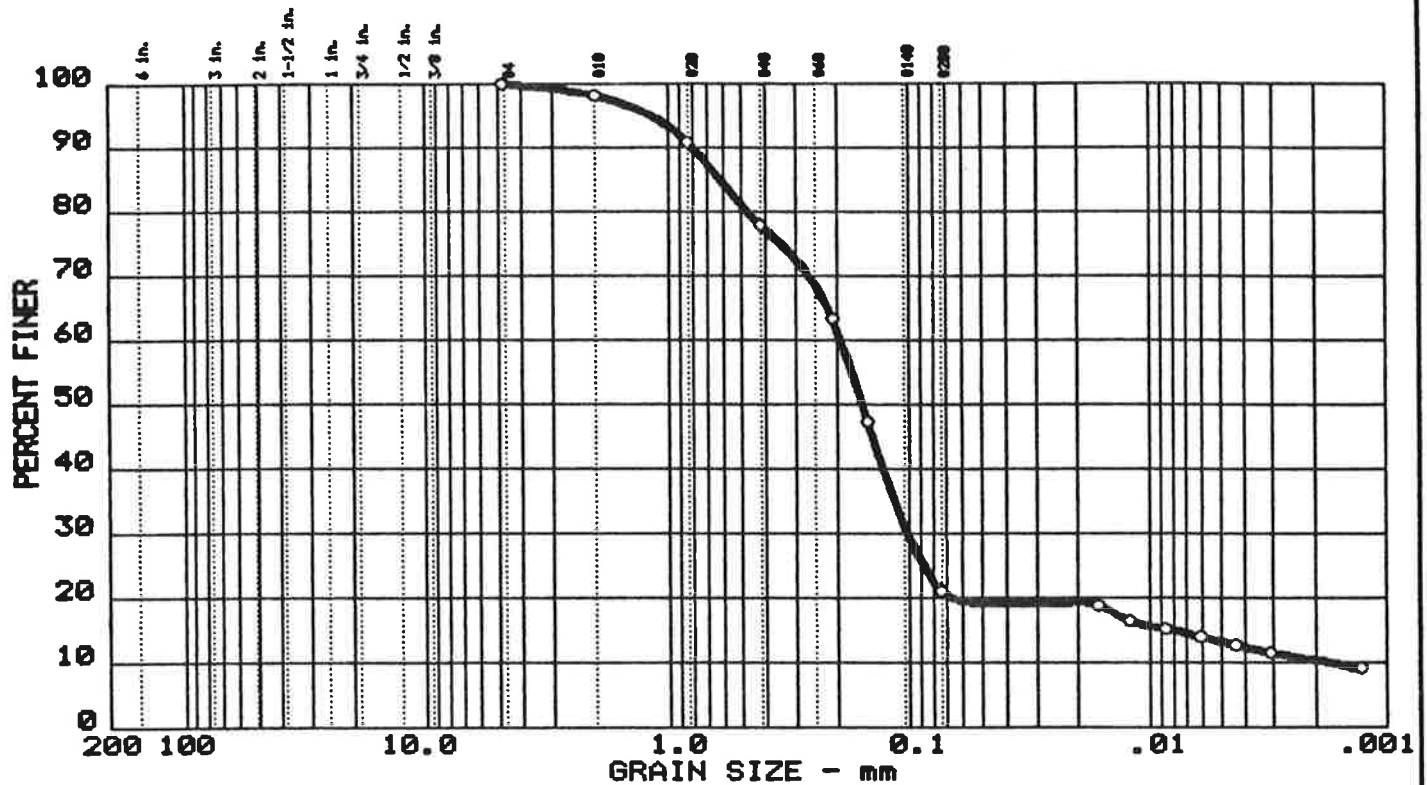
Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
8.0	26.5	1.0095	1.0079	0.0125	10.0	13.6	0.0164	18.9
15.0	26.4	1.0085	1.0068	0.0126	9.0	13.9	0.0121	16.5
30.0	26.3	1.0080	1.0063	0.0126	8.5	14.0	0.0086	15.2
60.0	26.1	1.0075	1.0058	0.0126	8.0	14.2	0.0061	14.0
120.0	25.9	1.0070	1.0053	0.0126	7.5	14.3	0.0044	12.7
240.0	26.0	1.0065	1.0048	0.0126	7.0	14.4	0.0031	11.5
1440.0	26.3	1.0055	1.0038	0.0126	6.0	14.7	0.0013	9.2

