Special Study Report

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ACUSHNET RIVER ESTUARY PCB STUDY

The Commonwealth of Massachusetts
Water Resources Commission
Division of Water Pollution Control
Boston, Massachusetts

December 1982

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THE COMMONWEALTH OF MASSACHUSETTS
ACUSHNET RIVER ESTUARY PCB STUDY

DECEMBER, 1982

EXECUTIVE SUMMARY

Study Objectives

The objectives of this Study are:

a) to characterize the nature of the PCB contamination problem in the Acushnet River Estuary - New Bedford Harbor area and;

b) to evaluate alternative programs including both remedial dredging programs to recover PCB from the estuary and harbor in order to reduce environmental contamination, and harbor dredging programs to relieve existing constraints on dredging for harbor improvement and development.

The study area is divided into five zones (see Figure 1-1):

Zone 1a: Upper Acushnet River Estuary (above New Bedford-Fairhaven Bridge)
Zone 1b: Inner New Bedford Harbor (above hurricane barrier)
Zone 2: Outer New Bedford Harbor
Zone 3: Inner Buzzards Bay
Zone 4: Outer Buzzards Bay

Basis of Study

Evaluations contained in this study are based upon available data and existing reports which are listed under References in Section 6. Recommendations were made by Malcolm Pirnie in April 1981 to obtain more extensive data in order to refine the present understanding of the nature and extent of PCB contamination and to provide for more reliable estimates of remedial program costs. Since that time, additional sediment sampling, water column and lobster sampling has been undertaken, and the results are incorporated into this report.

This report presents evaluations which are judged to be suitable for making a decision as to whether feasible remedial or harbor improvement programs exist. The next phases of work would include additional sampling and detailed studies of all aspects of a selected program.

Nature and Extent of Contamination

Available data indicate that the sediments and aquatic organisms in the Acushnet River-New Bedford Harbor area contain elevated levels of PCB. In the northern portion of the upper estuary (Zone 1a), sediment samples indicate levels generally exceeding 500 micrograms per gram (ug/g dry weight) with concentrations greater than 10,000 ug/g measured at several sampling stations. These sediment concentrations are the highest levels measured to date in the study area and are in the vicinity of a former PCB discharge point. Levels exceeding 50 ug/g are present in the estuary (Zone 1a) extending as far south as Pope's Island, in the northwest corner of the outer harbor (Zone 2) and in the vicinity of the New Bedford Sewage Treatment Plant outfalls (Zone 2). Concentrations of 10-50 ug/g occur in the peripheral areas of the inner harbor (Zone 1b) with lower sediment values in the navigation channel. An additional area containing PCB in the 10-50 ug/g range is located along the west shore of the outer harbor (Zone 2) near another former PCB discharge point. Areas of sediment PCB contamination have been outlined on Plate 7 on the basis of available data.

Aquatic organisms exhibit the highest PCB levels in the estuary and inner harbor area and decreasing levels seaward. A majority of the finfish sampled in the inner harbor (Zone 1b) have had PCB levels exceeding the FDA limit of

5 ug/g wet weight. Lobster samples from the inner bay (Zone 3), within the fishery closure area, show PCB levels fluctuating around 5 ug/g and exceeding this level in a significant portion of the samples on a seasonal basis.

In addition to high PCB levels in river and harbor sediments, limited data also indicate that the sediments contain significantly high levels of heavy metals such as copper, chromium, lead and zinc. It is recommended that further sampling be done in the Acushnet River-New Bedford Harbor area to supplement existing information on PCB and heavy metals distributions and concentrations.

Dredging Volumes

Several recent studies of PCB-contaminated waterways have shown removal of contaminated material as the only technically and economically feasible remedial action.[12,26] Estimates of contaminated bed material volumes in the Acushnet River-New Bedford Harbor area are based on a depth of removal of three feet in areas dredged. Dredged material volumes for Inner and Outer Harbor dredging alternatives (Zones 1a, 1b and 2) are indicated in Table S-1. Brief statements describing the basis of estimates contained in Table S-1 are given in footnotes to the table. More detailed information is provided in Section 3.

Conceptual Dredging Programs

The benefits to be expected from dredging programs are related to two primary issues involved:

- reduction in PCB levels in aquatic life generally, and specifically in organisms of commercial and sport fishing importance.
- lifting of constraints on harbor development projects.

TABLE S-1

PCB-CONTAMINATED VOLUMES

Based on Available Data

Project	Typical PCB Concentration in Dredged Area ug/g	Cumulative Volume of Dredged Material cu yds
	REMEDIAL DREDGING PROJECTS	
Hot Spots I	>500 (1)	70,000
Hot Spots II	> 50 (2)	2,200,000
Hot Spots III	> 10 (2)	4,400,000
	HARBOR DEVELOPMENT PROJECTS	
Project A: Channel Improvement Dredging	~ 10 (3)	80,000
Project B: Proj. A + Bridge Excavation	~ 10 (3)	120,000
Project C: Proj. B + Small Scale Harbor Development	~ 10 (3)	300,000
Project D: Proj. C + Large Scale Harbor Development	~ 10 (3)	900,000

(1) PCB concentration based on measured PCB values in top two feet of sediment.
(2) PCB concentrations based on surface samples (~0-4" depth) only, due to insufficient data at greater depths.
(3) Approximate concentrations based on minimal sampling; must be verified with detailed sampling on a site-by-site basis.

Reductions in PCB contamination levels in aquatic organisms will be related to, among other factors, the extent to which PCB-contaminated bed materials are removed, the effects of this removal on PCB levels in the water column, and the levels of PCB in the remaining undredged harbor areas. The various factors which must be considered in evaluating the potential for PCB reductions in aquatic organisms are discussed in Section 3 of this report. A discussion of the possible benefits to aquatic life in the Acushnet River Estuary-New Bedford Harbor area as a result of remedial dredging programs is presented in Section 4.

Constraints on harbor development projects would be reduced by the provision of containment sites for the PCB-contaminated fraction of the bottom muds in areas being considered for channel improvement dredging and various construction projects.

Five remedial dredging program alternatives have been formulated:

1. Dredge sediments containing greater than 500 ug/g PCB with disposal at a secure upland site. (Hot Spot I Project).

2. Dredge sediments containing greater than 50 ug/g with disposal at a secure upland site. (Hot Spot II Project).

3. Dredge sediments containing greater than 10 ug/g PCB with disposal of sediments containing 50 ug/g PCB or greater at a secure upland site, and shoreline disposal of sediment containing less than 50 ug/g. (Hot Spot III Project).

4. Allow implementation of channel improvement dredging, bridge excavation and initiation of small scale harbor development projects through removal and shoreline containment of the PCB-contaminated bed material volumes involved. (Harbor Development Project C).

5. Allow implementation of channel improvement dredging, bridge excavation and initiation of larger-scale harbor development projects through removal

and shoreline containment of the PCB-contaminated bed material volumes involved. (Harbor Development Project D).

Dredge Material Disposal

The federal Toxic Substances Control Act (TSCA) currently requires that dredged material containing PCB concentrations of 50 ug/g or greater (dry weight) be disposed of by one of the following three methods:

- o in an approved incinerator
- o in an approved chemical waste landfill
- o by use of another method approved by the EPA Regional Administrator

As a basis for developing the costs of various alternatives in this report, it has been assumed that sediments containing PCB concentrations equal to or greater than 50 ug/g will be disposed of at a secure upland chemical waste landfill either within a five-mile radius of the project area or at one of the two approved chemical waste landfills in New York State. The cost of transporting dredged material to EPA approved PCB incinerators in either Arkansas or Texas makes this disposal option economically prohibitive at the present time. If it is determined that landfill disposal either in the State of Massachusetts or out-of-state is not feasible, alternate methods of disposal must be investigated with the EPA Regional Administrator.

For dredging program alternatives involving sediment containing PCB concentrations less than 50 ug/g, shoreline containment has been assumed. Additional sediment analyses will be required to determine whether other contaminants might result in this material being classified as hazardous, based on federal and state regulations, in which case more stringent disposal site requirements would apply. Two available reports have presented evaluations of potential shoreline containment sites for dredged material with less than 50 ug/g PCB.[24,25] Two site categories are of interest:

a) Sites which are suitable for disposal of contaminated harbor muds and which are not needed for harbor facilities.

b) Sites desirable for harbor development which need both structurally sound fill and containment areas for less structurally sound contaminated material removed during site development.

Sites identified in the two reports are shown on Plate 8. A review of possible contaminated dredged volumes and a comparison with identified containment areas suggests that available sites may limit otherwise feasible dredging programs. Further evaluation of these shoreline sites and other possible shoreline disposal options may be required.

Characterization of each of the five alternative programs assuming disposal sites within a five-mile radius of the areas to be dredged, and associated costs, are indicated in Table S-2.

Combinations of the five alternative programs could be implemented to provide for varying degrees of PCB recovery and harbor development. Order of magnitude costs may be developed from the information in Table S-2.

Conclusions

1. Available sediment data indicate that high levels of PCB (greater than 50 ug/g) exist throughout much of the Acushnet River Estuary and in portions of the outer harbor. In the northern tip of the estuary, levels generally exceed 500 ug/g with concentrations greater than 10,000 ug/g indicated at several sampling stations.

TABLE S-2

CONCEPTUAL DREDGING PROGRAMS
(IN-STATE DISPOSAL)
(1981 Dollars)

Alternative	Dredged Material Volumes, Cu.Yds. Remedial Program	Harbor Development Program	Cost $ Millions
1. Dredging and secure containment containing PCB concentration >500 ug/g (Hot Spots I)	70,000	-	6-12
2. Dredge and secure containment of sediments containing PCB concentration >50 ug/g (Hot Spots II)	2,200,000	-	60-70
3. Dredging and containment of sediment with PCB concentration >10 ug/g. Sediment containing PCB concentration equal to 50 ug/g or greater will be contained at a secure upland site. Sediments containing PCB concentrations <50 ug/g will be handled in shoreline disposal areas. (Hot Spots III)	4,400,000		110
4. Initiation of Small Scale Harbor Development (Harbor Development Project C)	-	300,000	15
5. Initiation of Large Scale Harbor Development (Harbor Development Project D)	-	900,000	25

Notes:
Initiation of harbor development projects refers to removal of 3 ft. of harbor muds at sites to be developed.
Small-scale harbor development includes channel improvement dredging, bridge excavation and 35 acres of new harbor development area.
Large-scale harbor development includes channel improvement dredging, bridge excavation and 170 acres of new harbor development area.
Remedial dredging program costs are based on assumptions listed in Section 4 and represent only order of magnitude estimates.

2. Remedial dredging programs to recover PCB-contaminated sediments are technically feasible. The order of magnitude costs given in this report must be compared to anticipated benefits to determine economic feasibility.

3. A remedial dredging program to remove the areas of greatest PCB contamination will probably reduce PCB levels in the water column and in aquatic organisms; however, a quantitative estimate of the extent of PCB reduction in species of commercial and recreational value cannot be made without additional study of PCB transport and uptake.

4. Harbor development programs can be undertaken separately or in conjunction with remedial dredging programs. Disposal site requirements for the dredged material will play a major role in determining the economic feasibility of harbor dredging projects.

Recommendations

1. It is recommended that sampling of sediment, water column and biota PCB levels be continued in the study area. Modeling studies should be undertaken to provide more reliable estimates of the effects of remedial dredging programs on PCB levels in aquatic organisms.

2. In order to refine the technical aspects of remedial dredging programs and their associated costs, several studies should be undertaken including a site investigation study, a probing and sampling study of harbor sediments and pilot studies to determine the settleability and treatability of dredged spoil.

3. A phased remedial dredging program should be implemented if economically feasible. The first stage of the program should include removal of the most contaminated sediments. The extent of the initial dredging program will depend on the availability of both funding and a suitable disposal site with sufficient capacity. After completion of the first stage of remedial dredging, a detailed monitoring program of water column and biota PCB levels should be implemented to determine the actual effects of the dredging program. The need for further dredging can then be evaluated.

4. If it is determined that a remedial dredging program is economically feasible, the implementation stages identified in Item 10 should be initiated.

5. If there is interest in implementing a dredging program for harbor improvement or development, separately or in conjunction with remedial programs, the implementation stages identified in Item 10 should be initiated.

6. The following implementation stages are recommended as a basis for any remedial and/or harbor dredging programs undertaken. The scale and details of the stages would be tailored to the specific program adopted.

   - Detailed planning and preliminary design of elements of the adopted program.
   - Preparation of materials necessary to meet environmental and regulatory requirements.
   - Preparation of final program plans.
   - Execution of adopted program.

THE COMMONWEALTH OF MASSACHUSETTS

ACUSHNET RIVER ESTUARY PCB STUDY

DECEMBER, 1982

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THE COMMONWEALTH OF MASSACHUSETTS
ACUSHNET RIVER ESTUARY PCB STUDY

DECEMBER, 1982

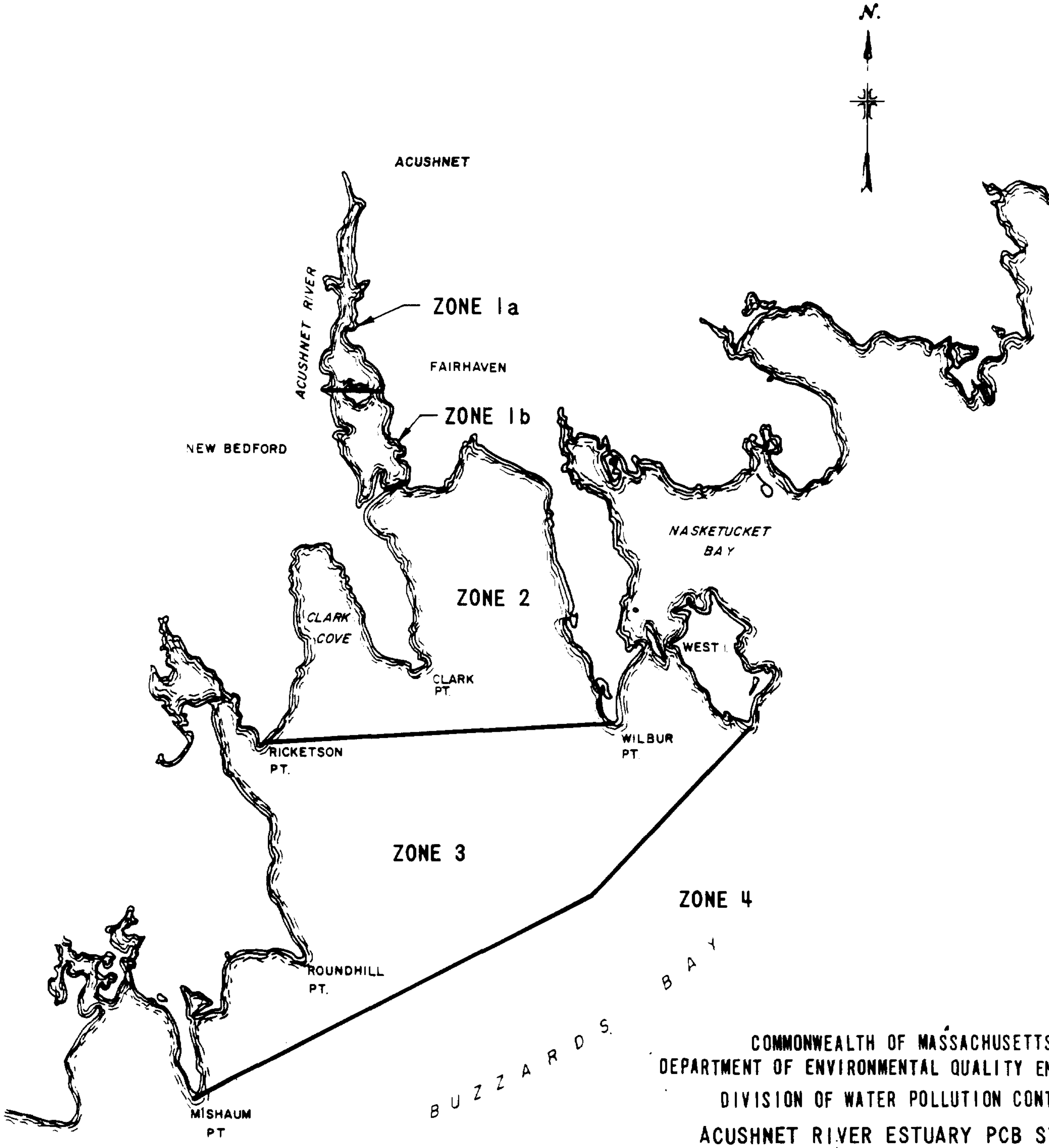
1. INTRODUCTION

This report has been prepared for the Division of Water Pollution Control in order to:

- o assess the nature and extent of the PCB problem in the Acushnet River Estuary-New Bedford Harbor area.
- o identify desirable objectives for environmental improvement.
- o develop alternative improvement strategies.

The Acushnet River is located in southeastern Massachusetts. It has a drainage area of approximately 3.6 square miles. The mouth of the river, a tidal estuary forming New Bedford-Fairhaven Harbor, discharges into the northwestern side of Buzzards Bay. New Bedford is situated on the west side of the harbor and Fairhaven on the east. The Town of Acushnet lies directly north of Fairhaven and is also adjacent to the Acushnet River. Water bodies in the study area are divided into five zones as indicated in Figure 1-1. Copies of navigation charts for these areas are provided in Plates 1 and 2.

FIGURE 1-1



COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF ENVIRONMENTAL QUALITY ENGINEERING
DIVISION OF WATER POLLUTION CONTROL

ACUSHNET RIVER ESTUARY PCB STUDY

STUDY AREA ZONES
1982

SCALE 1: 115,000

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2. PROBLEM DEFINITION AND PROJECT OBJECTIVES

This section provides a summary of the Acushnet River Estuary and New Bedford Harbor PCB problem in terms of:

- o River and Harbor Characteristics
- o PCB Distribution in the Environment
- o Project Objectives

River and Harbor Characteristics

The Acushnet River discharge is relatively small. Discharge rates measured in the Town of Acushnet, approximately three miles upstream of the Coggeshall Street Bridge, over the period 1972 to 1974 ranged from 26 cubic feet per second (cfs) in October 1972 to 0.55 cfs in August 1974.[1] Due to the small river discharge, the Acushnet River Estuary is partially mixed and weakly stratified. The mean tidal range in the estuary is 3.7 feet, and the spring tidal range is 4.6 feet. The small river discharge and tidal fluctuation do not provide vigorous flushing of the harbor.[2]

Harbor Dredging and Other Projects

Within the New Bedford Harbor federal project area, the Corps of Engineers (COE) dredged the maneuvering area and portions of the main channel in and approaching the harbor to a depth of 30 feet in 1952. Approximately 107,700 cubic yards of material were removed and disposed of at a site in Buzzards Bay south of West Island. The COE has indicated that no maintenance dredging is presently planned for the federal project area.[7] Since the COE dredging activities in 1952, local and state interests have undertaken other smaller dredging projects in the harbor.[8]

During the period 1964 to 1966, a hurricane barrier was constructed by the COE to protect the inner harbor from coastal storms and hurricanes. A 150 foot wide opening, which may be closed off with gates, allows access to the inner harbor.[8]

A report prepared by the COE in 1970 recommended several channel improvement projects on the Fairhaven side of the harbor.[8] Although the recommended improvements were not implemented, the New Bedford City Planning Department has recently recognized the need for channel improvements in the federally maintained area and for additional dredging improvements near the marine repair yards within the bulkhead line on the Fairhaven side of the harbor. Dredging is also anticipated in conjunction with the replacement of the New Bedford-Fairhaven (Route 6) Bridge and is necessary to implement several proposed harbor development projects. Potential dredging activities in the harbor are limited by the difficulty involved in satisfying regulatory requirements for the disposal of contaminated dredge material.[9]

Sediment Characteristics

The Acushnet River and New Bedford Harbor have formed in a drowned river valley. Subsurface profiles in the New Bedford area indicate granitic gneiss bedrock overlain with eight to nine feet of glacial till and/or six to nine feet of gravelly sediment. Sands and silts cover these materials. Where bedrock is deepest in the harbor and dredging has not occurred, up to 60 feet of unconsolidated sediment has accumulated.[2]

The movement and distribution of sediments and industrial and organic waste in New Bedford Harbor and its approaches have been studied extensively by Summerhayes et al.[2] Their findings indicate that fine-grained sediments, comprised of silt and clay in suspension, exhibit a net landward movement from the continental shelf via Buzzards Bay into New Bedford Harbor. They estimate that the sedimentation rate in Buzzards Bay and approaches to the inner harbor is about 2 to 3 millimeters per year (mm/yr). Prior to construction of the hurricane barrier in 1966, this rate also applied to shallow areas in the inner harbor, while in deeper, dredged areas of the harbor, sedimentation occurred at a rate of 1 to 2 centimeters per year (cm/yr). The sedimentation rate throughout the inner harbor has increased four to five times since construction of the barrier and is now estimated to be in the range of 8 mm/yr to 1.5 cm/yr in shallow areas. In the deeper areas, the sedimentation rate is estimated to be about 4 cm/yr.

Surface sediments are characteristically dark, organic and fine-grained. Muddy sediments (silt plus clay) cover much of the inner harbor area and the navigation channel.(2) The New England Division Corps of Engineers sampled these areas and found that fine materials account for up to 70 percent of the sediment composition.(3) More mud has accumulated in deeper depressions in the harbor area than in the shallower areas. Deposits of surface silt up to 15 feet thick occur north of the New Bedford-Fairhaven Bridge. North of the hurricane barrier, muds contain less clay and more silt than outside the barrier. Sandy sediments are more predominant near the barrier where stronger tidal currents prevent the settling of fines.(2)

Heavy Metals Distribution

The sediments in New Bedford Harbor and the navigation channel contain sigificant quantities of heavy metals resulting from industrial discharges. The most enriched sediments are surface deposits of silt and clay. These fine-grained particles, having a large surface area to volume ratio, tend to adsorb pollutants and incorporate them into the sediment.(2)

According to Summerhayes et al., the principal contaminants in the inner harbor are copper, chromium, lead and zinc. Copper is the most abundant metal. Chromium, copper and zinc locally comprise more than one percent of the dry weight of sediments in the harbor. Division of Water Pollution Control sampling data indicates that the sediments just north and south of the Coggeshall Street Bridge are most enriched by metals. Copper occurs in greatest concentrations just south of the bridge, in close proximity to a metal discharge on the western bank. Copper concentrations as high as 8,000 ug/g have been measured in sediments in this area.[2,4] The thickest copper deposits are in deeper parts of the harbor; deposits decrease in shallower areas and seaward.[2]

Metal concentrations were analyzed in 14 sediment samples collected from the northern part of the estuary in July 1982. Twelve of the 14 samples had significantly high metal levels. Zinc exceeded 3,500 ug/g dry weight in four samples, copper exceeded 1,000 ug/g in three samples and lead was at least 1,000 ug/g in three of the samples.[33]

The navigation channel south of the hurricane barrier also contains metal-enriched sediments, although not at levels as high as the upper estuary and inner harbor. Moving away from the channel, metal concentrations in sediments indicate no enrichment above typical background levels measured in central Buzzards Bay.[4,5]

Although there is a net landward movement of silt and clay in bottom currents, contaminated sediments still slowly migrate from the harbor, probably by eddy diffusion of resuspended particles. Summerhayes <u>et al.</u> estimate that 24 percent of the metals discharged into the inner harbor have been transported to Buzzards Bay by this mechanism and have formed a carpet 10 to 20 cm thick in some areas.[2]

<u>PCB Distribution in the Environment</u>

PCB was formerly discharged at two locations in New Bedford. One discharge was on the west side of the Acushnet River, north of the Coggeshall Street Bridge. The second discharge was south of the hurricane barrier, on the west side of the outer harbor. In addition, PCB has been and continues to be discharged from the New Bedford Wastewater Treatment Plant. Combined sewer overflows (CSOs) in New Bedford are also suspected of discharging PCB to area waters. The locations of the New Bedford treatment plant outfalls and combined sewer overflows are shown on Plate 3.