Fractional Components

% + 3 in. = 0.0 % GRAVEL = 0.0 % SAND = 79.0
 % SILT = 7.8 % CLAY = 13.2

D75= 0.35 D60= 0.194 D50= 0.157
 D30= 0.1020 D25= 0.08780 D10= 0.00173
 Cc = 31.0099 Cu = 111.8150

GRAIN SIZE DISTRIBUTION TEST REPORT



Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
2	0.0	0.0	79.0	7.8	13.2

LL	PI	D ₇₅	D ₆₀	D ₅₀	D ₃₀	D ₂₅	D ₁₀	C _c	C _u
		0.35	0.19	0.16	0.102	0.0878	0.0017	31.01	111.8

MATERIAL DESCRIPTION	USCS	AASHTO
○ SURFACE "GRAB" SAMPLE	SM	

Project No.: 100-573-2
 Project: SAUGUS RIVER, MASS.
 Location: SAMPLE LOCATION "D"

Date: 8-14-92

GRAIN SIZE DISTRIBUTION TEST REPORT
 CORPS OF ENGINEERS - NEW ENGLAND

Remarks:
 SILTY SAND
 COLOR: DK. GREY TO BLACK

Fig. No. 2

GRAIN SIZE DISTRIBUTION TEST DATA

Test No.: 2

Date: 8-14-92
Project No.: 100-573-2
Project: SAUGUS RIVER , MASS.

Sample Data

Location of Sample: SAMPLE LOCATION "D"
Sample Description: SURFACE "GRAB" SAMPLE
USCS Class: SM Liquid limit:
AASHTO Class: Plasticity index:

Notes

Remarks: SILTY SAND COLOR: DK. GREY TO BLACK

Fig. No.: 2

Mechanical Analysis Data

Initial
Dry sample and tare= 65.10
Tare = 0.00
Dry sample weight = 65.10
Sieve tare method

Sieve	Weight retained	Sieve tare	Percent finer
# 4	0.00	0.00	100.0
# 10	1.20	0.00	98.2
# 20	4.80	0.00	90.8
# 40	8.40	0.00	77.9
# 70	9.50	0.00	63.3
# 100	10.40	0.00	47.3
# 200	17.10	0.00	21.0

Hydrometer Analysis Data

Separation sieve is number 10
Percent -# 10 based on complete sample= 98.2
Weight of hydrometer sample: 65.1
Calculated biased weight= 66.3
Table of composite correction values:
Temp, deg C: 23.0 24.0 25.0 26.0 27.0
Comp. corr: - 2.4 - 2.2 - 1.9 - 1.7 - 1.6
Meniscus correction only= 0.5
Specific gravity of solids= 2.68
Specific gravity correction factor= 0.993
Hydrometer type: 151H Effective depth L= 16.294964 - 0.2645 x Rm

Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
0.5	26.8	1.0140	1.0124	0.0125	14.5	12.5	0.0624	41.9
1.0	26.8	1.0120	1.0104	0.0125	12.5	13.0	0.0450	35.1
2.0	26.8	1.0100	1.0084	0.0125	10.5	13.5	0.0325	28.4
4.0	26.8	1.0090	1.0074	0.0125	9.5	13.8	0.0232	25.0
8.0	26.8	1.0080	1.0064	0.0125	8.5	14.0	0.0166	21.6
15.0	26.9	1.0070	1.0054	0.0125	7.5	14.3	0.0122	18.3
30.0	26.9	1.0065	1.0049	0.0125	7.0	14.4	0.0087	16.6
60.0	26.6	1.0060	1.0044	0.0125	6.5	14.6	0.0062	14.8
120.0	26.1	1.0055	1.0038	0.0126	6.0	14.7	0.0044	12.9
240.0	26.0	1.0050	1.0033	0.0126	5.5	14.8	0.0031	11.2
1440.0	26.3	1.0045	1.0028	0.0126	5.0	15.0	0.0013	9.6

Fractional Components

% + 3 in. = 0.0 % GRAVEL = 0.0 % SAND = 50.3
 % SILT = 36.1 % CLAY = 13.6

D75= 0.23 D60= 0.124 D50= 0.075
 D30= 0.0353 D25= 0.02304 D10= 0.00259
 Cc = 3.8681 Cu = 48.1393

Saugus River Dredge Sediment Evaluation
 File: none Transform: NO TRANSFORMATION

TUKEY method of multiple comparisons

GROUP	IDENTIFICATION	TRANSFORMED MEAN	ORIGINAL MEAN	GROUP			
				0	0	0	0
				3	4	2	1
3	Site D	7.000	7.000	\			
4	Site G	10.400	10.400	.	\		
2	Site C	20.400	20.400	*	*	\	
1	Reference Site	24.400	24.400	*	*	.	\

* = significant difference (p=0.05)

. = no significant difference

Tukey value (4,16) = 4.05

s = 7.725

Saugus River Dredge Sediment Evaluation
 File: none Transform: NO TRANSFORMATION

WILLIAMS TEST (Isotonic regression model) TABLE 1 OF 2

GROUP	IDENTIFICATION	N	ORIGINAL MEAN	TRANSFORMED MEAN	ISOTONIZED MEAN
1	Reference Site	5	24.400	24.400	24.400
2	Site C	5	20.400	20.400	20.400
3	Site D	5	7.000	7.000	8.700
4	Site G	5	10.400	10.400	8.700

Saugus River Dredge Sediment Evaluation
 File: none Transform: NO TRANSFORMATION

WILLIAMS TEST (Isotonic regression model) TABLE 2 OF 2

IDENTIFICATION	ISOTONIZED MEAN	CALC. WILLIAMS	SIG P=.05	TABLE WILLIAMS	DEGREES OF FREEDOM
Reference Site	24.400				
Site C	20.400	2.276	*	1.75	k= 1, v=16
Site D	8.700	8.931	*	1.83	k= 2, v=16
Site G	8.700	8.931	*	1.86	k= 3, v=16

s = 2.779

Note: df used for table values are approximate when v > 20.

Saugus River Dredge Sediment Evaluation
 File: none Transform: NO TRANSFORMATION

KRUSKAL-WALLIS ANOVA BY RANKS - TABLE 1 OF 2 (p=0.05)

GROUP	IDENTIFICATION	TRANSFORMED MEAN	MEAN CALCULATED IN ORIGINAL UNITS	RANK SUM
1	Reference Site	24.400	24.400	85.000
2	Site C	20.400	20.400	70.000
3	Site D	7.000	7.000	16.500
4	Site G	10.400	10.400	38.500

Calculated H Value = 16.485 Critical H Value Table = 7.810
 Since Calc H > Crit H REJECT Ho: All groups are equal.

Saugus River Dredge Sediment Evaluation
 File: none Transform: NO TRANSFORMATION

DUNNS MULTIPLE COMPARISON - KRUSKAL-WALLIS - TABLE 2 OF 2 (p=0.05)

GROUP	IDENTIFICATION	TRANSFORMED MEAN	ORIGINAL MEAN	GROUP			
				0	0	0	0
				3	4	2	1
3	Site D	7.000	7.000	\			
4	Site G	10.400	10.400	.	\		
2	Site C	20.400	20.400	*	.	\	
1	Reference Site	24.400	24.400	*	.	.	\