Based on sampling results collected over several years, PCB is evident in significant quantities in the sediments and aquatic organisms in the Acushnet River-New Bedford Harbor area. Its presence in other segments of the environment has been the subject of several recent studies (cited below). This section will include discussions of:

- o sediment data
- o surface water quality data
- o wastewater sampling studies
- o biological data
- o ambient air studies
- o landfill studies

Sediment Data

Sediment data for the period 1976 to 1982 are summarized in Table 2-1. Data have been organized to depict geographical variations in PCB levels in Zones la through 4. Data on sediment PCB levels in the Acushnet River-New Bedford Harbor area have also been compiled by the Office of Coastal Zone Management, Woods Hole Oceanographic Institution and the Division of Water Pollution Control.[30,31,32]

Five groups of data were used to estimate the extent of sediment PCB contamination in the upper Acushnet River Estuary and the inner and outer New Bedford harbor (Zones la, lb and 2). Raw data and testing procedures are presented in Appendix A.

1. U.S. Coast Guard sediment data collected in the northern Acushnet River Estuary adjacent to a former PCB discharge point between April 14 and 21, 1982.

TABLE 2-1

ACUSHNET RIVER, NEW BEDFORD HARBOR
AND BUZZARDS BAY

PCB LEVELS, 1976-1982
(ug/g wet weight, except sediment and water column)

Samples	Zone A Upper Estuary	Zone B Inner Harbor	Zone C Outer Harbor	Zone D Inner Bay	Zone E Outer Bay
SEDIMENT(1) 1976-1980					
Number of sampling locations(2)	35	36	26	1	21
Minimum	ND	ND	0.2	ND	ND
Maximum	1250.0	82.0	143.0	ND	0.54
Median	10.8	3.5	5.6	*	0.113
SEDIMENT(1) 1981-1982					
Number of sampling locations(2)	59	12	23	0	0
Minimum	23.0	0.6	0.9	-	-
Maximum	31,195.0	36.0	93.0	-	-
Median	459.0	9.0	11.0	-	-
WATER COLUMN(3) 1976-1982					
Number of samples	7	3	9	0	0
Minimum	ND	ND	ND	-	-
Maximum	4.0	ND	<0.5	-	-
Median	ND	*	ND	-	-
SHELLFISH 1976-1982					
Number of samples	4	3	34	19	13
Minimum	14.6	1.6	0.001	0.001	0.001
Maximum	53.0	15.8	3.5	0.6	0.321
Median	*	*	0.4	0.2	0.05
CRUSTACEANS(4) 1976-1980					
Number of samples	1	2	67	77	13
Minimum	1.0	4.2	0.6	0.1	0.02
Maximum	1.0	5.6	68.2	35.5	7.2
Median	*	*	5.6	3.4	0.07
CRUSTACEANS(4) 1981-1982					
Number of samples	0	0	0	69	21
Minimum	-	-	-	0.1	0.3
Maximum	-	-	-	8.9	7.0
Median	-	-	-	2.0	1.5

TABLE 2-1
(Continued)

ACUSHNET RIVER, NEW BEDFORD HARBOR
AND BUZZARDS BAY

PCB LEVELS, 1976-1982
(ug/g wet weight, except sediment and water column)

Samples	Zone A Upper Estuary	Zone B Inner Harbor	Zone C Outer Harbor	Zone D Inner Bay	Zone E Outer Bay
EEL(4) 1976-1982					
Number of samples	12	4	3	0	0
Minimum	11.0	19.0	12.2	-	-
Maximum	730.0	41.0	38.0	-	-
Median	335.0	*	*	-	-
BOTTOM FEEDING FISH(4) 1976-1982					
Number of samples	0	21	52	39	19
Minimum	-	2.1	ND	ND	0.01
Maximum	-	22.0	57.0	11.0	20.0
Median	-	10.0	1.8	0.9	0.1
MIGRATORY OR SURFACE FEEDING FISH 1976-1982					
Number of samples	0	0	21	0	23
Minimum	-	-	0.11	-	0.1
Maximum	-	-	16.5	-	1.3
Median	-	-	0.9	-	0.5

Notes:
(1) Units are ug/g dry weight for sediments samples.
(2) Data presented are based on average core values at sampled locations as well as individual surface samples.
(3) Units are ug/l for water column samples.
(4) Samples from a single sampling site (or in close proximity to one another) which were composited or averaged together were considered as one single PCB value.
* Insufficient data to determine median
ND None detected

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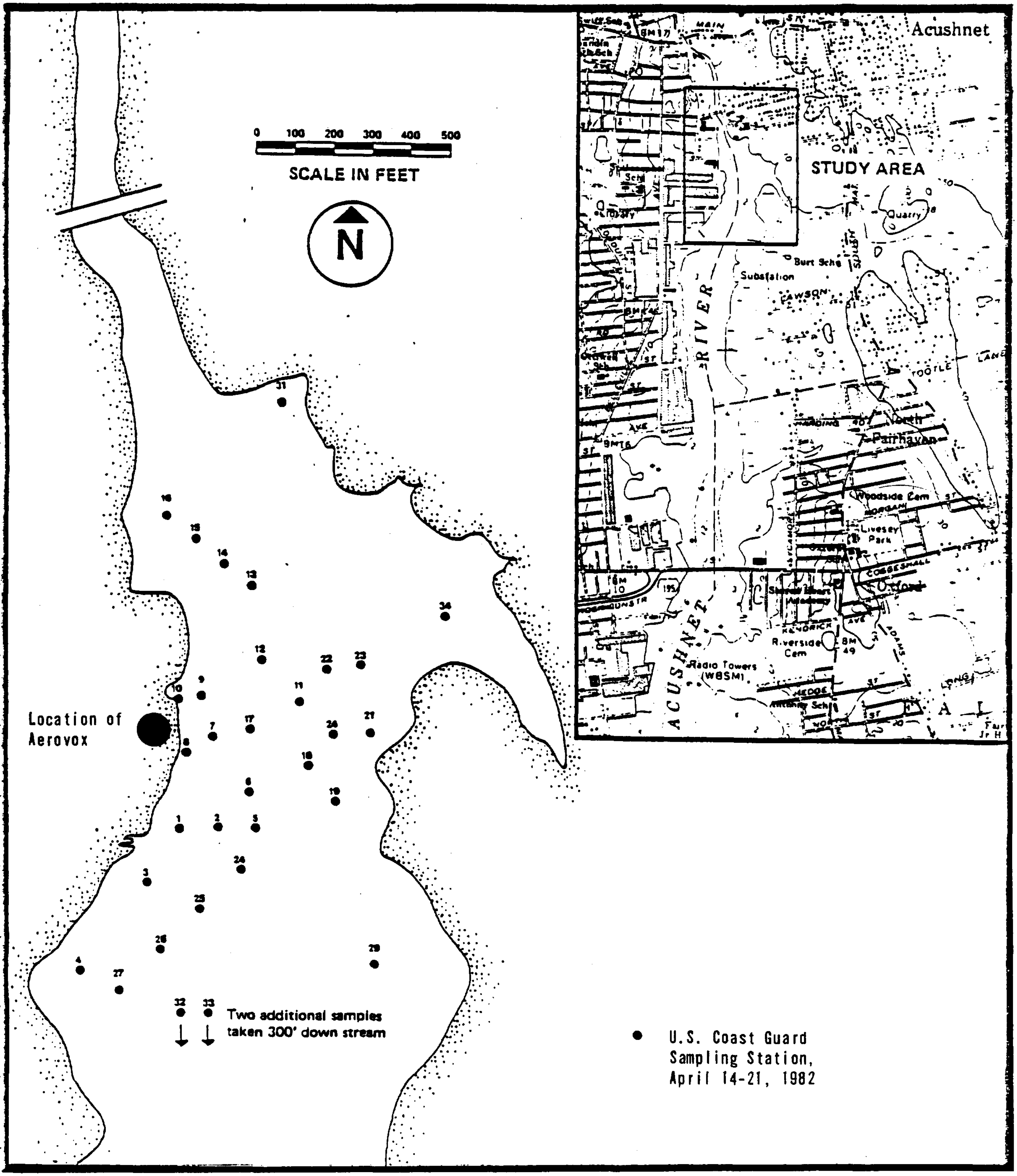
Three cores (A, B, C) were taken at each of the 33 sampling stations shown on Figure 2-1. Core depths averaged approximately 13 inches, although sample depths varied between 6-1/2 and 26 inches. A total of 99 composite samples from the 33 sites were tested for PCB. Three composite PCB concentrations are presented for each sampling station - one for the top inch of sediment, one for the sediment slice between 5½ and 6½ inches of depth, and one for the bottom inch or two of the cores taken at that station. PCB concentrations in these samples were calculated against Aroclor 1254 as a standard.

2. U.S. Coast Guard sediment data collected June 7, 1982. Ten sediment cores were taken along two transects approximately 1800 feet north of the Coggeshall Street Bridge as shown on Plate 4. PCB concentrations were analyzed in terms of Aroclor 1254 for three slices of each core - the top inch, the slice between 5½ and 6½ inches, and the bottom inch or two.

3. Commonwealth of Massachusetts Division of Water Pollution Control sediment data collected in July and October 1981. Samples were collected along nineteen transects beginning in the northern part of the estuary and running south to the outer harbor in the area of the New Bedford Sewage Treatment Plant outfalls as shown on Plate 5. Although many of the samples taken in the upper estuary were cores of depths between eight and 22 inches, all of the samples collected in the inner and outer harbor areas were surface samples of approximately four inches in depth. In general deeper cores (>4 inches) were tested in composite sections, i.e. 0-4", 4-8" and 8-12" for a 12 inch core. Surface samples (0-4") were tested on a single composite. Samples were tested for Aroclors 1248, 1242, 1260 and 1254. Test results were reported as Aroclor 1248 and 1254 with Aroclor 1248 predominating greatly in the estuary and a mixture of both found in the inner and outer harbor areas.

4. Commonwealth of Massachusetts Department of Environmental Quality Engineering data collected in May 1978, August 1979 and on September 30, 1980 at each of the 24 DEQE PCB sediment stations shown on Plate 6. Sediment samples ranged in depth from two inches to 14 inches. In general, deeper cores (over 4 inches) were tested in composite sections, i.e. 0-4", 4-8" and 8-12" for a 12-inch core. Surface



Adapted from Figure by Geotechnical Engineers, 1982.

LOCATION OF 33 SEDIMENT STATIONS SAMPLED BY THE U.S. COAST GUARD BETWEEN APRIL 14 AND 21, 1982 samples (0-4" and less) were tested as a single composite. Samples taken in 1978 and 1979 were measured against Aroclor 1254; 1980 samples were analyzed for Aroclors 1016 and 1254.

5. Additional sediment data from a number of other sources was also considered. These sources include the U.S. Environmental Protection Agency (USEPA), Camp, Dresser, and McKee, Inc. (CDM), Tibbets Engineering Corp., Woods Hole Oceanographic Institution (WHOI), New England Aquarium, Dept. of Environmental Quality Engineering (DEQE) and the Division of Marine Fisheries (DMF). Although less comprehensive than the data described above, this data was also used in evaluating the extent and level of PCB contamination in the study area.

Available sediment data indicate that in the northern portion of the upper estuary (Zone 1a), PCB concentrations generally exceed 500 microgram per gram (ug/g) dry weight, and at some locations are greater than 10,000 ug/g. These are the highest PCB levels which have been measured to date and are in the vicinity of a former PCB discharge point. PCB levels exceeding 50 ug/g extend as far south as Pope's Island in Zone 1a, and are present in the northwest corner of the outer harbor and in the vicinity of the New Bedford Sewage Treatment Plant Outfalls (Zone 2). Concentrations of 10-50 ug/g occur in the periphery areas of the inner harbor (Zone 1b) with lower concentrations evident in the navigation channel. Another area containing PCB in concentrations of 10-50 ug/g is also located along the western shore of the outer harbor (Zone 2), near another former PCB discharge point.

PCB sediment concentrations are based on the levels of various PCB Aroclors measured in the sample. From the description of data used, it is evident that analytical methods for determination of PCB concentrations differ considerably. In some cases, samples were analyzed for Aroclors 1242, 1248, 1254 and 1260 while in other cases only Aroclor 1254 or 1254 and 1016 were used as standards for analysis. Sediment analyses conducted previously by Woods Hole Oceanographic Institution indicate that the majority of PCB in the sediments is in the form of Aroclors 1016 or 1242, which are very similar mixtures, with a much smaller amount of Aroclor 1254.(27) According to the Woods Hole data, the ratio of Aroclors 1242-1016 to 1254 is approximately three to one. The Woods Hole data indicates that actual PCB quantities may be up to three times higher than estimated in some areas. Additional evaluation of analytical procedures is necessary to resolve this discrepancy and make more accurate estimates of PCB quantities in the sediments.

Surface Water Quality Data

Surface water data is summarized in Table 2-1. In connection with the 301(h) waiver evaluation, Camp, Dresser and McKee, Inc. (CDM) collected two grab samples in the vicinity of the New Bedford Wastewater Treatment Plant outfalls to assess water quality.(17) All aroclors were undetected except 1254. In the two samples, Aroclor 1254 was detected at <0.05 micrograms per liter (ug/l) and <0.5 ug/l.

The Division of Water Pollution Control collected water samples for PCB analysis from the estuary and the inner and outer harbor in July 1981. An additional sample was collected from the Acushnet River at Hamlin Street, north of the estuary. This sample and another sample collected at the Main Street Bridge at the extreme northern end of the estuary did not have detectable levels of PCB. The detection limit in these analyses was 0.5 ug/l. However, measurable levels of PCB were detected at five other sampling stations north of Pope's Island. Of these, the three northernmost samples showed Aroclor 1248 at levels of 4.0, 2.7 and 2.4 ug/l. The highest levels were measured in the area of the highest sediment concentrations. Closer to Pope's Island, the two other samples both measured 1.2 ug/l of Aroclor 1242. Although not quantifiable, a trace amount of Aroclor 1242 was also noted in an additional sample collected north of Pope's Island near the Coggeshall Street Bridge. All other stations south of Pope's Island and in the outer harbor, including in the vicinity of the New Bedford treatment plant outfall, did not have detectable levels of the seven Aroclors analyzed.

Although the measured levels do not exceed EPA's criterion of 10 ug/l for an acute toxic concentration, these levels would, if measured over a 24-hour period, exceed the EPA 24-hour criterion of 0.03 ug/l.

Wastewater Sampling Studies

A sampling program was conducted in February and March 1981 to evaluate PCB levels in the New Bedford sewers and in the wastewater treatment plant streams. Sewers above and below two former PCB industrial dischargers were sampled. PCB was detected in sewer samples collected below one of these industries. Concentrations were 118.8, 51.0 and 13.9 ug/l in these samples, which contained both PCB Aroclor 1016 and 1254. PCB was also reported in samples of treatment plant influent. Measured values were 7.61 ug/l PCB 1254 and 1.28 ug/l PCB 1016. PCB in other influent samples was probably below the detectable level of 0.02 ug/l. Two of the eight effluent samples had measurable quantities of PCB 1016, with concentrations of 8.16 and 1.43 ug/l. Assuming a treatment plant flow of 27 million gallons per day, these correspond to effluent discharges of 1.8 and 0.3 pounds per day PCB, respectively. PCB was detected in the five treatment plant sludge samples. The average value of the samples was 325 micrograms per kilogram. PCB 1016 and 1254 were reported in all but two samples, which contained only PCB 1016.[6]

CDM also measured PCB in New Bedford treatment plant effluent during wet and dry periods. Aroclor 1254 was measured at 10 ug/l during wet weather in both a homogeneous and supernatant sample. Aroclor 1016 was measured at 11 ug/l and 10 ug/l in homogeneous and supernatant samples during the same wet weather period. Dry weather flows had 9.3 and 7.1 ug/l of Aroclor 1232 in the homogeneous and supernatant samples.[17] Other studies have indicated that PCB concentrations in primary treatment plant effluent from highly industrialized areas range from 1.7 to 4.4 ug/l.[34]

Other than the New Bedford Wastewater Treatment Plant, a single industrial firm is the only other active PCB discharger in New Bedford. The NPDES permit for this firm allows small quantities of residual PCB to be discharged into a combined sewer line flowing to the outer harbor. Monthly sampling records for 1980 indicate that the PCB discharge ranged from 1.9×10^{-4} to 7.5×10^{-3} pounds per day.[19] PCB is not normally expected in sewer lines below this firm which are tributary to the treatment plant. However, the February-March 1981 sampling program indicated that PCB may enter the sewer system and treatment plant from this source.[6]

Other combined sewer overflows are also suspected of discharging PCB to the inner and outer harbor during storm events, although comprehensive sampling of CSOs has not be undertaken to quantify the potential PCB contribution from these overflows.

In summary, it is apparent that PCB is still present in New Bedford wastewater flows and is entering area waters in measurable quantities via treatment plant and industrial discharges.

Biological Data

Sources of biological data used in this report and summarized in Table 2-1 include:

- o Massachusetts Division of Marine Fisheries (DMF)
- o Massachusetts Department of Environmental Quality Engineering (DEQE)
- o U.S. Food and Drug Administration (FDA)
- o U.S. Environmental Protection Agency (EPA)

- Woods Hole Oceanographic Institution (WHOI)
- Southeastern Massachusetts University (SMU)
- Camp, Dresser and McKee, Inc. (CDM)

The biological data summarized in Table 2-1 indicate that aquatic organisms inhabiting the Acushnet River-New Bedford Harbor area contain elevated levels of PCB. PCB concentrations in fish flesh are generally higher in the upper estuary and inner harbor (Zones 1a and 1b), with decreasing levels seaward. Eels collected in Zone 1a have had PCB levels as high as 730 ug/g wet weight, well above the current FDA limit of 5 ug/g (2 ug/g is the proposed limit). Levels exceeding 5 ug/g have also been measured in finfish collected from the inner harbor (Zone 1b). More than half of the lobster samples (crustaceans) collected in Zone 2 have had PCB levels greater than 5 ug/g. In Zones 3 and 4, median levels have been less than 5 ug/g, but individual samples still exceed the FDA limit.

As a result of high PCB levels measured in aquatic species in the area, the Massachusetts Department of Public Health placed restrictions on the fishery in September 1979. At that time, Zones 1a, 1b and 2 were already closed to shellfishing due to bacterial contamination. The result of the PCB-related fishery closure was that Zones 1a and 1b are closed to the taking of all shellfish, finfish and lobster, Zone 2 to the taking of bottom-feeding finfish and lobster, and Zone 3 to the taking of lobster. Lobster is the principle commercial species affected by the PCB closure. Eel and numerous finfish species, including flounder, are among the recreational species affected.

Results of lobster sampling in Zone 3 over the past three years have indicated that PCB levels are generally higher in samples collected in the spring than in those samples collected during the fall-winter season. The most recent lobster sampling undertaken in Zone 3, in the spring of 1982, showed average PCB levels greater than 5 ug/g at 8 of the 11 sites sampled. None of the samples collected and analyzed in the fall of 1981 exceeded 5 ug/g.[35] Based on similar results in preceding years, the Division of Marine Fisheries requested in 1981 that the Department of Public Health consider reopening Zone 3 to lobstering.[22]

Ambient Air Data

Airborne PCB, the result of volatilization, may occur in either the vapor phase or be adsorbed onto suspended particles. Its presence in air may be a source of low level exposure for residents near the PCB source. In addition, PCB may be removed from the atmosphere by deposition and rainfall washout, thereby increasing concentrations on land and in water. Three short-term air sampling programs have been conducted in New Bedford to measure ambient air PCB levels. The first sampling program was undertaken at the New Bedford municipal landfill in June 1977.[13] Additional sampling was performed in January and September 1978 upwind and downwind of the landfill, the New Bedford sewage sludge incinerator (January only), and two industrial firms which previously used PCB in their manufacturing processes.[14,15]

The highest PCB value noted during the three periods, 1.19 micrograms per cubic meter (ug/m^3), was measured in June 1977 at the municipal landfill. Landfill values were lower during the other two sampling periods, indicating that summer temperatures may increase PCB volatilization from this source. None of the samples collected at the landfill or at other sites in January and September 1978 exceeded 1 ug/m^3. During the January 1978 sampling, values measured downwind of the sewage sludge incinerator and one of the industries were higher than upwind values. In September 1978, both industries measured higher downwind than upwind PCB values.[14,15]

A sampling and analysis program was carried out at the New Bedford sewage sludge incinerator in 1977 to determine PCB concentrations and mass emission rates emanating from the incinerator. Results indicated that PCB compounds are broken down during incineration although the actual efficiency of the incinerator could not be determined from the data. Dichloro and trichloro PCB derivatives were emitted in the flue gas, presumably the incomplete and potentially toxic breakdown products of incineration. A mass balance of influent and effluent streams for the incinerator/scrubber system indicated an average PCB reduction of approximately 60 percent.(16)

The amount of PCB emitted in flue gas from the stack accounted for only two to three percent of the total PCB input while scrubber water effluent represented from 16 to 37 percent of the input. Concentrations in the flue gas ranged from 3.08 ug/m^3 to 10.56 ug/m^3, resulting in emission rates of 8.28 milligrams per hour (mg/hr) to 25.48 mg/hr.(16)

The air quality and incinerator emissions data available to date indicate that the municipal landfill, the two industrial firms sampled in the New Bedford area and the sewage sludge incinerator are low level sources of atmospheric PCB.

Landfill Studies

The New Bedford municipal landfill is located north of Interstate 95 and west of Route 140. Apponagansett Swamp lies to the north and west. The Paskamanset River is one-half mile to the west. The landfill contains over one-half million pounds of PCB which have been disposed of by two New Bedford capacitor manufacturing plants. The landfill has not been used for PCB disposal since 1976. A study was conducted in 1977 to evaluate the movement of PCB from the landfill and its impact on the surrounding environment. The major findings of the study were that PCB had moved into the shallow aquifer northwest of the landfill but that the areal extent of contamination was limited. Low level PCB accumulation was evident in aquatic and terrestrial organisms near the landfill, especially benthic organisms. Surface soils and river bottom sediments north of the landfill also exhibited PCB contamination. Elevated PCB levels were apparent in landfill ambient air samples and in herring gull eggs from a nearby colony.[13]

Another New Bedford site known as Sullivan's Ledge was formerly used by the city as an industrial dumpsite. Although no longer utilized, it is believed that PCB was disposed of at this site in the past. There is little information on the potential extent of contamination. Two samples have been collected from the area and analyzed for PCB. In a water sample obtained from a brook adjoining the property, no detectable levels of PCB were found. A sediment sample from the brook contained PCB at a concentration of 0.288 ug/g. Other historical dumpsites in New Bedford and adjacent communities may also contain PCB wastes.[30]

Project Objectives

The presence of PCB-contaminated sediments in the Acushnet River Estuary-New Bedford Harbor area has two major economic impacts:

- A fishery closure in Zones 1a, 1b, 2 and 3.
- Restrictions on harbor development in Zones 1a and 1b.