* = significant difference (p=0.05)
 Table q value (0.05,4) = 2.639

. = no significant difference
 SE = 3.722

Saugus River Dredge Sediment Evaluation
File: none Transform: NO TRANSFORMATION

ANOVA TABLE

SOURCE	DF	SS	MS	F
Between	3	1007.350	335.783	43.467
Within (Error)	16	123.600	7.725	
Total	19	1130.950		

Critical F value = 3.24 (0.05,3,16)
Since $F > \text{Critical } F$ REJECT H_0 : All groups equal

Saugus River Dredge Sediment Evaluation
 File: none Transform: NO TRANSFORMATION

BONFERRONI T-TEST - TABLE 1 OF 2 Ho:Control<Treatment

GROUP	IDENTIFICATION	TRANSFORMED MEAN	MEAN CALCULATED IN ORIGINAL UNITS	T STAT	SIG
1	Reference Site	24.400	24.400		
2	Site C	20.400	20.400	2.276	
3	Site D	7.000	7.000	9.899	*
4	Site G	10.400	10.400	7.964	*

Bonferroni T table value = 2.33 (1 Tailed Value, P=0.05, df=16,3)

Saugus River Dredge Sediment Evaluation
 File: none Transform: NO TRANSFORMATION

BONFERRONI T-TEST - TABLE 2 OF 2 Ho:Control<Treatment

GROUP	IDENTIFICATION	NUM OF REPS	Minimum Sig Diff (IN ORIG. UNITS)	% of CONTROL	DIFFERENCE FROM CONTROL
1	Reference Site	5			
2	Site C	5	4.094	16.8	4.000
3	Site D	5	4.094	16.8	17.400
4	Site G	5	4.094	16.8	14.000

Saugus River Dredge Sediment Evaluation
File: none Transform: NO TRANSFORMATION

ANOVA TABLE

SOURCE	DF	SS	MS	F
Between	3	1007.350	335.783	43.467
Within (Error)	16	123.600	7.725	
Total	19	1130.950		

Critical F value = 3.24 (0.05,3,16)
Since $F > \text{Critical } F$ REJECT H_0 :All groups equal

Saugus River Dredge Sediment Evaluation
 File: none Transform: NO TRANSFORMATION

TUKEY method of multiple comparisons

GROUP	IDENTIFICATION	TRANSFORMED MEAN	ORIGINAL MEAN	GROUP			
				0	0	0	0
				3	4	2	1
3	Site D	7.000	7.000	\			
4	Site G	10.400	10.400	.	\		
2	Site C	20.400	20.400	*	*	\	
1	Reference Site	24.400	24.400	*	*	.	\

* = significant difference (p=0.05)
 Tukey value (4,16) = 4.05

. = no significant difference
 s = 7.725

Saugus River Dredge Sediment Evaluation
 File: none Transform: NO TRANSFORMATION

WILLIAMS TEST (Isotonic regression model) TABLE 1 OF 2

GROUP	IDENTIFICATION	N	ORIGINAL MEAN	TRANSFORMED MEAN	ISOTONIZED MEAN
1	Reference Site	5	24.400	24.400	24.400
2	Site C	5	20.400	20.400	20.400
3	Site D	5	7.000	7.000	8.700
4	Site G	5	10.400	10.400	8.700

Saugus River Dredge Sediment Evaluation
 File: none Transform: NO TRANSFORMATION

WILLIAMS TEST (Isotonic regression model) TABLE 2 OF 2

IDENTIFICATION	ISOTONIZED MEAN	CALC. WILLIAMS	SIG P=.05	TABLE WILLIAMS	DEGREES OF FREEDOM
Reference Site	24.400				
Site C	20.400	2.276	*	1.75	k= 1, v=16
Site D	8.700	8.931	*	1.83	k= 2, v=16
Site G	8.700	8.931	*	1.86	k= 3, v=16

s = 2.779

Note: df used for table values are approximate when v > 20.