There are other impacts associated with the presence of PCB in the study area, including the potential effects on public health and overall environmental quality, which are not addressed in this report.

Restoring the viability of the commercial and recreational fishery in the Acushnet River Estuary-New Bedford Harbor area is a principal objective in undertaking a study of remedial programs to reduce PCB in the environment. In order to meet the FDA limit, PCB levels in fish flesh must be less than 5 ug/g wet weight. Reopening of the fishery would reduce adverse recreational and economic impacts resulting from the present closure.

A second major objective in considering possible dredging programs is to reduce present constraints on harbor improvement and development projects. Regulatory requirements currently make it difficult to dredge areas where harbor projects are proposed due to the presence of PCB and other contaminants, such as heavy metals, in the sediments. In order to implement the proposed projects, it is necessary to develop acceptable methods for sediment dredging and disposal.

3. TECHNICAL CONSIDERATIONS

The development of an effective improvement program for the Acushnet River Estuary PCB problem requires the consideration of several engineering and environmental factors.

Engineering Elements

Two previous studies of PCB-contaminated waterways, Hudson River, New York[12] and Waukegan Harbor, Illinois[16], have concluded that dredging is the only currently feasible remedial action. Concepts of in-place fixation, neutralization or stabilization do not appear to have either technical, economic or environmental feasibility. Therefore, the action considered is recovery of contaminated sediments by dredging and placement in a suitable containment site.

Dredging systems for removal and disposal of PCB contaminated sediments have two distinct operations: 1) the excavation and transport of sediment from the contaminated areas, and 2) the subsequent disposal of the excavated material at a suitable site where it will be stabilized and covered.

Previous studies of similar problems have concluded that two types of dredging equipment are the most feasible and environmentally acceptable: the hydraulic cutterhead dredge and the clamshell dredge. For the hydraulic cutterhead dredge, the transportation of the excavated material would be via hydraulic pipe with or without a booster pump, depending on the location of the disposal site and the particular area dredged. For the clamshell dredge, the transportation of the dredge material would be via barges to the disposal area. The method of unloading the barges would depend on the type of excavated material and its physical properties. Mechanical unloading of the material to the site or a hydraulic pumpout system with or without recycling of the waters are possible alternatives.

A third type of dredge which may be applicable to New Bedford Harbor has been recently developed by Amtec Development Company and is currently available and operating in the United States. This Amtec dredge, which is based on pneumatic dredging principles, deserves further consideration because of its supposed applicability in sediments containing mostly silts and clays, and its ability to minimize sediment suspension downstream of the dredging operation. A more detailed discussion of alternative dredging technologies is presented in Appendix B.

The final selection of the dredging-transport-unloading system will depend on the following:

1. Type and physical properties of the dredge material.
2. Location of the disposal site.
3. Ease of access to the disposal site.
4. Ease of rehandling of the dredge material at disposal site.
5. Availability of land for treatment of return waters.
6. Economic effectiveness of the system for the above conditions.

Sediment Data Analyses

Available sediment data were analyzed, and the upper Acushnet River Estuary and inner and outer New Bedford Harbor areas (Zones 1a, 1b and 2) were delineated into four categories based on present PCB concentrations.

- Areas with PCB concentrations greater than 500 ug/g (ppm) dry weight.
- Areas with PCB concentrations between 50 and 500 ug/g (ppm) dry weight.
- Areas with PCB concentrations between 10 and 50 ug/g (ppm) dry weight.

- o Areas with PCB concentrations less than 10 ug/g (ppm) dry weight.

The following subsections describe the methods of data analysis, the delineation of areas of PCB concentration, and volumes of PCB contaminated sediment.

Sediment data analysis is presented for three levels of PCB contamination - PCB levels greater than 500 ug/g dry wt; PCB levels between 50 and 500 ug/g; and, PCB levels between 10 and 50 ug/g.

PCB Concentrations Greater than 500 ug/g Dry Wt

The highest levels of PCB concentration (levels greater than 500 ug/g) exist in the northern estuary in the area of a former PCB discharge point. As discussed earlier in Section 2, the U.S. Coast Guard took sediment samples at 33 stations in this area in April 1982. In general, this data showed high levels (greater than 500 ug/g) of PCB concentration in the 0-1 inch samples and the sample slice between 5½ and 6½ inches, with lower concentrations in the bottom sediment sample slice. Median and average PCB concentrations for each core section are given in the following table.

Core Slice	Median PCB Concentration ppm dry weight	Average PCB Concentration ppm dry weight
0-1"	1250	1947
5½-6½"	1430	7581
Bottom 1 or 2"	26	231*

* Excludes one value of 19,650 ug/g dry weight. Including this unusually high value yields an average PCB concentration of 838 ug/g dry weight.

Seven of the 99 samples tested showed levels of PCB concentration in excess of 10,000 ug/g (dry weight) - one sample in the top 0-1 inch, five in the slice between 5½ and 6½ inches, and one in a bottom slice between 8½ and 9½ inches. As evidenced by a comparison of median and average PCB values in the above table, these seven very high data points greatly influence the average concentrations over the entire area.

In general the data seems to indicate that elevated PCB concentrations exist to a depth of two feet in this area. Only two samples were tested at depths slightly greater than 24 inches, one with a PCB concentration of 9 ug/g, the other 20 ug/g.

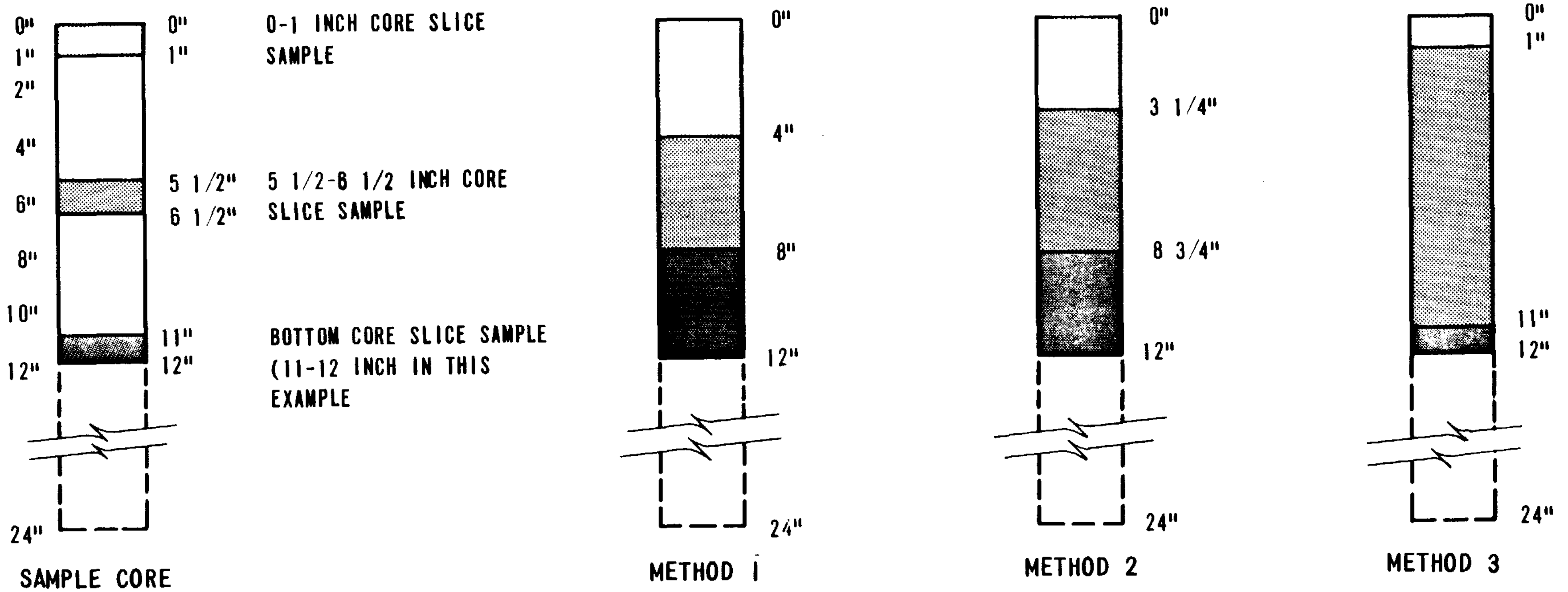
In order to determine a range of average PCB concentrations throughout the entire sampled area, four methods were used on the Coast Guard data to weight the given PCB concentrations over the depth of the samples (see Figure 3-1).

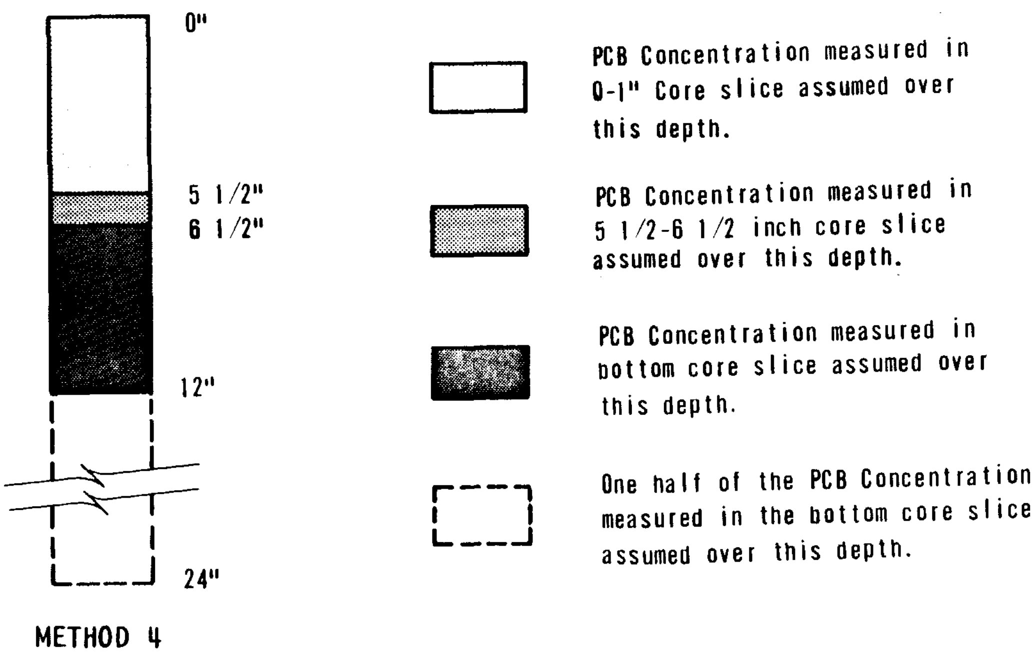
Method 1 - The concentration at each tested slice in a core was assumed to exist over one-third of the core's depth. This method weights each sample equally.

Method 2 - Centerlines were established between each tested core slice, and the concentration measured at each slice was assumed to exist over the depth of the core bounded by the centerlines above and below the tested slice. The upper boundary for the top 0-1 inch slice was the top of the core; the lower boundary for the bottom slice was the bottom of the core.

Method 3 - This method was used to establish a reasonable worst case average PCB concentration. Because the 5½-6½ slice had the highest median and average PCB concentrations when calculated over all 33 stations, the 5½-6½ slice PCB concentration was assumed to exist over the entire depth between the bottom of the top slice and the top of the bottom slice.

Method 4 - In this analysis, the PCB concentration tested in the 5½-6½ inch slice was assumed to exist only in that slice. The core above 5½ inches was assumed to have the top slice PCB concentration and the core below 6½ inches was assumed to have the bottom slice concentration from 6½ inches to the bottom of the sample.





NOTES:

1: Example is based on a sample core depth of 12 inches.

2. A two-foot depth of PCB contamination is assumed in this area of the Acushnet River Estuary.

FOUR METHODS USED TO ANALYZE COAST GUARD SEDIMENT DATA COLLECTED AT 33 STATIONS IN APRIL 1982

FIGURE 3-1

Under each of these methods the depth of PCB contamination was assumed to be 24 inches. The PCB concentration tested in the bottom slice of the sample core was assumed to decrease linearly to a concentration of zero at a depth of two feet.

The average PCB concentration calculated for each sampling station under each of the four methods is presented in Table 3-1.

The average PCB concentrations calculated for the entire sampling area of approximately 31 acres under each method are listed below. In this calculation each sampling station was weighted equally. These values are useful only in providing a general range of contamination level and PCB poundage due to the offsetting effect of several very high values in the data base.

Method	Ave. PCB Concentration in top two feet of sediment over 31 acres in Northern Estuary Area Sampled by Coast Guard	Corresponding Estimate of PCB Quantity in Pounds
1	2500 ug/g	600,000
2	2900 ug/g	700,000
3	4200 ug/g	1,000,000
4	1400 ug/g	350,000

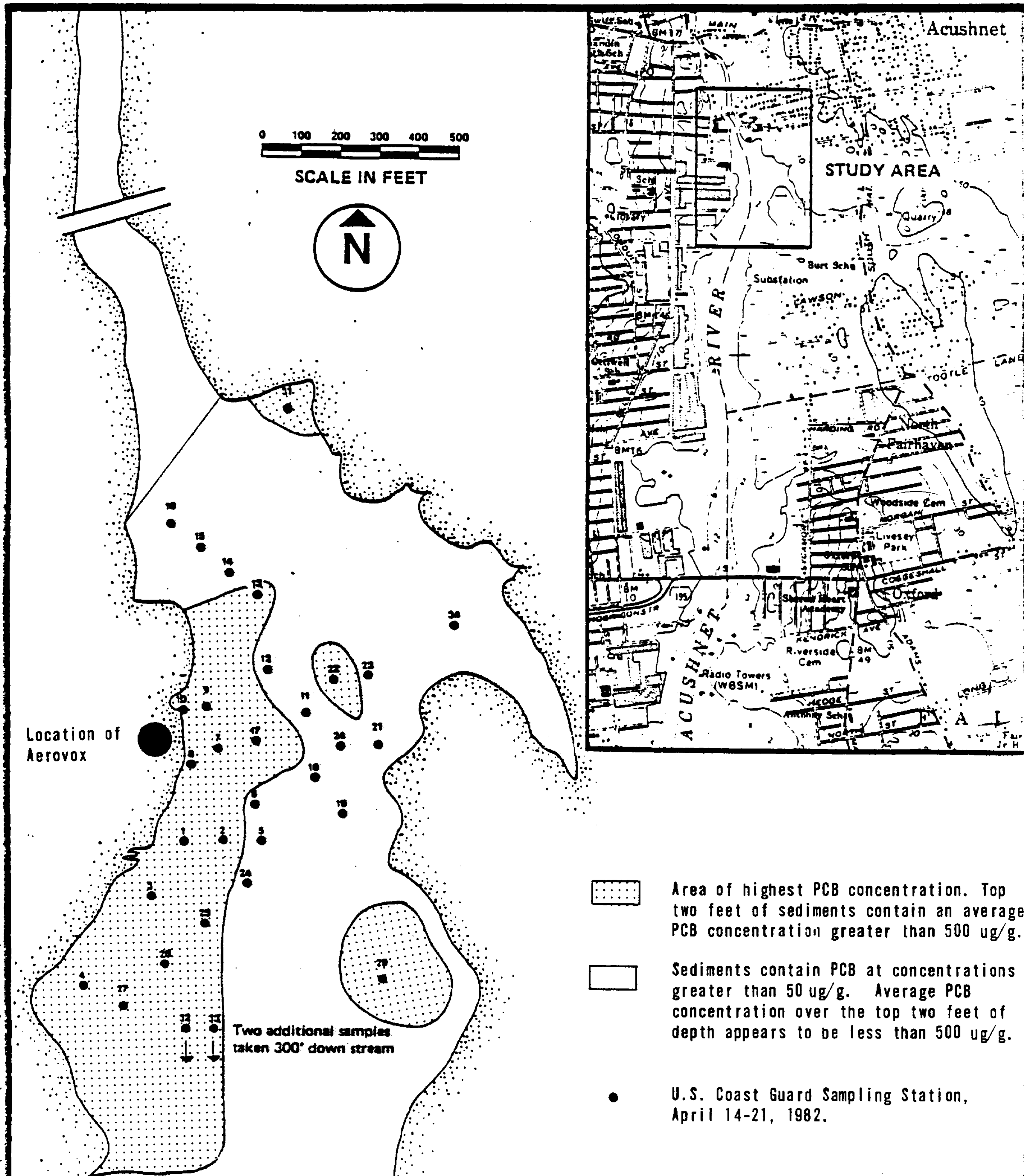
Method 2 was then chosen to do a more detailed analysis of the extent and concentration of PCB contamination in this area. Figure 2-1 shows the location of each of the 33 sampling stations. Using the PCB concentration calculated over the two-foot contamination depth from Method 2, an area of PCB concentration greater than 500 ug/g (dry wt) was delineated. As shown in Figure 3-2, the area of greatest contamination is generally along the western bank of the estuary although several areas of very high (greater than 500 ug/g) concentration were found at several places along the eastern bank. Results of the analysis show that this area

TABLE 3-1

RESULTS OF ANALYSES OF U.S. COAST GUARD DATA
FROM 33 STATIONS IN THE NORTHERN ACUSHNET RIVER ESTUARY

(APRIL 1982 SAMPLING)

Sample Station No.	Ave. PCB Conc. ppm dry weight in 24-inch contaminated depth assuming bottom of sample PCB concentration decreases linearly to a PCB concentration of zero at a depth of 24-inches Method #1	Method #2	Method #3	Method #4
1	1,017	1,066	1,216	918
2	6,812	9,230	16,719	1,742
3	897	720	747	693
4	501	436	426	446
5	184	172	182	170
6	225	213	208	216
7	2,370	2,468	4,170	767
8	3,192	3,891	6,333	1,449
9	21,446	21,447	23,478	16,284
10	9,864	9,189	9,994	9,610
11	286	188	192	303
12	132	156	117	195
13	422	509	770	248
14	232	240	290	192
15	315	300	364	236
16	36	30	16	45
17	1,161	1,419	2,151	686
18	366	402	458	346
19	418	422	512	333
20	348	366	411	318
21	321	387	484	288
22	582	735	1,192	276
23	231	202	90	314
24	248	375	360	266
25	1,287	1,540	2,196	687
26	1,782	2,164	3,309	1,020
27	12,375	16,904	30,568	3,234
28	10,540	13,497	24,566	2,412
29	927	902	1,473	326
30	478	393	312	474
31	662	742	741	742
32	2,457	2,504	2,949	2,058
33	872	1,118	1,852	381



Adapted from Figure by Geotechnical Engineers, 1982.

PCB CONCENTRATIONS IN THE NORTHERN ACUSHNET RIVER ESTUARY BASED ON DATA COLLECTED BY THE U.S. COAST GUARD IN APRIL 1982 contains approximately 14 acres of PCB contaminated sediment at levels greater than 500 ug/g over a two-foot contaminated depth. This acreage contains approximately 300,000 to 400,000 pounds of PCB. Assuming a dredging depth of three feet the volume of material to be dredged would be approximately 70,000 cu yds.

PCB Concentrations between 50 and 500 ug/g Dry Weight

In order to delineate areas in the lower estuary and inner and outer harbor areas with PCB concentrations between 50 and 500 ug/g dry weight, all of the available data was plotted and all of the areas with any PCB levels measured between 50 and 500 ug/g were delineated. More recent data collected in 1981 and 1982 showed PCB concentrations much higher than earlier data. In general this more recent data supplemented rather than contradicted earlier data because more recent samples were not taken at the same stations as the earlier data.

Three areas were identified with PCB concentrations in this range and are shown on Plate 7.

- o Most of the Acushnet River Estuary south to Pope's Island.
- o The northwest corner of the outer harbor just outside the hurricane barrier.
- o The area surrounding the large outfall at the New Bedford Sewage Treatment Plant.

No samples have been taken in the eastern portion of the estuary immediately north of Pope's Island, so the inclusion of this area is only tentative.

PCB Concentrations between 10 and 50 ug/g Dry Weight

A similar analysis was made to delineate areas of possible PCB contamination with concentrations between 10 and 50 ug/g. Again, all areas with any tested PCB levels greater than 10 ug/g but less than 50 ug/g were included. Areas containing PCB concentration in this range were delineated along the periphery of the inner New Bedford Harbor (Zone 1b) and along the western shore of the outer harbor (Zone 2) in the area of a former PCB discharger as shown on Plate 7.

Dredging

There are two categories of areas to be dredged, areas of greatest PCB contamination and harbor development sites. Plates 7 and 8 identify these areas. Dredge volumes are based upon a three-foot depth of cut. This depth is used for planning purposes in order to insure recovery of contaminated material and allow for variations in dredging equipment performance. The major dredging system assumed for this preliminary analysis is a clamshell dredge and barge transport system. The clamshell dredge would employ a five-cubic-yard bucket and have a production rate of about 100,000 cubic yards per month. This system would use 1,000 cubic yard barges for transport of dredge material. The daily production would be 4,000 cubic yards, which would require four barge trips per day. Details of the dredge system and cost analysis are given in Appendix A. For small projects involving highly contaminated material and a nearby upland disposal site, hydraulic dredging is assumed. Dredging and disposal operations in or affecting state waters will be subject to state water quality certification and Corps of Engineers permit approval, in addition to applicable disposal regulations discussed below.

Dredge Material Disposal

The federal Toxic Substances Control Act (TSCA) currently requires that dredged material containing PCB concentrations of 50 ug/g or greater (dry weight) be disposed of by one of the following three methods:

- in an approved incinerator

- o in an approved chemical waste landfill
- o by use of another method approved by the EPA Regional Administrator

The 50 ug/g TSCA designation is based on the highest measured PCB concentration in the sediment in situ, not on the estimated PCB concentration in the proposed dredged volume. Estimated PCB levels in the dredged sediment could be considerably less due to the inclusion of less contaminated material.

There are currently only two incinerators approved by the EPA for PCB disposal - one in El Dorado, Arkansas and one in Deer Park, Texas. The cost of transporting dredged materials from the New Bedford area to either Arkansas or Texas makes the option of disposal in an approved incinerator economically prohibitive at this time.

The second alternative, disposal in an approved chemical landfill, can be achieved in several ways:

- o Development of an approved chemical waste landfill within a five-mile radius of the area of PCB contamination.
- o Development of an approved chemical waste landfill within the State of Massachusetts at a distance of greater than five miles from the area of PCB contamination, and the construction of a temporary dewatering and material rehandling area within a five mile radius of the area of PCB contamination.
- o Disposal of PCB-contaminated dredge spoil out-of-state at a currently operating approved chemical waste landfill. This will require the construction of a temporary dewatering and material rehandling area within a five mile radius of the area of PCB contamination.

A preliminary review of the soils within a five-mile radius of the New Bedford Harbor indicates that a limited number of acceptable sites for upland disposal may exist in the area. In addition to meeting TSCA regulations, a chemical waste landfill in the State of Massachusetts would also have to satisfy state hazardous waste landfill siting requirements. Resource Conservation and Recovery Act (RCRA) regulations may also apply to the disposal site facility if RCRA-regulated substances, such as heavy metals, are present at hazardous concentrations in the dredged sediments.

In the event that a suitable site for the development of a chemical waste landfill cannot be found within a reasonable distance of New Bedford Harbor, out-of-state disposal at an existing approved chemical waste landfill might be feasible. The two closest out-of-state approved landfills for chemical wastes are both in the State of New York - a landfill operated by SCA Chemical Services, Inc. in Model City, and a landfill operated by CECOS International in Kenmore.

The third alternative under TSCA is to determine another method which would be approved by the EPA Regional Administrator. The chosen method would also have to comply with other federal regulations, including RCRA requirements for any RCRA-regulated substances, and all applicable State of Massachusetts regulations.

The feasibility of ocean dumping as an alternative dredge material disposal method would depend upon the results of additional evaluations. The New England District, U.S. Army Corps of Engineers would require solid phase bioassay testing and bioaccumulation tests for cadmium, mercury, PCB, DDT and petroleum hydrocarbons. Based on the findings, the dredge material would either be allowed unrestricted disposal at a designated dump site (provisions for capping with a cleaner layer of sand may be required), or be barred from ocean disposal. In the latter case, the applicant may apply for a waiver from the EPA Administrator which would allow ocean disposal to occur. To accomplish this, the applicant must demonstrate that the project is imperative, no alternative disposal means exist, and no known harm to key components of the marine system would result. To date no waiver has been applied for or issued in the New England District. Based on the high levels of PCB and heavy metals in Acushnet River and New Bedford Harbor sediments, approval for ocean disposal of this dredged material may be difficult to obtain.

Dredge materials with PCB concentrations less than 50 ug/g (dry weight) are not currently regulated by TSCA. Harbor development programs or maintenance dredging programs that involve sediments with less than 50 ug/g PCB, which are not classified as hazardous based on RCRA and state regulations, could utilize a shoreline disposal area. The following paragraphs describe the site criteria required for a chemical waste landfill. In addition a review of potential shoreline sites is presented.

Chemical Waste Landfills

Site selection for development of a chemical waste landfill in the State of Massachusetts would be based on a minimum of two levels of evaluation. First, sites would be evaluated in terms of both federal regulations (TSCA, RCRA, if applicable) and state regulations for siting of a hazardous waste landfill. Secondly, other important environmental engineering and other practical considerations would be addressed. A summary of the major site requirements to be addressed during site selection for chemical waste landfills as regulated by TSCA are presented in the following table.

Additional environmental, engineering and physical factors to be considered in the site selection process after applicable TSCA, RCRA and state regulations have been addressed include:

Environmental Factors

- Distance of 300 ft. should be maintained to any pond or lake used in recreational or livestock purposes or any surface water body officially classified under state law.

TABLE 3-2

Chemical Waste Landfill Site Requirements
TSCA (40 CFR 761.41)

Parameter	Requirements
Soils	o Permeability $\leq 1 \times 10^{-7}$ cm/sec
	o In-place soil thickener four feet or compacted soil liner thickener three feet
	o Percent soil passing No. 200 Sieve >30
	o Liquid Limit >30
	o Plasticity Index >15
Synthetic Liners	o Synthetic membrane liners with adequate soil under-lining and soil cover may be required to provide a permeability at least equivalent to the soils described above.
Hydrologic Conditions	o Bottom of landfill liner shall be at least fifty feet from the historical high water table.
	Avoid floodplains, shorelands and groundwater, recharge areas.
Flood Protection	o If site is below the 100-year floodwater elevation, perimeter diking with a minimum height equal to two feet above the 100-year flood elevation is required.
	o For sites above the 100-year flood elevation, division structures must be provided to hand surface water runoff from a 24-hour, 25-year storm.
Topography	o Site shall have low to moderate relief.

- State-designated wetlands should be avoided.
- Biologically sensitive areas containing endangered plant or animal habitats or unique or regionally significantly habitats should be avoided.

Engineering and Practical Factors

- The site should have adequate size and capacity for the projected disposal needs.
- Site should be in close proximity to the waterway being dredged, and to the anticipated dredge area.
- Sites at low elevations will have lower associated transport costs.
- Site accessibility through existing nearby roads, etc. is advantageous.
- The absence of obstacles such as utilities, pipelines and other structures is advantageous.
- Site should have sufficient screening from parks, residential areas, agriculture districts, historic sites, reservoirs and other sensitive land uses.
- Site ownership is optimal if only one or two owners are involved as opposed to multiple owners.

Site components for a chemical waste landfill would include:

- containment area
- containment site liner
- roughing and storage pond (if required)
- dewatering areas (if required)
- water treatment plant
- chemical feed system (if required)
- storm water drainage system
- leachate collection system
- containment site cover
- air, ground-water and leachate monitoring systems
- perimeter fencing

- access road
- appurtenances

Shoreline Disposal Sites for Sediments Containing Less Than 50/ug/g

Two available reports[24,25] have delineated possible disposal sites for contaminated dredge material with PCB concentrations less than 50 ug/g dry weight. Four possible shoreline disposal sites are outlined on Plate 8. The largest site, the one south of Marsh Island, was used to develop disposal site costs. Sediment sampling in the Marsh Island area will be required before a determination can be made on the acceptability of this area as a disposal site. In addition, further sampling will be required to determine if any of the dredge material with PCB concentrations less than 50 ug/g dry weight contains other contaminants which may cause it to be classified as hazardous under RCRA or State of Massachusetts hazardous waste regulations.

The capacity of the site depends upon available area, depth of fill and the consolidation of the dredge material. The containment site is divided into two areas. The northern area covers 25 acres and has a capacity of about 500,000 cubic yards. The southern area covers 45 acres and has a capacity of about 1,000,000 cubic yards. The volumes are based upon filling the areas to an elevation of +12. The disposal area would be contained by placement of a retaining dike along the outline indicated on Plate 8. The muck area under the dike would be dredged to a depth of 15 feet to reach consolidated material. A temporary cofferdam would be built within the site to contain the muck generated by dike construction. The dike would be constructed of select fill, with an interior slope of 3:1, a ten-foot top, and a three-foot layer of rip rap on the exterior slope of 1.5:1. The dike height would vary depending upon the amount of dredge material and disposal site layout. The containment site concept which was evaluated and used as the basis of cost estimates does not include the use of a bottom liner. There are two considerations: a) the difficulty and cost of placing a reliable liner under the site conditions involved, b) the relatively low loss potential from the site.

Other proposed site components would include fill stabilization, water treatment, site cover and perimeter drainage systems. Dredged material would be dewatered at the containment site by use of prefabricated drainage wicks. This would accomplish two ends: a) shortening of the time required prior to use of the fill for park purposes, b) increase in site capacity by reducing the volume of placed material.

Water contaminated by dredge material disposal will be given treatment prior to return to the harbor area. Treatment would consist of a 1 million gallon per day plant for removal of suspended solids by polymer addition.

After the material has been properly consolidated the site would be covered for protection against loss of contaminated material and to minimize leakage of precipitation into the fill. The cover consists of two layers of fill, 18 inches of sand covered by 18 inches of fine grained material. The cover would be grassed to protect against soil erosion and sloped to drain storm water. A system of drainage channels would convey storm water to the harbor.

Environmental Considerations

An evaluation of PCB levels in the Acushnet River Estuary and New Bedford Harbor area has been previously presented in this report. This section discusses general factors which should be considered in evaluating the environmental impacts of a remedial dredging program.

Impacts of Remedial Dredging on PCB Levels in Aquatic Life

The effectiveness of a remedial dredging program in terms of decreasing PCB levels in the tissues of aquatic organisms is dependent on a number of critical factors. These include:

- The transfer of PCB through the study area food chain and within the study area food web.
- Spatial and temporal distributions of aquatic organisms with respect to the proposed dredge areas.
- The nature and rate of PCB exchange between the water column and sediments in proposed dredge areas and the relationship of this exchange to availability of PCB to biotic uptake.
- Patterns of PCB transport both within the outer harbor and bay and the area upstream of the hurricane barrier to the outer harbor and bay.

PCB in Food Chains and Food Webs - Biological uptake of PCB may occur through a number of pathways. Burrowing benthic organisms or animals feeding upon them may physically disrupt the sediments, resuspending PCB in the water column. PCB may also be passed along the food chain from contaminated plants or detritus to benthic invertebrates and subsequently to fish, waterfowl, and other higher organisms. Uptake of biologically available PCB in the water column may occur via gill respiration, or consumption of PCB which is adsorbed on plankton or other food sources. PCB not retained in the food chain may be returned to the surrounding environment through excretion, or be released upon organism death and decomposition.

Recent USEPA research has examined modes of PCB uptake into the tissues of various species of fish and shellfish.[28] This research indicates that in carnivorous fish inhabiting waters containing less than 0.1 parts per billion (ug/l) PCB in the water column, as much as 80 percent of the PCB present in the tissues is attributable to the food chain (oral route of uptake) with the remainder entering via passive diffusion through the gill filaments (gill route of uptake). In more herbivorous species inhabiting the same waters, the converse appears true, i.e. 80 percent of the uptake is via the gill route with 20 percent via the oral route. As water column PCB levels increase above 0.1 ug/l, the gill route of uptake appears to become progressively more important. At PCB concentrations of 0.4 ug/l and higher, the gill route is believed to contribute 80 percent or more of the PCB found in the tissues of both herbivorous and carnivores. Studies have also shown that PCB in aquatic organisms may be concentrated at levels of 50,000 to 100,000 times water column PCB levels, depending on the position of a species in the food chain and whether the organism obtains PCB from the water, food or both sources.(36) Data compiled from the literature indicates that for small organisms of approximately four inches the bioaccumulation factor for PCB is about four times higher from food and water than from water alone. The food component plays a relatively greater role in PCB accumulation in larger fish.(37) Tissue PCB concentrations in shellfish (clams, mussels, and oysters) are generally lower than in finfish inhabiting the same waters. This is attributed to the lower tissue lipid content in shellfish (PCB is fat soluble) and the ability of bivalve molluscs to purge themselves of most organic compounds.(28) It is thus evident that the mode of PCB uptake by aquatic species is not only a function of the type of organism and its position in the food chain, but is also greatly dependent upon ambient PCB concentrations.

For systems in which water column, sediment, and tissue PCB concentrations have been established, it is possible to develop food web and food chain models capable of examining the potential effectiveness of remedial measures on biological uptake of PCB. One such model was recently developed and applied to the Hudson River Estuary.[11] It employed a seven compartment food web model to assess changes in fish PCB body burden in response to reductions in water column PCB levels. It also took into account numerous other factors such as food chain uptake, PCB excretion rates and growth rates. However, the model was not related to any specific program of contaminated sediment removal in the Hudson River.

Fish PCB levels were determined assuming an 80 percent reduction in average water column concentrations, from the present average level of 0.2 ug/l to 0.04 ug/l total PCB. It was also assumed that only the dissolved fraction, approximately 25 percent of the total PCB in the water column, was biologically available. At the reduced water column PCB levels, the model predicted that small fish (less than 300 mm) would exhibit levels of 3 to 7 ug/g PCB in the upper estuary and 2-3 ug/g in the lower estuary. Present median PCB levels in small fish flesh were estimated to be 15-30 ug/g in the upper estuary and less than 5 ug/g in the lower estuary. For striped bass, assuming no PCB excretion, the reduced water column levels would not decrease tissue PCB levels to less than 5 ug/g from the present median level of 10 ug/g.

In order to reach the proposed FDA standard of 2 ug/g in the flesh of small fish, the model predicted that water column concentrations of 0.02 ug/l total PCB or less would be required. For larger fish, at higher trophic levels, total PCB levels in the water column would have to be in the range of 0.008 to 0.016 ug/l.[11] Based on these estimates, it was believed that attainment of the 2 ug/g tissue limit in the near term in the Hudson River would be very difficult. However, it was concluded that employment of remedial measures, such as sediment dredging in areas containing high PCB concentrations, would act in combination with natural processes effecting a decline in PCB levels throughout the ecosystem.

In more recent modeling of PCB contamination in Waukegan Harbor, Illinois, decreases in water column PCB levels and fish PCB body burdens were predicted and related to the alternative dredging programs proposed.[38] The initial model results indicated that in order to reduce PCB levels in Waukegan Harbor fish species to a range of 5 to 10 ug/g, levels of dissolved PCB in the water column would have to be reduced to approximately 0.01 to 0.02 ug/l from present levels of 0.01 to 0.3 ug/l dissolved PCB. Total PCB levels of over 10 ug/l have been measured in the most highly contaminated areas. As in the Hudson River modeling, these predictions incorporated factors such as food chain PCB uptake, exretion rates and growth rates, as well as uptake from the water column directly. It was assumed that the bioconcentration factor (uptake from the water column alone), for all food chain levels was 10^5 times dissolved water column concentrations, or 100 ug/g wet weight in the organism per 1 ug/l dissolved PCB in the water column.

Initially, three dredging alternatives were proposed for Waukegan Harbor: 1) dredge all areas containing greater than 100 ug/g PCB in the sediments; 2) dredge all areas containing greater than 50 ug/g in the sediments; and 3) dredge all areas containing 10 to 50 ug/g in the sediments in addition to the areas above. The water quality model was utilized to evaluate the effectiveness of the dredging alternatives on water column levels and subsequently on fish PCB body burdens. It was determined that dredging all sediments containing greater than 100 ug/g PCB would result in a significant decrease in PCB transport and generally reduce the body burden of resident fish in the vicinity of the harbor to between 2 and 5 ug/g.

Subsequently, this evaluation was refined by adding a fourth alternative, dredging all material over 500 ug/g. It was then predicted that dredging of the most highly contaminated area (greater than 500 ug/g) was the most effective alternative, although this area encompasses less than 10 percent of the total contaminated harbor area. The extremely high sediments concentrations (up to 10,000 ug/g) and apparently high water column interaction appear to be most responsible for present levels of water column contamination in the harbor. It also appears that residual levels of PCB remaining after dredging are more significant in terms of water column concentrations than the aerial extent of dredging. The model predicted that reducing residual sediment PCB levels to a range of 10 to 100 ug/g in this highly contaminated area alone would reduce water column concentrations to a range of 0.01 to 0.02 ug/l dissolved PCB. As discussed earlier, this is the level required to reduce PCB body burdens to near acceptable levels in Waukegan Harbor species. If this same area was dredged to a residual sediment concentration of only 500 ug/g, fish PCB levels would remain in the range of 20 to 40 ug/g.[39]

<u>Relationship of Organisms to Potential Dredge Areas</u> - In order to accurately predict the potential benefits of a remedial dredging program in the Acushnet River-New Bedford Harbor area, a model should be developed for the area. Development and use of the model requires basic data concerning water column, sediment, and tissue PCB levels. In addition information pertaining to ecosystem dynamics is needed to refine the accuracy of model predictions. Such information includes the distribution, both spatially and temporally, of aquatic species of primary concern within the study area, especially within those portions of the study area in which sediment PCB levels are known to be relatively high.

In the Acushnet River-New Bedford Harbor system, this pertains especially to the fish species of commercial and recreational importance. For example, limited data suggest that PCB concentrations in lobsters from Zones 3 and 4 may fluctuate seasonally. This may result from lobster migration patterns and/or exposure to seasonally high water column concentrations resulting from spring flows. However, these factors are not well enough understood to offer a clear explanation for the trend.

Sediment and Water Column Interchange - The mechanisms involved in the exchange of PCB between sediments and the water column, as well as the actual rate of this exchange, are also important factors affecting PCB availability to the biota and the accuracy of model predictions. In the Hudson River, partition coefficients (sediment to water column) were estimated for contaminated sediments of greater than 70 ug/g and less than 70 ug/g. For areas, greater than 70 ug/g, the partition coefficient was estimated at 1×10^4. In areas less than 70 ug/g, the coefficient was estimated at 5×10^3. In the absence of information concerning such variables, conservative assumptions must be made and used as model input. Under these circumstances, model results tend to be conservative, often producing "worst case" predictions that may greatly under-estimate the effects certain measures such as dredging may have on reducing PCB body burdens, or may over-estimate the time period during which such reductions would occur.

PCB Transport - The impact of hydrologic factors on the validity or accuracy of model predictions may be quite variable. Estuaries and coastal embayments exhibit a complex hydrologic pattern of diurnal and seasonal flows and are affected by both freshwater flows and tidal influences. The direction or pattern of circulation of water within the estuary or embayment, and resulting occurrences and magnitude of sediment scouring and deposition, are quite variable on a diurnal as well as a seasonal basis. These highly dynamic systems require a greater amount of field monitoring data, compared to large rivers, for the establishment of baseline flow conditions upon which accurate predictions concerning sediment scouring, deposition, and transport of PCB throughout the system can be made. While the movement and distribution of sediments within New Bedford Harbor and its approaches have been extensively studied in terms of deposition rates in the harbor and over relatively large areas of the bay, the contribution of local areas known to contain high sediment PCB levels to the PCB concentrations elsewhere in the bay has not been defined. The accuracy of predictions concerning the effectiveness of dredging these areas on the PCB body burden in aquatic organisms is very much dependent upon such patterns of PCB transport within the bay, especially the transport pattern between the area upstream of the existing hurricane barrier and the outer harbor and bay.

Summary

In summary, it is evident that numerous factors must be considered in evaluating the potential impacts of any remedial dredging program on PCB levels in aquatic life. Information pertaining to many of these critical factors for the Acushnet River Estuary-New Bedford Harbor system is as yet unknown but is required for an accurate assessment of the quantitative benefits to affected organisms. However, based on existing limited information and the results of studies of other PCB contaminated waterways, a general discussion of potential benefits to be derived from proposed dredging programs in the study area is included in Section 4.

4. ALTERNATIVE DREDGING PROGRAMS AND POTENTIAL IMPACTS

Alternative Dredging Programs

Available data has been used to develop alternative dredging programs for the Acushnet River and New Bedford Harbor area.

Based on contaminated sediment volumes listed in Table 4-1, and the project objectives discussed in Section 2, five program alternatives have been formulated:

1. Dredge sediments containing greater than 500 ug/g PCB with disposal at a secure upland site. (Hot Spots I)

2. Dredge sediments containing greater than 50 ug/g PCB with disposal at a secure upland site. (Hot Spots II)

3. Dredge sediments containing greater than 10 ug/g PCB with disposal of sediments containing 50 ug/g PCB or greater at a secure upland site, and shoreline disposal of sediment containing less than 50 ug/g PCB. (Hot Spots III)

4. Allow implementation of channel improvement dredging, bridge excavation and initiation of small scale harbor development projects through removal and containment of the PCB-contaminated sediment volumes involved. (Harbor Development Project C)

5. Allow implementation of channel improvement dredging, bridge excavation and initiation of larger-scale harbor development projects through removal and containment of the PCB-contaminated sediments volumes involved. (Harbor Development Project D)

Discussion of Alternative Dredging Programs and Costs

These five alternative dredging programs define a range of possible actions including three remedial programs to minimize PCB in the New Bedford Harbor ecosystem and two harbor development programs. The following paragraphs briefly describe the cost and feasibility of each program.

TABLE 4-1

PCB-CONTAMINATED VOLUMES

Based on Available Data

Project	Typical PCB Concentration in Dredged Area ug/g	Cumulative Volume of Dredged Material cu yds
	REMEDIAL DREDGING PROJECTS	
Hot Spots I	>500 (1)	70,000
Hot Spots II	> 50 (2)	2,200,000
Hot Spots III	> 10 (2)	4,400,000
	HARBOR DEVELOPMENT PROJECTS	
Project A: Channel Improvement Dredging	~ 10 (3)	80,000
Project B: Proj. A + Bridge Excavation	~ 10 (3)	120,000
Project C: Proj. B + Small Scale Harbor Development	~ 10 (3)	300,000
Project D: Proj. C + Large Scale Harbor Development	~ 10 (3)	900,000

(1) PCB concentration based on measured PCB values in top two feet of sediment.
(2) PCB concentrations based on surface samples (~0-4" depth) only, due to insufficient data at greater depths.
(3) Approximate concentrations based on minimal sampling; must be verified with detailed sampling on a site-by-site basis.

Remedial Programs

Program 1 (Hot Spots I) includes removal and secure containment of sediments containing greater than 500 ug/g PCB at a chemical waste landfill. This project involves removal of approximately 70,000 cu yds in the northern estuary over approximately 14 acres of the most highly contaminated sediments in the New Bedford Harbor area (see Figure 3-1). The cost of removal and secure containment for this volume of highly contaminated material at a chemical waste landfill within a five mile radius of the dredging area is on the order of $6-12 million. This cost estimate includes the following items:

- general site construction
- material dewatering in settling basins without chemical addition
- removal and transport of dredge spoil to the site
- hydraulic booster station for dredge spoil transport, if required
- site closure
- effluent treatment with chemical addition
- engineering design
- construction administration
- legal and administrative costs
- contingencies

The lower end of the range is based upon the following general assumptions:

- Site includes containment cell, roughing and storage cell, and a small scale water treatment plant.
- Site is located near to dredging area and contaminated sediments can be pumped directly from a hydraulic dredge to the containment area.

- In-situ soils are appropriate for construction of containment site diking.

- Dredge material will dewater sufficiently enough by gravity that special dewatering technique will not be required.

- Site meets TSCA regulations for ground and surface water clearances, or waivers can be obtained on these issues.

- Site meets RCRA requirements, if applicable, or waivers can be obtained for conflicting parameters.

- Site meets all requirements for a hazardous waste landfill under State of Massachusetts regulations, or waivers can be obtained for conflicting parameters.

- Site is easily accessible by existing thoroughfare.

- No obstructions such as utilities, pipelines or other structures are present or the site.

High range costs, $9-12 million, are based upon the following less optimistic assumptions:

- Site includes dewatering cells, containment cell and water treatment facility.

- Dredge material will not dewater easily, and separate settling basins will be required to prepare dredge spoil for containment. It is assumed that chemical addition will not be required for material settling.

- Site size will be sufficient to accommodate both containment area, and dewatering and treatment facilities.

- Dredging system will require a booster station (hydraulic dredge) or pumpout station (clamshell dredge) between the dredge area and the dewatering area. Site is within a five-mile radius of the dredging area.

- Impervious soils will have to be imported for construction of a three-foot compacted clay liner meeting TSCA requirements for permeability.

- Site meets TSCA regulations for ground and surface water clearances, or waivers can be obtained these issues.

- Site meets RCRA requirements, if applicable, or waivers can be obtained for conflicting parameters.

- Site meets all requirements for a hazardous waste landfill under State of Massachusetts regulations, or waivers can be obtained for conflicting parameters.

- No obstruction such as utilities, pipelines or other structures are present on the site.

- Site is reasonably accessible by existing roadways.

A preliminary investigation of soils in the New Bedford area indicates that there is some potential for a containment site capable of handling a small project in the vicinity of the highly contaminated area in the northern estuary. It is likely that such a site would require either a pumping station or a material rehandling area, and a ground water waiver. Before a detailed cost estimate can be developed for the project further studies need to be implemented including the following:

- A detailed siting study to identify sites meeting the requirements previously discussed in Section 3.

- A continued sampling program to define conclusively the nature and extent of the PCB contamination in the area, especially in areas that have not yet been sampled.

- A probing and sampling study to identify the grain size and compaction of the river bed sediments and the depth of bedrock in this area.

- In addition, pilot studies to determine the settle-ability and treatability of the dredge material will be required.

In the event that an acceptable site cannot be found within a reasonable distance of the project area, disposal of highly contaminated materials may be feasible in currently operating chemical waste landfills in either Model City or Kenmore, New York. Based on preliminary evaluations, the cost of out-of-state disposal of 70,000 cubic yards of material with PCB concentrations greater than 500 ug/g would be on the order of $25 million (1982 dollars). This estimate includes:

- o construction of a temporary dewatering (settling basins) and material rehandling site within a five-mile radius of the area to be dredged.
- o dredging and transporting 70,000 cu yds to the dewatering area.
- o water effluent treatment by chemical coagulation.
- o trucking of dewatered material to approved chemical waste landfills in either Model City or Kenmore, New York.
- o final disposal at the chosen approved chemical waste landfill.
- o restoration and decontamination of the temporary dewatering and material rehandling site.

Estimates for trucking and final disposal costs were based on information received from SCA Chemical Services and CECOS International.

Program 2 (Hot Spots II) includes removal and secure upland containment of sediments containing greater than 50 ug/g PCB. This project involves removal and containment of approximately 2,200,000 cu yds over approximately 450 acres. This volume is based on limited sampling data in many areas, and could be greatly affected by further sampling programs. The majority of this material is located above Pope's Island with two additional areas in the outer harbor. The cost of this program would be on the order of $60-70 million assuming that an acceptable site could be located within a reasonable distance of the area to be dredged. The cost estimate includes the following items:

- o general site construction

- material dewatering in settling basins without chemical addition
- removal and transport of dredge spoil to the site
- hydraulic booster station for dredge spoil transport, if required
- site closure
- effluent treatment with chemical addition
- engineering design
- construction administration
- legal and administrative costs
- contingencies

This cost range assumes a clamshell dredging operation requiring only a small shoreline rehandling area. Material would be transported from the rehandling area to the containment site via a hydraulic pumpout station and associated pipeline. It may not be possible to find an acceptable site for this volume of material that is both located within a five-mile radius of the dredging area and easily accessible to a shoreline rehandling area. If this is so, an alternative program might include the construction of a major dewatering and rehandling site at a shoreline location, and land transport (truck, rail) to the containment site itself. If out-of-state disposal was chosen, preliminary estimates indicate that the cost for simply transporting and disposing of 2,200,000 cu yds of dewatered material from a shoreline dewatering and rehandling area to either Model City or Kenmore, New York may be on the order of $450 million dollars (1982 dollars). Out-of-state disposal for this volume of material does not appear feasible. This option would be much more costly, and involve numerous additional regulatory, environmental, and public concerns.

As discussed under Program 1, detailed siting studies, continued sampling programs, a probing and sampling study, and pilot studies for settleability and treatability of dredge material will be required before a more rigorous project description can be developed. These studies will better define the quantity of material which requires secure upland containment and provide the data needed to select a dredging and transport system and an appropriate chemical waste landfill location.

<u>Program 3</u> (Hot Spots III) includes removal and containment of sediments with PCB concentrations greater than 10 ug/g. This project involves removal and secure containment of approximately 2,200,000 cu yds of material containing PCB concentrations greater than 50 ug/g, and removal and shoreline containment of approximately 2,200,000 cu yds of material containing PCB concentrations between 10 and 50 ug/g. The cost of this project is on the order of $110 million. This includes two separate programs. The estimated cost for removal and secure containment of 2,200,000 cu yds is $60-70 million based on the assumptions presented under Program 2 for removal and local containment of the material containing greater than 50 ug/g. The estimated cost for removal and shoreline containment of an additional 2,200,000 cu yds is $40 million. It is assumed that this dredged material contains less than 50 ug/g PCB and is not classified as hazardous based on state or federal regulations. The cost is based on clamshell dredging and the shoreline disposal site components discussed in Section 3.

Although this program is technically feasible, the large volumes of material involved present serious siting difficulties. Siting for upland disposal areas capable of handling 2,200,000 cu yds of TSCA regulated sediments has been discussed previously under Program 2. The availability of siting for harbor sediments with PCB concentrations less than

50 ug/g at shoreline disposal areas in New Bedford Harbor is also limited. Disposal site locations for approximately 3,000,000 cu yds of dredged material have been identified in two previous reports.(24,25) This available volume can be utilized for containment of dredge spoil from either maintenance dredging, specific harbor development projects or remedial dredging of areas with PCB concentrations less than 50 ug/g. The need for disposal options for maintenance dredging and harbor development projects may make remedial dredging programs involving materials with PCB concentrations less than 50 ug/g infeasible both economically and practically.

Harbor Development

Program 4, (Harbor Development Project C) small scale harbor development, involves the removal and containment of 300,000 cu yds of dredged material. Included under this program are channel improvement dredging (80,000 cu yds), Route 6 bridge excavation (40,000 cu yds) and initiation of harbor development (180,000 cu yds) to remove three feet of harbor muds over 35 acres of potential development area. Assuming sediment concentrations at proposed dredging locations are less than 50 ug/g and the material does not contain contaminants which may result in it being classified as hazardous based on federal or state regulations, disposal would be in a shoreline containment site. Additional sediment sampling will be required prior to the initiation of any harbor dredging project in order to better characterize sediment containment levels. PCB levels greater than 50 ug/g or hazardous levels of other constituents, could require more costly upland disposal. Based on clamshell dredging and shoreline disposal, the cost of this program including site preparation, dredging and transport of dredge spoil, site closure, effluent treatment, engineering design, administration and contingencies is approximately $15 million.

Program 5, (Harbor Development Project D) large scale harbor development, involves the removal and containment of 900,000 cu yds of material. This program includes channel improvement dredging, bridge excavation and the dredging of three feet of harbor muds (780,000 cu yds) over 170 acres of new development area. Disposal would be in a shoreline containment site, assuming additional sampling confirms that PCB sediment concentrations are less than 50 ug/g and hazardous levels of other regulated constituents are not present in areas to be dredged. The cost of removing this material, assuming clamshell dredging and shoreline containment, is $25 million. This includes site preparation, dredging and transport of dredge spoil, site closure, effluent treatment, engineering design, administration and contingencies.

Table 4-2 presents the volume of contaminated dredge material and order of magnitude cost for each of the five alternative dredging programs.

Combinations of these alternative programs could be implemented to provide for varying degrees of harbor development and PCB recovery. Order of magnitude costs may be developed from the information in Table 4-2.

All of the alternative programs, as well as variations of them, must be subjected to a much more detailed evaluation before implementation. The programs presented, however, are judged to be sufficient as a basis for a decision as to the feasibility of further action.

Potential Impacts of Alternative Dredging Programs and No Action

This section discusses the impacts of alternative dredging programs and a program of no action. In addition, general considerations applicable to implementation of any of the dredging programs are presented.

TABLE 4-2

CONCEPTUAL DREDGING PROGRAMS
(IN-STATE DISPOSAL)
(1981 Dollars)

Alternative	Dredged Material Volumes, Cu.Yds. Remedial Program	Harbor Development Program	Cost $ Millions
1. Removal and secure containment of sediments containing >500 ug/g PCB (Hot Spots I)	70,000	-	6-12
2. Removal and secure containment of sediments containing >50 ug/g PCB (Hot Spots II)	2,200,000	-	60-70
3. Removal and containment of sediments containing >10 ug/g PCB. Sediments with PCB concentrations >50 ug/g will be contained at a secure upland site. Sediments containing PCB concentrations >50 ug/g will be handled a shoreline disposal area. (Hot Spots III)	4,400,000	-	110
4. Initiation of Small Scale Harbor Development (Harbor Development Project C)	-	300,000	15
5. Initiation of Large Scale Harbor Development (Harbor Development Project D)	-	900,000	25

Notes:
Initiation of harbor development projects refers to removal of 3 ft. of harbor muds at sites to be developed.
Small-scale harbor development includes channel improvement dredging, bridge excavation and 35 acres of new harbor development area.
Large-scale harbor development includes channel improvement dredging, bridge excavation and 170 acres of new harbor development area.

PCB Reductions in Aquatic Species Resulting from Remedial Dredging Programs

As discussed in Section 2, the Massachusetts Department of Public Health has imposed a fishing ban in the Acushnet River-New Bedford Harbor area for species exhibiting elevated levels of PCB in their tissue. The reopening of this area to fishing would be directly related to reductions in fish PCB body burdens. Therefore, the impacts of a remedial dredging program on fish PCB levels are of significant importance.

Both the commercial and recreational fishery are affected by the closure. Although no commercial fishing took place north of the hurricane barrier prior to the closure, the shorelines were occasionally used for sportfishing. Sportfishing also occurred to a greater extent in the outer harbor south of the hurricane barrier. The sportfishing season runs from March through October. Important sportfish in the Acushnet River-New Bedford Harbor area include bluefish, striped bass, winter flounder, tautog, scup, mackerel and eel.[20] Of these, winter flounder, tautog, scup and eel are primarily bottom feeders.

The closure has also affected approximately 50 commercial and 100 recreational lobstermen who fished the waters south of the hurricane barrier. Catches were characteristically best in the spring and fall and poorer in the summer, which may be due to a seasonal lobster migration pattern. The annual value of the commercial lobster fishery in 1977 was estimated at greater than $125,000.[21]

Each of the three remedial dredging programs which has been presented would be expected to have a beneficial impact on reducing PCB body burdens in aquatic organisms of the Acushnet River-New Bedford Harbor ecosystem. However, without additional information and more refined studies, such as those described in Section 3, accurate quantitative predictions of expected PCB decreases resulting from implementation of these programs cannot be made. It is possible, however, to consider the results of other PCB dredging studies and to use existing information to make a general assessment of potential improvements given the remedial programs presented.

The Hudson River and Waukegan Harbor studies discussed in Section 3 indicate the significance of water column concentrations in determining fish PCB body burdens. In Waukegan Harbor, the model demonstrated that the area containing the most contaminated harbor sediments was the major source of PCB to the water column, food chain and ultimately to higher level aquatic organisms. Both sediment resuspension and desorption of PCB from particulates into the water column, as well as direct dissolution from the sediments, are responsible for water column PCB concentrations. The sediment-water column interchange in a given waterbody is increased by turbulence resulting from currents, tides, dredging and other disturbances affecting the sediment-water interface.

In the Acushnet River-New Bedford Harbor area, available data indicates that the most contaminated sediments, those greater than 500 ug/g PCB and as high as 10,000 ug/g, occur in a fairly well defined area in the northern tip of the estuary. In addition, recent water column samples collected in this area and as far downstream as Pope's Island show very high ambient PCB levels. Water column concentrations of 4 ug/l (total PCB) were reported in the area of the most contaminated sediments. Levels decreased to 1.2 ug/l (total PCB) near Pope's Island. These higher levels are up to an order of magnitude higher than average concentrations in the Hudson River or Waukegan Harbor. Additional samples collected south of Pope's Island were below the detection limit of 0.2 ug/l.

The significantly greater sediment and water column PCB concentrations evident in the northern part of the estuary indicate that this area may be a major source of PCB to the water column and ultimately to the harbor area fishery. Although this must still be demonstrated by more detailed studies and modeling, it does suggest that Program 1, removal of the contaminated sediments greater than 500 ug/g, could have a significant impact on reducing water column levels and PCB body burdens in aquatic species of commercial and recreational importance.

In terms of the commercial fishery, lobster is the species of greatest importance. PCB levels for this species appear to fluctuate seasonally which may result from seasonal migrations in and out of more contaminated areas, or seasonal elevations in water column PCB levels associated with higher flows. A significant reduction in water column PCB levels in the highly contaminanted area could lower PCB levels in the food chain and have a measurable impact on lobster PCB levels. Similarly, other migratory fish which are only seasonally exposed to water column and food chain PCB levels in the Acushnet Estuary area could show comparable improvement. Levels in resident finfish may not be reduced to the same extent due to their continuous exposure to ambient water column levels in and near the estuary, unless these levels are reduced to significantly low levels. Flounder and other bottom feeding fish may continue to accumulate PCB directly from contact with remaining contaminated sediments. Therefore, whether this action alone (Program 1) would be sufficient to reduce water column concentrations to levels which would allow attainment of the 5 ug/g FDA limit in resident fish species cannot be determined without further study. In addition, the precise water column concentration which would permit these levels to be attained in the major species of the Acushnet River-New Bedford Harbor area is not known. In the Hudson River and Waukegan Harbor, water column concentrations of approximately 0.01-0.02 ug/l dissolved PCB and less were predicted as necessary for attainment. It should be noted that this level is well below the detection limit identified in the most recently completed water column sampling in the study area. In summary, it is possible that the extremely high sediment levels in the northern part of the estuary have a significant impact on water column and food chain levels in the area ecosystem. If this can be demonstrated by modeling, then dredging of the highly contaminated area alone may be sufficient from an environmental viewpoint and is certainly the most economically feasible program.

It is quite conceivable that dredging all areas containing greater than 50 ug/g, Program 2, would reduce PCB levels in the food chain and important fish species to within or near acceptable levels. Improvements in PCB levels of resident finfish species might be expected to be greater as a result of the implementation of this larger scale dredging program. The increased costs associated with the execution of this program would require that potential benefits to aquatic species be carefully evaluated and compared to the expected benefits associated with smaller scale dredging of the more highly contaminated area.

Dredging of all sediments greater than 10 ug/g (Program 3) would not appear to be a cost-effective solution for reducing high PCB levels in fish flesh. A large portion of the inner harbor would be affected by dredging which could seriously impede navigation. In addition, disposal sites for this volume of material would be difficult to obtain. The additional benefits in terms of PCB body burden reductions to be achieved by this program are not likely to justify the costs and logistical considerations associated with an extensive dredging program.

Impacts of No Action

The impacts of taking no remedial action in the study area should also be considered in relationship to the potential benefits of a remedial dredging program. The results of taking no action would be the continued presence of high PCB levels in the sediments, water column and aquatic organisms of the Acushnet River Estuary-New Bedford Harbor area and the associated economic and public health impacts. However, the movement of PCB out of the New Bedford Harbor ecosystem can be expected to occur over time, with natural reductions in PCB concentrations continuing as long as stringent control strategies prevent any new entry of the chemical into the system. Because the mechanisms involved in PCB movement are not well understood at present (e.g. the role of physical factors such as increased flow and sediment transport versus the role of biological factors such as PCB uptake in finfish and lobster), it is very difficult to project the rate or level of natural reduction in PCB levels if no action were taken. Recent information has indicated that in the Hudson River this natural reduction may be occurring more rapidly than previously predicted.[29] Similar declines have been noted in Lake Michigan.[40,41] However, because natural mechanisms responsible for this reduction may be somewhat unique to the Hudson River or Lake Michigan ecosystems, extrapolations from observed rates of PCB reductions in these water bodies to other systems are not necessarily valid. It appears obvious, however, that PCB reductions in the ecosystem would occur at a much slower rate if no action were taken than if a remedial dredging program was implemented to remove highly contaminated sediments.

Impacts of Harbor Dredging Projects

Areas which have been studied for potential industrial development in New Bedford Harbor include North Terminal, Pope's Island, South Terminal, Marsh Island and Alpine Marine.[24] Dredging would be required to implement any of these projects, and a suitable site would be needed for the disposal of contaminated sediments which could not be used for fill.

Dredging for channel improvement, harbor maintenance and bridge replacement are also hindered by the lack of suitable disposal sites for contaminated sediments. Channel improvements have been recommended in the federal project area on the east side of the harbor. Dredging is also needed within the bulkhead line on the east side of the harbor near the marine repair yards. Only localized maintenance dredging appears necessary in the main channel and anchorage areas of the inner harbor.(9) Replacement of the New Bedford-Fairhaven Bridge (Route 6) also requires dredging of contaminated sediments and location of a suitable spoil disposal site.

The two harbor dredging programs described, Programs 4 and 5, have been designed to lift constraints on these development and improvement projects by providing disposal site capacity for low-level contaminated sediments. Because they are not directed towards removal of the most contaminated sediments, their impact on PCB levels in aquatic species would be minimal. However, their implementation would provide economic benefits in terms of greater harbor use and area commerce.

General Dredging Impacts

Any of the five dredging programs developed would cause environmental impacts associated with typical dredging operations. Organisms inhabiting areas to be dredged in the upper estuary, inner harbor, or outer harbor (Zones, 1a, 1b, and 2) would experience temporary adverse impacts due to increased suspended solids in the water column in areas to be dredged. In addition, dredging in areas of high PCB and metals concentrations would temporarily increase ambient water column levels of these constituents. Relatively sessile organisms inhabiting proposed dredged areas (e.g. clams) would be destroyed. However, following the completion of dredging activities, areas of disturbed sediments would recolonize and re-establish the type of biotic community currently found in the area.

5. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. Available sediment data indicate that high levels of PCB (greater than 50 ug/g) exist throughout much of the Acushnet River Estuary and in portions of the outer harbor. In the northern tip of the estuary, levels generally exceed 500 ug/g with concentrations greater than 10,000 ug/g indicated at several sampling stations.

2. Remedial dredging programs to recover PCB-contaminated sediments are technically feasible. The order of magnitude costs given in this report must be compared to anticipated benefits to determine economic feasibility.

3. A remedial dredging program to remove the areas of greatest PCB contamination will reduce PCB levels in the water column and in aquatic organisms; however, a quantitative estimate of the extent of PCB reduction in species of commercial and recreational value cannot be made without additional study of PCB transport and uptake.

4. Harbor development programs can be undertaken separately or in conjunction with remedial dredging programs. Disposal site requirements for the dredged material will play a major role in determining the economic feasibility of harbor dredging projects.

Recommendations

1. It is recommended that sampling of sediment, water column and biota PCB levels be continued in the study area. Modeling studies should be undertaken to provide more reliable estimates of the effects of remedial dredging programs on PCB levels in aquatic organisms.

2. In order to refine the technical aspects of remedial dredging programs and their associated costs, several studies should be undertaken including a site investigation study, a probing and sampling study of harbor sediments and pilot studies to determine the settleability and treatability of dredged spoil.

3. A phased remedial dredging program should be implemented if economically feasible. The first stage of the program should include removal of the most contaminated sediments. The extent of the initial dredging program will depend on the availability of both funding and a

suitable disposal site with sufficient capacity. After completion of the first stage of remedial dredging, a detailed monitoring program of water column and biota PCB levels should be implemented to determine the actual effects of the dredging program. The need for further dredging can then be evaluated.

4. If it is determined that a remedial dredging program is economically feasible, the implementation stages identified in Item 10 should be initiated.

5. If there is interest in implementing a dredging program for harbor improvement or development, separately or in conjunction with remedial programs, the implementation stages identified in Item 10 should be initiated.

6. The following implementation stages are recommended as a basis for any remedial and/or harbor dredging programs undertaken. The scale and details of the stages would be tailored to the specific program adopted.

   - Detailed planning and preliminary design of elements of the adopted program.

   - Preparation of materials necessary to meet environmental and regulatory requirements.

   - Preparation of final program plans.

   - Execution of adopted program.

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APPENDIX A

RAW SEDIMENT DATA AND TESTING PROCEDURES
(MAJOR DATA SOURCES ONLY)

U.S. COAST GUARD SEDIMENT DATA

APRIL AND JUNE 1982

6/22/82

MARINE SAFETY OFFICE
JUN [illegible] 1982
PROVIDENCE, RHODE ISLAND
U.S. COAST GUARD

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

	INFO	ACT		I.. O	ACT
XO			MIB		
ACI			MIB		
P/O		✓	DCC		
SIP			SEC		
APX			YN		
MIH			SK		

MAILING ADDRESS:
COMMANDING OFFICER
USCG R&D CENTER
AVERY POINT
GROTON, CT. 06340

724154.3
11 JUN 1982

From: Commanding Officer, CG Research and Development Center
To: Commanding Officer, CG Marine Safety Office, Providence, RI

Subj: Acushnet River sediment sample analysis report

Ref: (a) COMDT (G-DMT-4/54) ltr 3913 Ser: 4-1202V of 11 Mar 1982

1. Reference (a) directed the R&D Center to provide chemical analytical support to MSO Providence which was involved in an emergency investigation concerning polychlorinated biphenyl (PCB) contamination in the Acushnet River estuary. Six sediment samples were received at the R&D Center on Friday, 12 March 1982 for determination of PCB concentrations. Chemical analyses were completed on 14 March 1982. Chemical analytical methods used and PCB concentration levels found were reported to MSO Providence by message on Monday, 15 March 1982. As a follow on to our initial quick turn-around response, continued support for the PCB contamination investigation was provided to MSO Providence.

2. Sediment core samples collected between 14 April and 21 April 1982, from the Acushnet River at 33 sampling locations, 3 cores per each location (A,B,C) were analyzed for their PCB contamination by liquid chromatography (LC), thin-layer chromatography (TLC) and gas chromatography (GC).

3. Prior to analysis, the samples were prepared in the following manner. The top inch, the slice between 5½ and 6½ inches and the bottom 2 inches of the 3 core samples from each of the 33 sampling locations were combined and homogenized. The resulting samples were then air dried for approximately 24 hours. Eight (8) mL of solvent were added to 4 g of dried sediment from each sample and sonified for 3 minutes in a test tube. Methanol was used as the solvent to extract PCB from the sediment for LC and TLC; a mixture of 10% acetone in hexane was used as the solvent to extract PCB from the sediment for GC.

4. The chemical analyses were conducted in the following manner.

a. For GC, the samples were analyzed on a 2 foot 3% OV-101 column by electron capture detection. The separation was conducted isothermally at 165°C for 15 minutes, followed by temperature programming at 10°/min to 215°C with a 1 minute hold to bake out the column. Sulfur-containing impurities which interfered with the GC analysis were readily removed with tetrabutylamomium sulfite reagent prior to analysis.

b. For TLC analysis, 5 µL aliquots of methanol extracts were spotted on thin layer chromatographic plates coated with silica gel. Ten (10) samples, i.e., 3 reference standards at concentration levels from 200 ppm to 1000 ppm and 7 sediment samples, were applied to each plate. The plates were air dried for 15 minutes and then developed for 30 to 35 minutes in a vertical chamber containing hexane. The dried plates were then analyzed using a Farrand Optical, Inc. VIS/UV Chromatographic Plate Analyzer in the absorption mode at a fixed wavelength of 235 nm. All plates

SPEED LIMIT 55
It's a law we can live with.

were measured at a scan speed of 1 cm per minute. Quantitative values for environmental samples were determined by comparing the response to that of the calibration standards present on each plate.

c. LC analysis was carried out on a ODS Zorbax (DuPont) column with a Whatman guard column at 1 mL/min flow rate with methanol. 20uL standard injection volumes were used measuring UV absorption at 254 nm. All components eluting between 3.5 and 10 minutes were quantitated by measuring peak areas using an electronic integrator.

5. The standards employed for all three analytical methods was Aroclor 1254. Therefore, the tabulation which is attached as Enclosure (1), lists the PCB concentration as ppm 1254 levels. Only one value per sample is reported even though three different analytical methods were applied. The reported concentrations represent a consensus value of the three methods. The depth of the bottom slice analyzed from each core sample varied and is indicated in the last column of the table. (Sediment material for the bottom slice was not available from all core samples.)

6. In order to evaluate the capability of our mobile laboratory to respond in real time on scene to provide chemical analytical support, a field deployment to the Acushnet River in the New Bedford, MA area commenced on 7 June 1982. This deployment is in accordance with project plan 4154, "Sampling, Chemical Classification and Quantification for Pollution Response". The same analytical techniques are applied for this field test as were used in the laboratory investigation, the only difference being the real world environment of a remotely-located field condition on scene. Results of this study will benefit our research endeavor as well as the operational investigation by MSO Providence. Results will be reported when completed.

U. R. BRESLAU
By direction

Encl: (1) PCB Concentration In PPM

Copy: COMDT (G-DMT-4/54)
COMDT (G-WER-2/12)
Commander, First CG District (m)

PCB CONCENTRATION IN PPM

(Calculated against Aroclor 1254 as standard)

SAMPLE NO.	0-1"	5½-6½"	Bottom	Depth of Bottom Slice in Inches
1	1880	2150	830	11-12 (B, C)
2	1920	30700	40	14-15 (A, C)
3	2720	1000	49	16-17 (A,C)
4	1790	670	13	13½-14½ (A,B,C)
5	620	340	26	11-13 (C)
6	850	370	13	12-13 (A,B,C)
7	2520	4150	20	24½-25½ (A)
8	3550	11750	275	13½-14½ (B)
9	16700	38370	no sample	------------
10	4250	5870	19650	8½-9½ (A,B)
11	1200	320	28	11-13 (A)
12	670	260	78	6½-7½ (C)
13	670	1750	44	11-12 (A,B,C)
14	710	620	6	11-12½ (C)
15	910	600	3	14-15 (B,C)
16	190	20	2	10-12 (A)
17	1910	5180	69	10½-11½ (A,C)
18	1280	1060	20	10-11 (A,B)
19	1250	950	14	12½-13½ (B,C)
20	450	760	420	9-10 (A,C)
21	750	1290	150	8½-9 (A,B,C)
22	600	2770	48	11-12 (B,C)
23	1200	42	79	10½-11½ (B,C)
24	1070	480	---	10½-11½ (A,B,C)
25	1690	4740	200	12½-13½ (A,B)
26	1440	7230	810	11-12 (B,C)
27	1980	66500	27	12-13 (A,B,C)
28	1920	47000	25	13½-15½ (C)
29	1130	1430	9	25-26 (B)
30	1920	490	25	12-14 (A,C)
31	2900	1860	2	9-10 (A,B,C)
32	780	5100	3810	8-10 (A,B,C)
33	830	4350	20	11-12 (A,B)

Enclosure (1)

U.S. Coast Guard
samples in ppm dry wt.

6/22/82

SAMPLES TAKEN
Ø7 JUN 82

PCB'S ACUSHNET RIVER

RECEIVED BY PHONE
14 JUN 82

	Ø-1"	5½-6½"	7-8"
1.	3ØØ	55	25
2.	4ØØ	15Ø	1Ø-11" 5
3.	3ØØ	16Ø	8½-9½" 35
4.	TOP 5Ø		(2-4" BOTTOM) 45
5.	7Ø	95	15-17" 5Ø
6.	7Ø	1Ø	8-9" 1Ø
7.	6Ø	3Ø	16-18" 1Ø
8.	19Ø	32Ø	7-9" 85
9.	5Ø	33Ø	8-9" 125
1Ø.	11Ø	7Ø	7-8" 3Ø

MASSACHUSETTS DIVISION OF WATER POLLUTION CONTROL
SEDIMENT DATA

JULY AND OCTOBER 1981

RESULTS OF SEDIMENT SAMPLE ANALYSES

FOR PCB's IN NEW BEDFORD HARBOR

July and October 1981

Gerald Szal, DWPC, Westboro

Chemical Analysis by Cambridge Analytical Associates

STATION NO.		DATE	TYPE OF SAMPLE	DEPTH OF SAMPLE (inches)	PCB CONCENTRATION (ppm wet wt.) 1248	1254	% DRY WEIGHT
I	a	7/21	Pd	approx. 0-4	34	34	70
	a'	7/22	sc	0-4	35	--	*
	a'	7/22	sc	4-8	1.4	--	*
	b	7/21	Pd	approx. 0-4	14	18	78
	c	7/21	Pd	" "	230	200	71
	c'	7/22	sc	0-4	1300	--	*
	c'	"	sc	4-8	100	--	67
	c'	"	sc	8-12	10	--	*
II	a		sc	0-4	1140	--	*
	a'	"	Pd	approx. 0-4	130	--	43
	b	"	"	0-4	670	--	*
	b'	"	Pd	approx. 0-4	1080	--	41
	c	"	"	0-4	460	--	*
	c	"	"	4-8	10	--	*
	c	"	"	8-12	4.0	--	17
III	a	"	"	0-4	2300	--	*
	a	"	"	4-8	100	--	*
	b	"	"	0-4	500	--	*
	b'	"	Pd	approx. 0-4	1300	--	42
	c	"	"	0-4	150	--	67
	c	"	"	4-8	5.6	--	*
	c	"	"	8-12	3.6	--	52
IV	a	"	"	0-4	190	--	*
	a'	"	Pd	approx. 0-4	135	--	33
	b	7/23	"	0-5	460	--	36
	b	"	"	5-9½	60	--	46
	b	"	"	9½-14	1.5	--	48
	c	"	"	0-5	36	--	79
	c	"	"	5-10	.02	--	74
V	a	"	"	0-7	80	--	38
	a	"	"	15-22	0.8	--	42
	b	"	"	0-7	30	--	41
	b	"	"	7-14	1.0	--	46
	c	"	"	0-8	34	--	38
	c	"	"	8-16	70	--	44
	d	"	"	0-7	4.2	4.4	*
	d	"	"	7-14	100	26	*

Results of Sediment Sampling Analyses
For PCB's in New Bedford Harbor (Cont.)

STATION NO.	DATE	OF SAMPLE	DEPTH OF SAMPLE (inches)	PCB CONCENTRATION (ppm wet wt.) 1248	1254	% DRY WEIGHT
VI a	"	"	0-6½	170	22	*
a	"	"	6½-13	1.3	--	*
b	"	Pd	approx.0-4	12	--	*
c	"	"	" "	8.0	--	*
VII a	7/28	lc	0-4	12	5.3	*
b	"	"	"	8.0	3.6	*
c	"	"	"	13	10	40
VII.1a	"	"	"	11	3.3	*
b	"	"	"	24	34	39
c	"	"	"	10	13	35
VIII a	10/2	"	"	6.7	7.0	45
b	"	"	"	7.5	6.0	37
IX a	10/2	"	"	0.1	0.3	64
b	"	"	"	5.0	5.6	63
c	"	"	"	7.6	6.5	48
X b	7/28	"	"	8.6	13	*
a	"	"	"	5.4	2.3	*
XI a	7/21	Pd	approx.0-4	1.1	2.4	73
b	"	"	"	2.3	3.7	69
c	"	"	"	0.9	0.69	68
d	"	"	"	2.6	2.4	57
XII a	10/2	lc	0-4	1.8	2.8	62
b	"	"	"	4.2	4.0	59
c	"	"	"	1.4	3.2	57
XIIIa	10/2	"	"	25	5.5	59
b	10/2	"	"	23	6.2	55
XIV a	7/28	"	"	--	--	*
a'	10/1	"	"	6.4	6.8	64
b	7/28	"	"	5.0	5.7	52
b'	10/1	"	"	1.2	1.5	64
c	7/28	"	"	1.4	3.3	*
c'	10/1	"	"	0.6	6.6	69
XV a	7/28	"	"	2.6	3.2	*
a'	10/2	"	"	2.0	5.0	65
b	7/28	"	"	0.7	4.4	*
b'	10/2	"	"	4.5	2.0	68

Results of Sediment Sampling Analyses
For PCB's in New Bedford Harbor (Cont.)

STATION NO.		DATE	TYPE OF SAMPLE	DEPTH OF SAMPLE (inches)	PCB CONCENTRATION (ppm wet wt.) 1248	1254	% DRY WEIGHT
XV	c	7/28	lc	0-4	5.5	4.0	*
	c'	10/2	"	"	2.1	3.0	67
XVI	a	7/27	"	"	9.0	14	43
	b	"	"	"	--	15	57
	c	"	"	"	3.4	22	50
	c'	10/1	"	"	3.4	4.7	*
XVII	a	7/27	"	"	1.3	45	50
	a'	10/1	"	"	7.0	16	42
	b	7/27	"	"	7.7	25	50
	b'	10/1	"	"	2.5	7.3	76
	c	7/27	"	"	3.0	4.0	65
	c'	10/1	"	"	2.2	1.8	62
XVIII	a	10/1	"	"	0.7	1.1	68
	b	10/1	"	"	0.5	1.2	69
	a'	7/27	"	"	1.7	2.2	74
	c	10/1	"	"	0.3	0.4	81
	d	"	"	"	0.2	0.5	61

<u>Legend</u>:

Pd = Peterson dredge

sc = 24" hand-held core

lc = winch-operated 4' core

Note: An apostrophe after a station represents a second sample taken at that station.

$$\% \text{ Dry Weight} = \frac{\text{dry weight (g)}}{\text{wet weight (g)}} \times 100$$

*insufficient volume of sample to calculate % dry weight

Cambridge Analytical Associates

Sample Preparation:

Sediment & Core Samples

50 grams of sample was passed through a 2 millimeter sieve and mixed thoroughly in a 250 milliliter erlenmeyer flask. 35 milliliters of 0.2M NH_4Cl solution was added and allowed to stand for 15 minutes. 125 milliliters of hexane-acetone (1+1) was added. The flask was covered and shaken overnight on a reciprocal shaker at 180 rpm. The supernatant was poured through a 3 centimeter column of florisil and the eluate was collected in a 1 liter separatory funnel. 200 milliliters of distilled water was added to the funnel and shaken for 30 seconds. The aqueous phase was drained into a second separatory funnel and extracted with 50 milliliters of hexane. The hexane layers were combined in the first separatory funnel and washed with 100 milliliters of distilled water. The water was discarded, the hexane was poured through a 5 centimeter column of anhydrous sodium sulfate and collected in a 1 liter round bottom flask. The hexane was evaporated to approximately 10 milliliters on a rotary evaporator and poured onto a 10 centimeter column of activated florisil topped with 1 centimeter of anhydrous sodium sulfate, prewet with 50 milliliters of hexane. Round bottom flasks were rinsed with 3 x 10 milliliters of hexane and this was poured onto the column. The column was then eluted with 200 milliliters of 6% ethyl ether in hexane.

Samples 810720-23 thru 810720-53; the eluate was collected in a 500 milliliter Kuderna Danish apparatus and concentrated to approximately 10 milliliters. All other samples were collected directly from the column into 250 milliliter glass bottles. The hexane extracts were then injected on a gas chromatograph with electron capture detector.

Analytical Efficiency:

	Recovery
Sample 810720-23 spiked with 25 ul of 1 mg/ml Aroclor 1248	75%
Sample 810720-24 spiked with 26 ul of 1 mg/ml Aroclor 1242	105%
Sample 810724-15 spiked with 40 ul of 1 mg/ml Aroclor 1260	96%
Sample 810729-1 spiked with 48 ul of 1 mg/ml Aroclor 1254	64%

Cambridge Analytical Associates

ANALYTICAL EFFICIENCY: (continued)

Duplicates:

Sample 810720-24	- 0.30 ppm Aroclor 1254
Sample 810720-24 dupe.	- 0.32 ppm Aroclor 1254
Sample 811005-22	- 6.8 ppm Aroclor 1254, 6.4 ppm Aroclor 1248
Sample 811005-22 dupe.	- 6.0 ppm Aroclor 1254, 5.7 ppm Aroclor 1248
Sample 811005-25	- 3.0 ppm Aroclor 1254
Sample 811005-25 dupe.	- 3.0 ppm Aroclor 1254
Sample 811005-34	- 7.0 ppm Aroclor 1254, 6.7 ppm Aroclor 1248
Sample 811005-34 dupe.	- 7.8 ppm Aroclor 1254, Aroclor 1248

CHROMATOGRAPHIC CONDITIONS:

Instrument:	Perkin Elmer - Sigma I, and 3920B
Column:	1/4" x 6' glass tube, 2 mm i.d.
Packing:	1.5% OV-17, 1.95% QF-1, on 80/100 Gas Chrom Q
Temperature:	185°C and 215°C - Sigma I 170°C and 200°C - 3920B
Carrier Gas:	5% Methane in Argon at 40 ml/min.
Detector:	Electron Capture
Attenuation:	See individual chromatograms
Injection Volume:	2.0 ul - Sigma I, 4.0 ul - 3920B

MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL QUALITY ENGINEERING SEDIMENT DATA

MAY 1978, AUGUST 1979 AND SEPTEMBER 1980

PCB Contamination in New Bedford Harbor Bottom Sediments

"May, 1978 and August, 1979"

Mg./Kg/ PCB's as 1254 (Dry Wt. Basis)

Sample Collection Station	Depth in Inches	May, 1978	August, 1979	%Change in 1979
1	0-4	7.4	39.7	+436%
1	4-8	10.4	25.9	+149%
1A	0-3	ND	72.7	-
1A	3-6	ND	0.1	-
2	0-3	1.9	3.2	+ 68%
2	3-6	3.9		-
3	0-3	2.5	11.8	+372%
3	3-6	4.7	41.5	+783%
4	0-3	6.3	67.4	+970%
4	3-6	2.9	1.4	- 52%
5	0-4	3.4		-
5	4-8	8.3		-
6	0-4	4.2	43.1	+926%
6	4-8	5.1	0.2	- 96%
7	0-4	20.4	0-3" 19.6	- 4%
7	4-8	31.6	3-6" 11.6	- 63%
8	0-3	19.9	11.6	- 42%
8	3-6	14.3	3-7" 4.4	- 69%
9	0-4	13.1	7.5	- 43%
9	4-7	13.7	11.9	- 13%
9	7-10	29.8		

Sample Collection tation	Depth in Inches	May, 1978	August, 1979	%Change in 1979
10	0-4	2.4	0-3" 7.9 (3-6"=3.2)	+229% -
11	0-3	4.9		-
11	3-6	4.0		-
12	0-3	3.3	0.3	- 91%
12	3-6	7.4	1.1	- 85%
12A	0-4	6.8		-
12A	4-8	12.7		-
13	0-5	12.0	0-3" 1.0	- 92%
13	5-8	5.2	3-6" 4.3 (6-9"=4.8)	- 17% -
14	0-4	1.8	2.0 (0-2"=2.0) (2-5"=1.6) (5-8"=9.6)	+ 11% - - -
14	4-6	3.6	4-8" 0.7	- 80%
15	0-3	7.1	0.8	- 89%
15	3-6	7.2	0.1 (6-10"=0.6)	- 99% -
16	0-5	9.7		-
16	5-10	4.3		-
17	0-3	7.9	0.3	- 96%
19	0-2	7.4	0.9 (2-8"=0.5)	- 88% -
20	0-2	5.2	12.4 (2-5"=4.1)	+138%
22	0-	7.2	0-1½" 3.3	- 54%
22A	0-4	6.8	0-3" 43.6	+541%
22A	4-8	8.4		-
23	0-4	0.4		-

+244.9 -1083
net increase 13[illegible]

The Commonwealth of Massachusetts
Department Of Environmental Quality Engineering
Lawrence Experiment Station
37 Shattuck Street, Lawrence, Massachusetts

SUBJECT: NEW BEDFORD HARBOR SEDIMENT - PCB STUDY

DATE OF COLLECTION: SEPTEMBER 30, 1980

COLLECTOR: PACKARD

LABORATORY NUMBER	STATION	DEPTH (inches)	% MOISTURE	PCB AROCHLORS (mg/Kg-Wet Weight) 1016	1254	TOTAL PCB (mg/Kg-Dry Weight)
003351	1	0 - 4	65.60	N.D.	2.6	7.6
003353	1	4 - 8	66.10	N.D.	10.0	29.5
003354	1	8 - 12	65.30	N.D.	1.3	3.7
003355	1	12 - 14	58.70	N.D.	0.92	2.2
003352	1A	0 - 4	60.30	N.D.	118.	297.
003371	1A	4 - 8	57.20	N.D.	.38	0.9
003372	2	0 - 3	48.50	N.D.	2.7	5.2
003373	2	3 - 6	45.10	N.D.	0.62	1.1
003374	2	6 - 10	48.20	N.D.	8.5	16.4
003375	3	0 - 4	61.50	N.D.	0.34	0.9
003376	3	4 - 8	58.40	N.D.	≤ .01	
003377	3	8 - 13	51.58	N.D.	≤ .01	
003378	4	0 - 4	53.50	N.D.	N.D.	N.D.
003408	4	4 - 8	53.12	N.D.	N.D.	N.D.
003409	4	8 - 12	48.40	N.D.	N.D.	N.D.
003410	5	0 - 4	58.00	N.D.	N.D.	N.D.
003411	5	4 - 8	36.82	N.D.	≤ .01	
003412	5	8 - 12	30.41	N.D.	N.D.	N.D.

LABORATORY NUMBER	STATION	DEPTH (inches)	% MOISTURE	PCB AROCHLORS (mg/Kg-Wet Weight) 1016	1254	TOTAL PCB (mg/Kg-Dry Weight)
003413	6	0 - 4	64.30	N.D.	4.7	13.2
003414	6	4 - 8	56.09	N.D.	N.D.	N.D.
003415	6	8 -12	54.00	N.D.	8.95	19.5
003421	7	0 - 4	73.00	N.D.	N.D.	N.D.
003422	7	4 - 8	68.72	N.D.	0.06	0.19
003423	8	0 - 4	60.93	N.D.	N.D.	N.D.
003424	8	4 - 8	57.65	N.D.	0.06	0.14
003425	9	0 - 4	67.15	0.09	0.10	0.58
003426	9	4 - 8	50.63	0.12	0.04	0.32
002427	9	8 - 12	48.73	0.09	0.10	0.37
003428	10	0 - 4	52.08	0.14	1.66	3.8
003476	10	4 - 8	33.84	N.D.	0.36	0.54
003477	10	8 - 12	53.87	N.D.	N.D.	N.D.
003478	11	0 - 4	68.04	N.D.	N.D.	N.D.
003479	11	4 - 8	64.88	N.D.	N.D.	N.D.
003480	11	8 - 12	60.02	N.D.	< 0.01	
003481	12	0 - 4	45.38	N.D.	1.06	1.94
003482	12	4 - 8	37.20	N.D.	N.D.	N.D.
003483	13	0 - 4	57.73	N.D.	N.D.	N.D.
003484	13	4 - 8	47.03	N.D.	N.D.	N.D.
003485	13	8 - 12	58.45	N.D.	N.D.	N.D.

LABORATORY NUMBER	STATION	DEPTH (inches)	% MOISTURE	PCB AROCHLORS (mg/Kg-Wet Weight) 1016	1254	TOTAL PCB (mg/Kg-Dry Weight)
003486	14	0 - 4	65.10	N.D.	N.D.	N.D.
003487	14	4 - 8	59.31	N.D.	N.D.	N.D.
003917	14	8 - 12	61.61	0.42	0.22	1.67
003918	15	0 - 4	49.33	N.D.	0.47	0.93
003919	15	4 - 8	49.42	N.D.	N.D.	N.D.
003920	15	8 - 12	47.17	N.D.	N.D.	N.D.
003921	16	0 - 4	40.50	0.25	0.40	1.1
003922	16	4 - 9	46.34	0.52	1.16	3.13
003923	16	9 - 11	48.80	0.08	0.69	1.5
003924	17	0 - 4	47.89	0.70	0.74	2.8
003925	18	0 - 4	65.23	0.30	1.25	4.5
003926	18	4 - 8	60.23	0.23	1.0	3.1
003936	18	8 - 12	58.95	< 0.01	0.17	0.4
003937	18	12 - 14	52.90	< 0.01	0.06	0.13
003938	19	0 - 4	65.15	< 0.01	< 0.01	
003939	19	4 - 8	58.00	N.D.	N.D.	N.D.
003940	19	8 - 12	55.63	0.66	0.18	1.9
003941	20	0 - 2	25.87	< 0.01	< 0.01	
003942	22A	0 - 5	44.38	0.20	0.92	2.0
003943	22A	5 - 10	43.28	0.01	0.37	0.65
003944	22	0 - 4	38.35	N.D.	0.14	0.22
003945	22	4 - 8	57.62	N.D.	1.72	4.0
003946	23	0 - 3	54.83	11.2	15.6	59.3
003947	23	3 - 7	56.35	N.D.	0.30	0.69
003948	23	7 - 10	55.37	N.D.	0.42	0.94

mg/Kg = parts per million

N.D. = None Detected

Wet Weight = Sample as is

APPENDIX B

ALTERNATIVE DREDGING TECHNOLOGIES

APPENDIX B

ALTERNATIVE DREDGING TECHNOLOGIES

Introduction

A dredge may be defined as a machine which removes materials from the bottom of waterways by means of scooping or suction devices. The removal of contaminated sediments is not a traditional dredging activity although no other system known can excavate this bottom material as economically. New technologies are being developed and applied to dredging which are expected to increase removal efficiency and minimize the loss of fine grained materials at the dredgehead. Some of these new systems are described herein.

There are three primary dredging methods in use today: hydraulic, mechanical, and pneumatic. This appendix investigates the types of dredges available in each category, their advantages and disadvantages in terms of cost, time, loss of material, depth requirements, and sediment types handled.

The transport of dredged material is an important aspect of dredging and is generally performed by pipelines, barges, or trucks. Transport types are often determined by the dredge system chosen: for example, material dredged hydraulically is generally conveyed by pipeline to the disposal site. This appendix investigates the types of transport available and their advantages and disadvantages in terms of travel time to the disposal site, cost, secondary pollution and return flow treatment requirements.

Material for this appendix was obtained from texts on dredging, World Dredging Conference (WODCON) publications, manufacturers' catalogues, discussions with dredge manufacturers and consultants and reports on dredging studies.

Hydraulic Dredges

Dredges which operate hydraulically use water as a medium to convey the dredged material. The material to be excavated is mixed with water and pumped through the system by a centrifugal pump as a slurry (generally 10 to 20 percent solids content). The material is transported to a spoil lagoon where the sediments are allowed to settle out. Owing to the large flows associated with this system, the disposal sites are relatively large to include areas for decanting the fine grained sediments as well as treatment of return water before discharge to the waterway. In addition, certain types of sediment exhibit a phenomena known as "fluffing" wherein the dredged material occupies a different volume in the disposal area than in the river or lake bottom. The fluff factor (cut to fill ratio) can range from 3 to 1 for benonitic clays and organic silts to 0.85 to 1 for sands.

The following types of hydraulic dredges are discussed herein:

- Cutterhead suction
- Plain suction
- Dustpan
- Hopper
- Sidecasting
- Clean Up

Advantages and disadvantages are summarized following a description of each type.

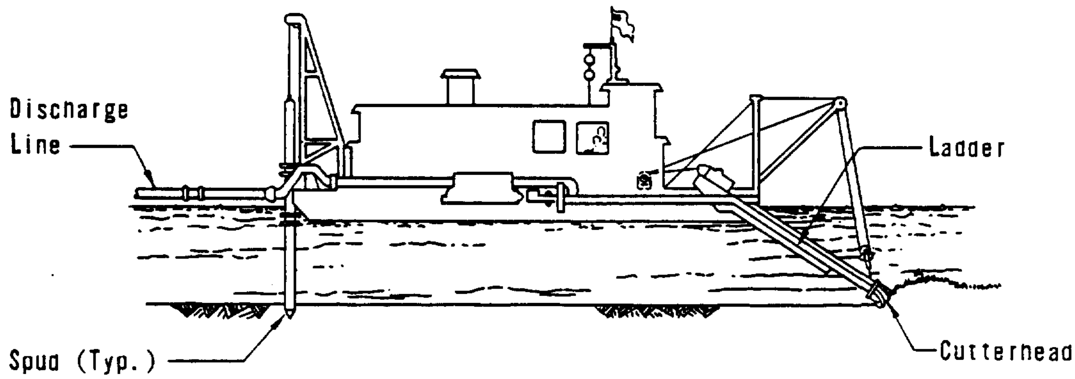
Cutterhead Suction - This type of dredge excavates subaqueous material by means of a rotating cutter at the end of a suction pipe. The cutter suspends material into a slurry which is then pumped hydraulically and discharged through a floating pipeline to shore. The dredge advances by swinging from side to side using spuds at the rear as pivots. Lateral movements are controlled by swing cables attached to anchors. The depth of cut is manually controlled by the operator who may raise or lower the ladder cutterhead. This type of dredge is illustrated in Figure B-1.

Dredge size is determined by the diameter of the discharge line and generally range from 6 to 42 in. Dredges in the 8 to 16 in. range may be most suitable for different dredging projects in the Upper Acushnet River Estuary and the New Bedford Harbor. Actual dredge size will depend on the quantity of material to be dredged, the location of the disposal site in relationship to the area to be dredged, the amount of solids in the material to be dredged, and the elevation of the containment site.

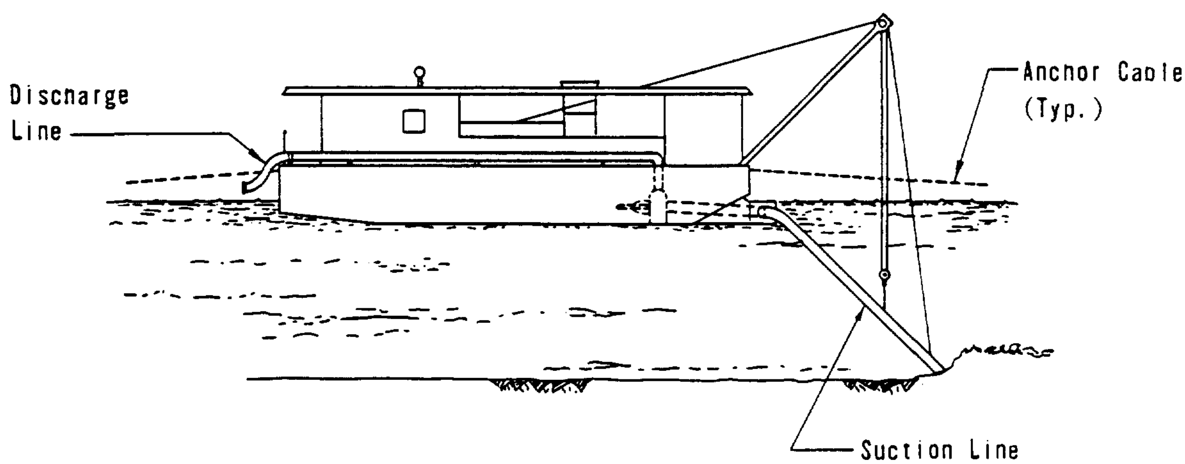
In general, 12 to 16 in. dredges are approximately 50 ft in length, 20 feet in width and require three to four ft draft. Production varies considerably with dredged material characteristics and piping lengths; ranges from 150-850 cu yd per hour are typical. Twelve to 16 in. dredges will efficiently excavate medium clays, silt, sand, gravel and soft rock. Material loss at the cutterhead can be controlled to some extent by the operator by varying the rate of ladder swing and cutter rotation speed. Twelve to 16 in. dredges generally have a maximum dredging depth of 25 to 30 ft.

<u>Advantages</u>

- o Large volumes of material are moved economically because of a virtually continuous operating cycle. High production for size of plant.
- o A wide range of materials, from light silts to heavy rock blasted to small sizes, can be excavated with a properly designed cutterhead.
- o The use of booster pumps in the pipeline allows material transport over relatively long distances from the waterway to the disposal site.
- o There is no rehandling of the sediment from the cutterhead to the spoil lagoon.



CUTTERHEAD SUCTION DREDGE



PLAIN SUCTION DREDGE

Disadvantages

- The floating pipeline and swing wires can be a obstruction to navigation.

- There is agitation and disturbance of the bottom sediment. Materials loss is a function of operational procedures such as cutter speed and swing, cutter design and the implementation of shielding devices.

Plain Suction - These are similar to ordinary cutterhead dredges except for the absence of the cutter. Occasionally, these dredges are equipped with a special suction head which uses water jets to loosen the material. Only loose and free-flowing sediments can be dredged using such equipment. See Fig. B-1.

Advantages

- Large volumes of the proper material can be moved economically.

- With booster pumps, the slurry can be transported over long distances to the disposal site.

- There is no materials handling beyond the dredge head.

Disadvantages

- The floating pipeline and swing wires can be an obstruction to navigation.

- Because of the nature of the material to be dredged, this system has a limited use in a waterway where a wide variety of sediment types exist.

- In the dredging of non-optimal materials, very low production rates are observed.

Dustpan - This plant is an adaptation of the plain suction dredge. The suction head resembles a large dustpan and has been primarily used to remove sandbars in the Mississippi River. The dredge head is generally 32 ft wide with a rectangular opening 31 ft wide and 16 in. high.

Equally spaced vertical members are fitted across the inlet to prevent oversized material from entering the suction. These members terminate in water jet nozzles to break up the sands and silts and form a slurry which can be pumped through the system. The dredge is slowly pulled towards two prepositioned anchors or spuds, generally placed upstream of the dredge. The slurry is usually discharged from a short pipeline in the water adjacent to the dredge. See Fig. B-2.

Advantages

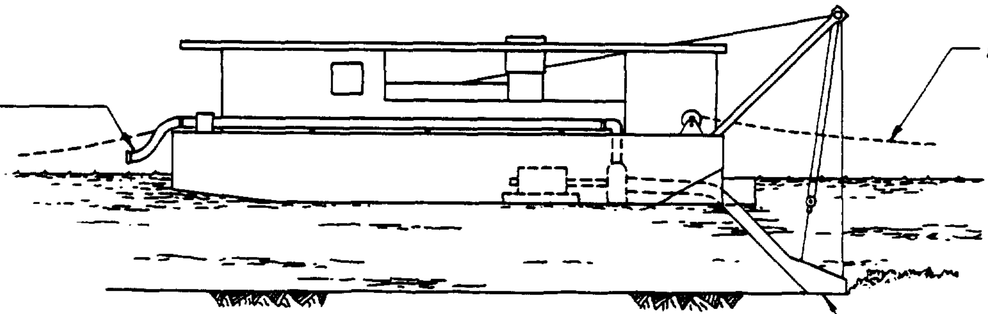
- o The material is forced into the suction resulting in a slurry with a high solids content. High production for the size of plant.

Disadvantages

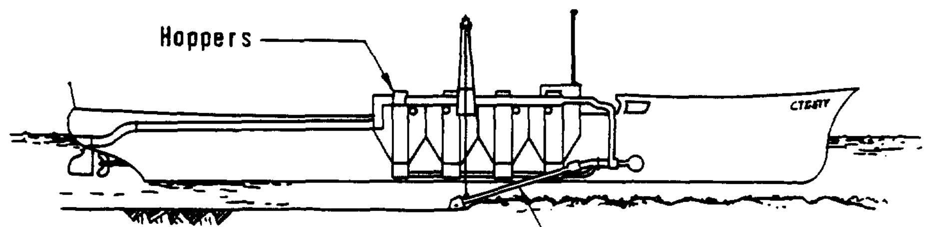
- o The nature of the disposal operation resuspends a large amount of material. In the case of contaminated material, this is environmentally unattractive.
- o As for the plain suction dredge, this system is best suited for a certain type of material and is of limited use in dredging an area with a wide variety of sediments and trash.
- o Normal mode of dustpan operation (i.e. sidecasting) is not suitable. This operation could be modified at additional cost.

Hopper - The hopper dredge is an ocean-going ship and functions like a plain suction dredge. The dredging operation is accomplished by two trailing drag arms extending from both sides of the ship to the waterway bottom. The material is removed from the bottom by suction and pumped into hopper bins aboard the ship. In general, dredging is continued beyond the point where the bins overflow to increase the amount of solids contained in the hoppers. When the hoppers are filled the dredge proceeds to deep water dumping grounds where the bins are opened and the material discharged. As an alternative, the bins may be pumped out and the slurry discharged in spoil

Figure B-2



DUSTPAN DREDGE



HOPPER DREDGE

MALCOLM PIRNIE

lagoons as in conventional hydraulic dredging practice. The dredge hopper sizes generally vary from 300 to 12,000 cu yd and a minimum draft of 15 ft is usually required for operation although shallower draft hopper dredges are currently being used by the Corps of Engineers and other private dredging concern. Production for a 3,000 cu yd hopper capacity ship is roughly 500,000 cu yd per month. See Fig. B-2.

Advantages

- The dredge is self-propelled and removes material while underway with no moorings or cables.

- There is minimum interference with navigation because of the dredge's high mobility. Can operate in rough waters.

- Suitable for all but the hardest materials. Production depends on the travel time to the dumping grounds and the mode of hopper discharge.

Disadvantages

- The overflow of the hopper bins resuspends fines, as does the bottom dumping of the dredged material. In dealing with contaminated materials, this method of operation is undesirable.

Sidecasting - This type of dredge is a relatively new development, which removes material by a draghead sliding over the bottom and discharges the material over the side of the vessel in the water through a 70 to 250 ft boom. The system is best suited for littoral or estuarine areas. The range of materials handled by the sidecasting dredge is similar to that excavated by the hopper dredges. The first sidecasting dredge was a converted tanker but smaller plants are manufactured today which can operate in five feet of water.

Advantages

- The dredges are self-propelled and therefore highly mobile. They are best suited for operating in shallow ocean inlets.

- There is minimum interference with navigation and the dredge can operate in rough waters.

Disadvantages

- o The method of disposal of the dredged material is self-defeating when dredging contaminated materials.

Clean-Up - The Clean-Up dredge is a hydraulic suction dredge modified by the replacement of a conventional cutter-head with a new suction design. The new suction head consists of an underwater pump and a shielded auger-like mixing device. There is also a movable plate which deflects currents generated by the dredge suction and a device for collecting gases released during the dredging process. Sonar devices and an underwater television camera permit close monitoring of the dredging operation.

This equipment has been developed by the Toa Harbor Works of Japan and is used exclusively for the removal of highly contaminated material.

Advantages

- o Turbidity generation and resuspension of fines is held to a minimum by special suction devices and by giving the operator an accurate picture, through sensors, of the most suitable operating conditions.
- o The use of sonar devices and television cameras allow accurate cutterhead positioning.
- o The advantages listed under the cutterhead suction dredge also apply here.

Disadvantages

- o This dredge does not appear to be available in the United States at this time.
- o It has a relatively low production rate and is therefore expensive. Trash and heavier materials would probably impede the successful operation of this machine.

Mechanical Dredges

Dredges which operate mechanically remove the bottom material with excavation devices but do not transport it to

GAHAGAN & BRYANT ASSOCIATES
219 MARINER SQUARE • SUITE 200
POST OFFICE BOX 18505
TAMPA, FLORIDA 33679
TEL. (813) 879-5871

BRYANT ENGINEERING, INC.
GAHAGAN DREDGING ASSOCIATES, INC.

J. FRANKLIN BRYANT
WILLIAM G. GAHAGAN
WALTER H. GAHAGAN
GEORGE G. FELPS
M. W. ROWLAND

June 1, 1981

Malcolm Pirnie, Inc.
Consulting Environmental Engineers
2 Corporate Park Drive
White Plains, New York 10601

Attn: Dr. Shahabian

Dear Dr. Shahabian:

Enclosed herewith are the estmates for the removal of the PCB's from New Bedford Harbor per your request.

- One, Based on the removal of approximately 1,000,000 c.y. of material and disposal into satisfacotry areas.

- Second, based on approximately 200,000 c.y. of material.

As you are aware, both of these estimates are simply reasonable costs based on certain assumptions which I have made and outlined. In order to provide you with accurate estimates, it would be necessary to make a site investigation.

Should you require further information, please call me.

Very truly yours,

GAHAGAN AND BRYANT ASSOCIATES

George G. Felps
Vice President

GGF:vl

cc:file
cc:WGG
enclosures

COSTS SUMMARY

200,000 Cubic Yards

Mobilization & Demobilization	$450,000.
Clamshell Operations Costs (2) 4.0 mo. @ $150,000.	600,000.
Clamshell Ownership Costs (2) 4.0 mo. @ $77,000.	308,000.
Scow Operating Costs (3) 4.0 Mo. @ $3,000.	12,000.
Scow Ownership Costs (3) 4.0 mo. @ $36,000.	144,000.
Tug Operation Costs (2) 4.0 mo. @ $70,000.	280,000.
Tug Ownership Costs (2) 4.0 mo. @ $12,000.	48,000.
Misc. Equipment Costs 4.0 mo. @ $20,000.	80,000.
Site Preparation (Diking)	600,000.
Supervision and Engineering 4.0 mo. @ $50,000.	200,000.
	$2,722,000.
Contingency @ 25%	680,500.
Profit and Overhead @ 35%	1,190,875.
Total	$4,593,375.

$4,593,375 / 200,000 c/y = $23. per Cubic Yard

COSTS SUMMARY

1,000,000 Cubic Yards

Mobilization & Demobilization	$ 750,000.
Dredging Costs - Excavate and Transport	
Clamshell Operations Costs (4) 5.0 mo. @ $300,000.	1,500,000.
Clamshell Ownership Costs (4) 5.0 mo. @ $154,000.	770,000.
Scow Operating Costs (5) 5.0 Mo. @ $5,000.	25,000.
Scow Ownership Costs (5) 5.0 mo. @ $60,000.	300,000.
Tug Operation Costs (3) 5.0 mo. @ $150,000.	525,000.
Tug Ownership Costs (3) 5.0 mo. @ $18,000.	90,000.
Misc. Equipment Costs 5.0 mo. @ $20,000.	100,000.
Site Preparation (Diking)	1,080,000.
Supervision and Engineering 5.0 mo. @ $50,000.	250,000.
	$5,390,000.
Contingency @ 25%	1,347,500.
Profit and Overhead @ 35%	2,358,125.
Total	$9,095,625.

$\frac{\$9,095,625.}{1,000,000\ c/y}$ = $9.10 Cost Per Cubic Yard

REMOVAL OF PCB'S FROM NEW BEDFORD HARBOR

In reference to the proposed removal of mud and silt contaminated material from the harbor at New Bedford, Mass., the following observations and assumptions have been made.

1. It has not been possible to make the usual and normal site investigation which is a prerequisite to any good job estimate.

2. That the material to be dredged is mud and fine grain silt containing no rock or objectional quantity of trash and that the layer of material to be removed is at least 3.0' deep.

3. That the contaminated material will be loaded directly into hopper barges by two clamshell dredges, moved under a bridge having a 6.0' clearance, taken directly alongside a diked disposal site where it can be unloaded by two crawler-type clamshells operating from the crown of the dike in a single swing with no rehandling considered.

4. That there is adequate operational water depths to permit free operation of the equipment without the necessity of access or non-productive dredging. Time loss in moving from one hot spot to another has not been considered.

5. That the production rate will be greatly reduced because of the soft nature of the material which will probably allow only a half load (half water - half material) to be taken to the disposal site.

6. That the following equipment will be utilized:
   - 2-Barge mounted 5 cubic yard clamshell excavators
   - 2-Crawler type 5 cubic yard clamshell excavators
   - 3-pusher type +/- 300 H.P. diesel tugs
   - 5-Hopper barges able to pass loaded and unloaded under the bridge with the least clearance

7. That the material to be dredged would be approximately 1,000,000 cubic yards.

8. That the dredging and disposal operation would be free and unencumbered by environmental, testing procedures or objections raised by interested groups or union activity.

9. That the disposed material would assume a natural flat slope so as not to impede the disposal operation.

10. That the estimated costs do not cover any effluent treatment, disposal area sealing procedures or use of hypalon or clay subbases or covers or silt curtains.

11. That the production rate of 100,000 cubic yards per month per clamshell be maintained for five months unhindered by winter or icing conditions.

12. That all permits necessary for the operation be provided by owner without delay to the contractor.

13. That a sufficient disposal area be provided, estimating 9,000 linel feet of 40 cubic yards per foot costing $3.00 per cubic yard.

the disposal site. A fleet of barges and tugs are used for this purpose. All mechanical dredge types resemble dry land excavation equipment; in fact, in many cases surface equipment is floated on a barge and used for dredging.

This report discusses four types of mechanical dredges:

- o Dipper
- o Clamshell
- o Bucket
- o Dragline
- o "Closed bucket" clamshell

Dipper - This dredge is essentially a barge mounted power shovel. The material is broken off by the force of the cutting edge of the shovel while the dredge remains stationary. The shovel is lifted through the water and the sediments are deposited in a barge or on shore. It is best used in the excavation of hard, compacted materials, and rock and demolition debris. See Fig. B-3.

Advantages

- o As the dipper stick forces the bucket into the material a strong "crowding" action is noted. Hard, compacted materials and demolition debris are best excavated by this system.

- o The dredged material approaches in-place density in sands and silts and approaches dry density in coarser materials.

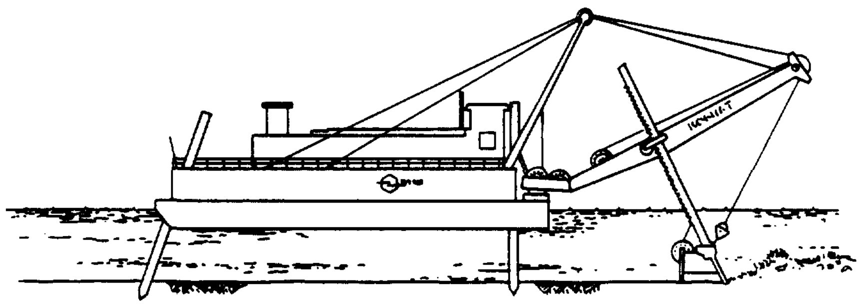
- o This system may be readily assembled.

Disadvantages

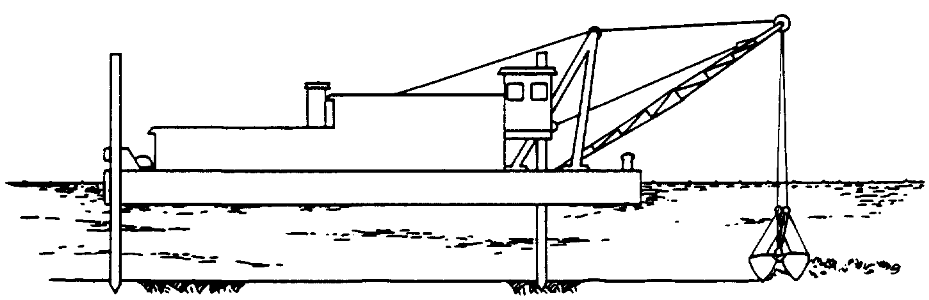
- o Low production for size of plant and investment.

- o The dredging method generates a large amount of turbidity during excavation and as the bucket is raised through the water.

Clamshell - This dredge consists basically of a derrick mounted on a barge with a "clam shell" bucket for excavating. The material is removed by forcing the opposing bucket edges



DIPPER DREDGE



CLAMSHELL DREDGE

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into the sediment. The bucket is lifted out of the water and deposits the spoil on a barge or on shore. The dredge itself remains stationary. This system works best in soft and cohesive materials. A wide variety of bucket and barge sizes are available.

Figure B-3 shows a typical clamshell dredge.

Advantages

- The dredge plant is readily available and easily assembled.
- Can work effectively in confined areas near docks and breakwaters.
- The dredged material approaches the in-place density in mud and silt.

Disadvantages

- In dredging very soft deposits, material washes out of the bucket. In dredging very hard materials, the bucket cannot penetrate the surface of the sediments and little material is excavated.
- Debris may not permit the full closure of the bucket jaws with attending material loss.
- There are technical problems in dredging sludges and sands which form a thin layer. The method of dredging results in the considerable agitation of sludges and other loose materials.
- Relatively low production.

Bucket - The bucket dredge is composed of an endless chain of buckets pulled around a dredging ladder. The sediment is removed by forcing the single cutting edge of each bucket into the material as the dredge is slowly moved between anchors. As the filled bucket rotates over the top tumbler, the load is dumped on an inclined chute to a hopper or barge.

This dredge is extensively used in Europe for all dredging purposes. In the United States, this system is used in the commercial production of sand and gravel and in the recovery of various ores and precious metals. It is suitable for dredging all but the very hardest materials.

Figure B-4 shows a typical bucket dredge.

Advantages

- o In dredging at large production rates (1,500 cu yd per hr), the bucket dredge uses less than half the power required by a cutterhead suction dredge of equivalent size.
- o The dredge operates more efficiently than other mechanical dredges because the excavation process is continuous. High production for its size.
- o The material dredged approaches the in-place density in muds and silts. Approaches dry density in coarser materials.

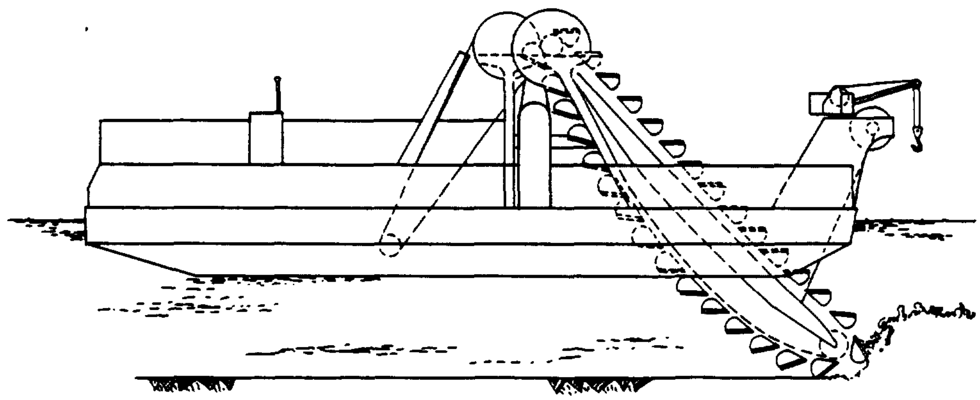
Disadvantages

- o Rehandling of dredged material required.
- o The nature of the operation results in sediment disturbance and resuspension of fines through the excavation process and as the filled buckets move through the water column.
- o This dredge is apparently not available in the United States as a dredge plant. It is used only as part of mining plant in sand and gravel, operations, and other type of mining operation.

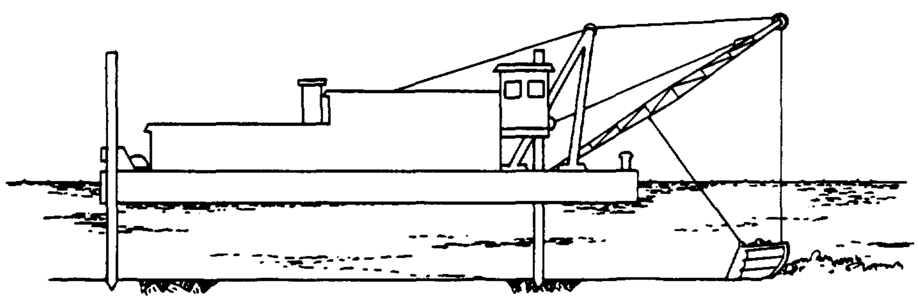
Dragline - This dredge plant is generally composed of a crane having a bucket suspended from a swinging boom which is mounted on a barge or truck. The dredge operates by scraping the material from the bottom by pulling the bucket towards the stationary crane. The spoil is lifted and deposited on a barge or on the bank. This system is readily available in a wide variety of sizes and is suitable for all but the hardest material. See Figure B-4.

Advantages

- o This system is frequently used to remove sediments found in shallow water.



BUCKET DREDGE



DRAGLINE DREDGE

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- o The dredge is quickly assembled.
- o Works well in moderate swells and waves.
- o The material dredged approaches the in-place density in muds and silts.

Disadvantages

- o Rehandling of dredged material required.
- o Considerable turbidity may be created during the operation depending on the nature of the material to be dredged.
- o This dredge has a low production and the work cannot be as precisely controlled as required to remove contaminated sediments.

"Closed Bucket" Clamshell

This is a recent modification of the clamshell dredge developed in Japan. Operation and design are as for a standard clamshell except that the bucket itself is specially designed to be watertight thus minimizing loss of material during the dredging process. This is achieved by the use of an upper cover closing the bucket top, and by the use of special seals along the bucket edges.

Figure B-5 shows two typical closed buckets, as manufactured by the Mitsubishi Seiko Co., Ltd., of Japan, and of two types of seal mechanism used for such a bucket.

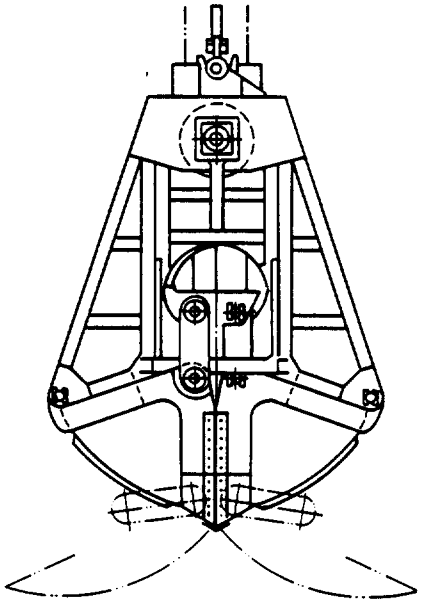
Advantages

- o Dredging in mud the bucket can excavate with a minimum of sediment loss and turbidity.

Disadvantages

- o The bucket's sealing mechanism is unlikely to work well dredging in coarse or debris-laden material.
- o The bucket does not appear to be available in the United States at this time.

Figure B-5



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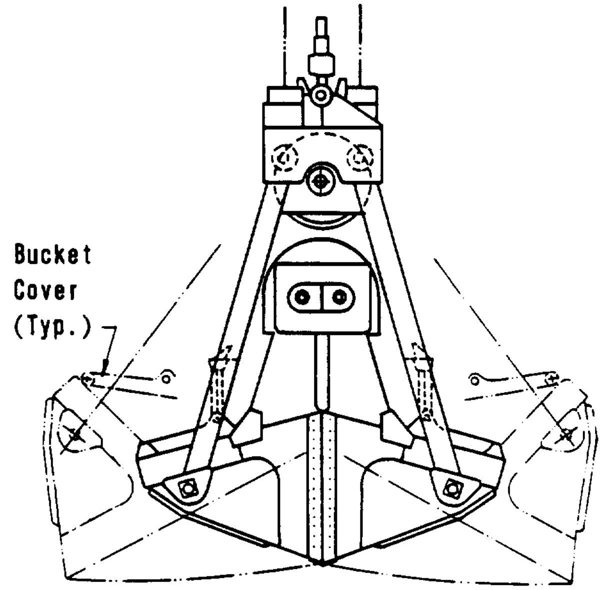
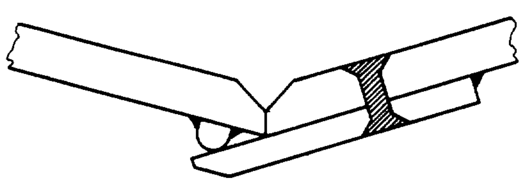
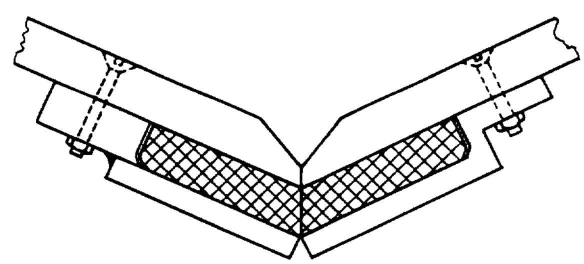


LATERAL DREDGING TYPE

MITSUBISHI CLOSED GRAB BUCKET



TWO-PLANE CONTACT METHOD



HARD RUBBER METHOD

LIP SEALING METHODS

SOURCE: MITSUBISHI SEIKO CO., LTD.

Pneumatic Dredges

These systems are a recent innovation in the dredging field. Hydrostatic head is used to force sediment into the dredge head from which it is ejected by pneumatic pressure. There are few moving parts in contact with the dredged material and, as a result, little wear and cavitation is experienced. Sludges, muds, and other loose and free-flowing materials can be removed at higher densities than generally experienced with hydraulic dredges. This material may be dumped in hopper barges or pumped to a suitable disposal site.

Three types of pneumatic dredge heads have been developed - Toyo Construction Ltd. of Japan has developed the oozer dredge; Pressure International S.A. of Italy developed the Pneuma dredge; and Amtec Development Company of Illinois, the "Amtec" dredge. The method of operation of these pneumatic devices is very similar and is described below.

These pneumatic devices are operated by compressed air. Water pressure (hydrostatic head) at the dredge intake is used to load material into cylinders which are then evacuated by compressed air. To obtain a smooth flow of dredged material, two or three cylinders are used, their cycles set at different points so that material is always flowing through the delivery pipeline. The deeper the system is lowered, the greater the head and the production rate. The system includes a barge upon which the compressors, air distributing units and winches are mounted, and a submersible pneumatic device (dredge head) which is lowered for dredging purposes.

Oozer - The Oozer pump dredge consists of four components: an air compressor, a vacuum pump, a pump control valve, and a pump tank. Suction pressure is supplied by the positive water pressure on the sediment layer and the negative pressure generated inside the tank. The sediment in the tank is discharged by forcing in compressed air. The suction and discharge cycles are controlled by two level detectors. To improve the suction process, a vacuum pump capable of generating a vacuum of 300 to 500 mm Hg is used. This allows the production rate to be less dependent upon depth of submergence. The dredge is operated in the same manner as a hydraulic dredge by swinging the craft from deadmen and using two spuds for control and propulsion.

The Oozer was developed by and is manufactured by the Toyo Construction Co., Ltd., of Japan. Figure B-6 illustrates the operation of the Oozer pump, and shows the Taian Maru, an oozer-equipped dredge owned and operated by Toyo Construction.

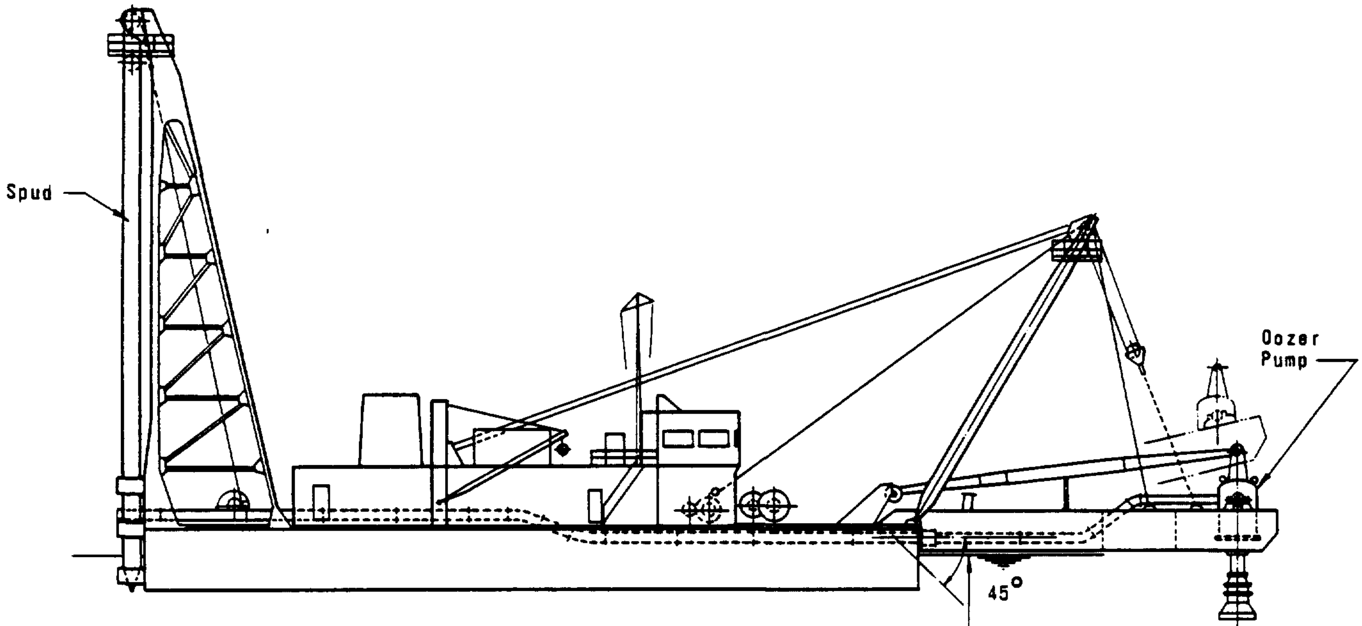
Advantages

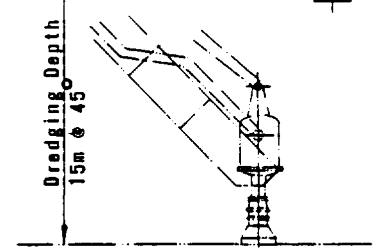
- This system generates very little turbidity and does not resuspend fines.
- Hazardous substances are less likely to be dissolved into the dilution water as compared to a centrifugal pump.
- The system can be easily modified to dredge near breakwaters and docks. An underwater TV camera and a device which measures sediment thickness allow precise monitoring of the dredge cut.

Disadvantages

- This system is not currently operating in the United States and is available only from Japanese concerns.
- Heavier materials such as sands and gravel as well as debris-laden materials would impede the successful operation of the machine.
- Limited pumping distance for horsepower of dredge.

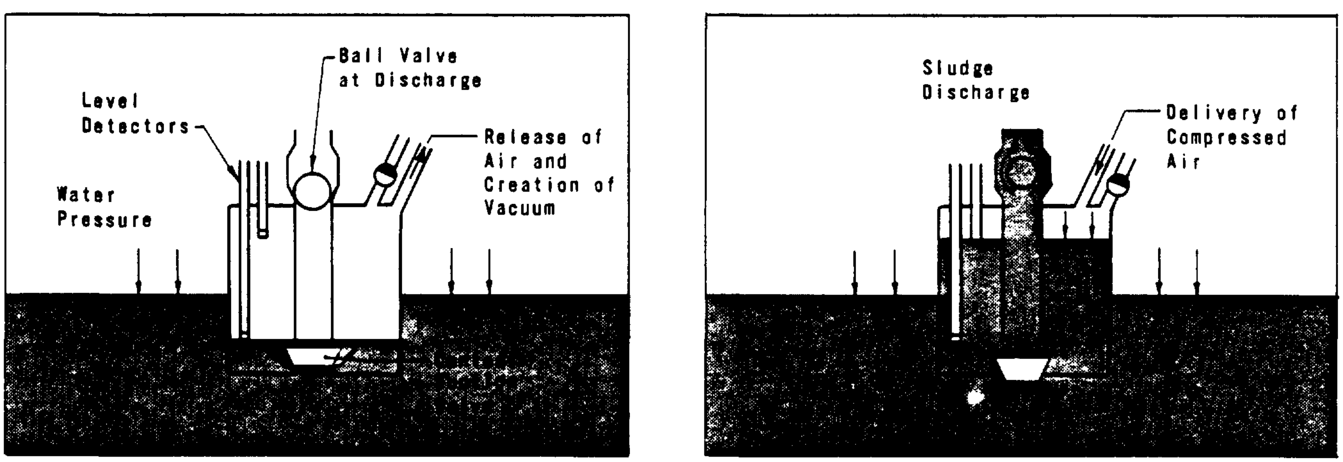
Pneuma - This system is similar to the Oozer dredge with the following exception: after the sludge has been discharged and the compressed air vented, the tank pressure is allowed to return to atmospheric. No vacuum pump is used to create negative pressure as is done in the Oozer system. Therefore,





THE TAIAN MARU

Length	37m (121.4 ft)
Width	12m (39.4 ft)
Depth	3m (9.8 ft)
Draft	2.2m (7.2 ft)



SUCTION

DISCHARGE

OOZER PUMP OPERATION

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SOURCE: TOYO CONSTRUCTION CO.

the depth of submergence has a greater effect on production rates in the Pneuma system.

Advantages

- o See those listed under the Oozer system. The monitoring capabilities are not as extensive, however.

Disadvantages

- o The dredge pump is not effective at shallow depths because of low hydrostatic pressure.
- o There are only three units available in the United States today.
- o There is a possibility of trash becoming lodged in the cylinders. This would clog the control valves and impede the pumping cycle.
- o Only soft and free-flowing materials can be effectively dredged.

"Amtec" - This system is the result of several years of refinements and modifications to the Italian Pneuma dredge design in response to technical problems the most notably being low production rates. The most significant modification was the inclusion of a vacuum system to increase this productivity.

Advantages

- o See those listed under the Oozer system.
- o This system is currently available in the United States and is manufactured by Amtec Developing Company of Illinois.

Disadvantages

- o Heavier material such as sand and gravel as well as debris-laden materials would impede the successful operation of the machine.
- o Operational data on this system is limited.

Other Systems

The dredging systems discussed in this section are not easily categorized. Mud Cat and Delta are modified hydraulic dredges exhibiting unique dredge head characteristics. These enable the dredges to work in restricted areas such as lagoons and canals. The IHC Amphidredge is a very versatile machine which can dredge mechanically or hydraulically and is capable of self locomotion on land by hydraulic "legs". The final dredging system investigated, the Terra Marine Scoop, is a land based dragline capable of reaching 2,000 ft. Each is described below.

Mud Cat - This dredge is a small, truck transportable hydraulic dredge which is designed to clean out sludge pits, industrial waste areas, and silting in small canals and reservoirs. The dredge head is comprised of an nine-foot wide, auger type, horizontal cutterhead surrounded by a mud shield. The auger pulls the material towards the pump suction intake, through a centrifugal pump and out a six-inch pipeline to a disposal site.

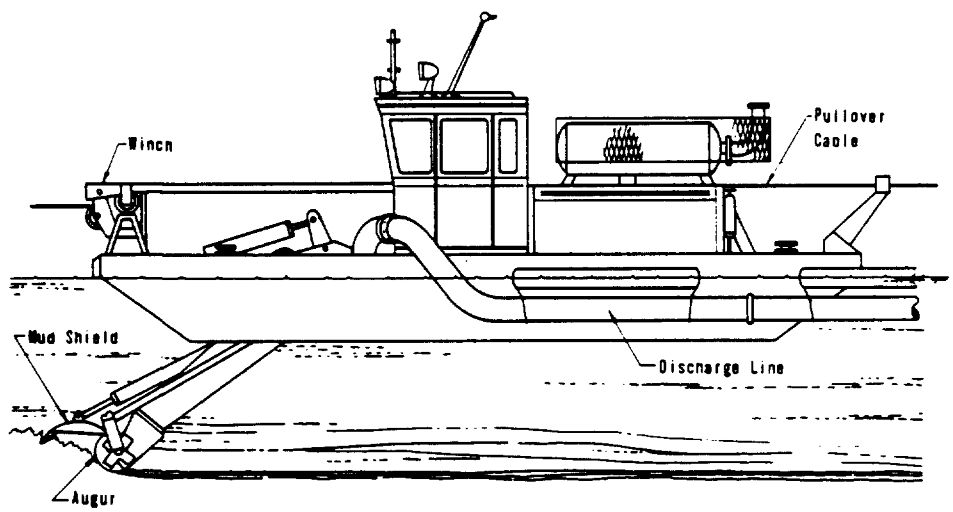
Figure B-7 illustrates a Mudcat Dredge.

Advantages

- o Operates near breakwaters, docks, and other confined areas such as sedimentation lagoons.
- o Portable, easily obtainable, shallow draft machine (21 in.).
- o Turbidity generation can be controlled by the utilization of the mud shield and by the auger-like cutter head arrangement which crowds the material into the suction pipe.

Disadvantages

- o Cannot easily dredge coarse or hard materials.
- o The low production rate (50-120 cu yd per hour) is best suited for small jobs.
- o Limited dredging depth of 15.0 ft. This be specially modified to a maximum dredging depth of 20 ft.



MUD CAT DREDGE

SOURCE: MUD CAT DIVISION
NATIONAL CAR RENTAL

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- o Not expected to perform satisfactorily in areas containing debris.
- o After each pass, the barge must be pulled over eight ft by pullover cables and the pipeline length adjusted until the project's completion. This operation interferes with navigation.

<u>IHC Amphidredges</u> - These machines are small dredging units designed for the maintenance of ditches, irrigation and drainage canals, city canals, fresh water reservoirs, and construction projects such as pipeline trench excavation in marshy and shallow areas. Three kinds of dredging techniques are available from IHC Holland: Clamshell grab dredging, cutter suction dredging, and backhoe dredging.

Clamshell grab dredging units consist of a self-powered grab dredge crane installed on a floating pontoon system. The crane may embark and disembark under its own power from the pontoon. The minimum water depth required is 0.5 m (19 in.) and the bucket is available in 350 and 500 l capacities (0.46 and 0.65 cu yd). The floating pontoon is pulled forward by a winching/anchor system.

Cutter suction dredging units have a milling system developed for the maintenance dredging of silt and organic sediments. A scoop is used to funnel the deposits into the direction of the suction opening. A pump is used to transport the spoil through a discharge pipeline to a disposal site. The craft is propelled forward by inching the craft along a guide wire. These dredges may be outfitted with three or four legs, allowing the machine to "turtle walk" from the transport vehicle into the water and around small bridges and other obstacles. Silts and loose materials are best dredged by this system; the production rate is roughly 150 cu yd per hour and the maximum dredging depth ranges from 11.5 to 17.5 ft.

The backhoe dredging system is composed of a main pontoon, three or four movable legs, and a hydraulic excavator with a backhoe, clam shell bucket, or mowing bucket. These units are amphibious and can move about on land or in the water. Terrestrial propulsion is accomplished by a turtle-like crawling motion. The legs also serve to steady the vehicle during dredging operations. The maximum dredging depth is 14.5 ft, the backhoe capacity is 400 l (0.5 cu yd). The dredge system is capable of excavating all but hard and compacted materials.

A typical Amphidredge is shown in Figure B-8.

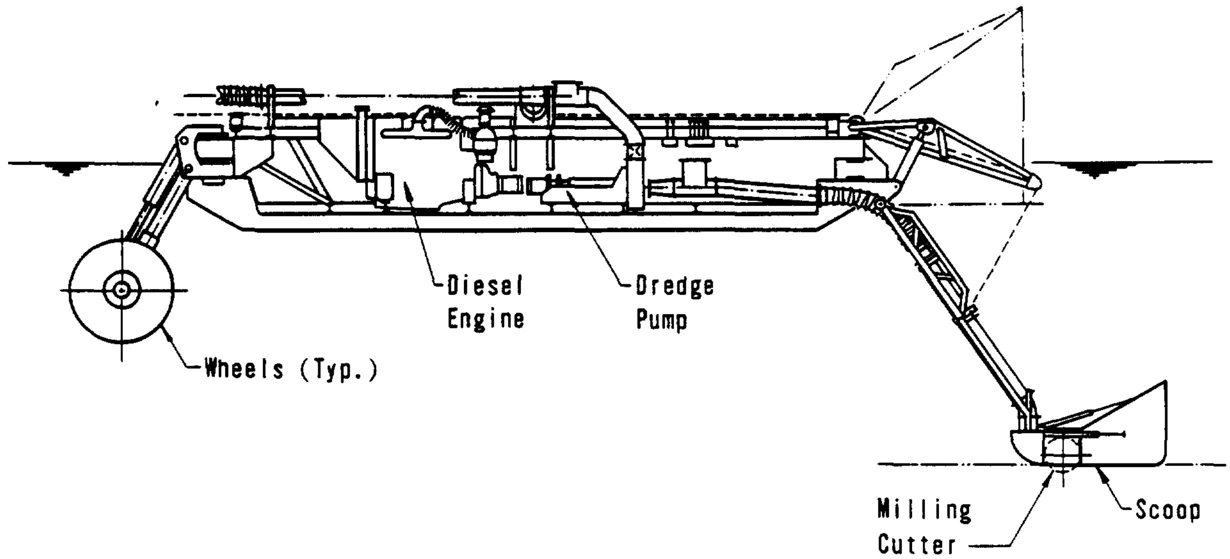
Advantages

- These dredges designed to operated in marshy and very shallow areas.
- Most models are equipped with legs and can get out of the water to avoid obstacles. All dredges are very mobile.
- These units exhibit a high dredging capacity in relation to size.

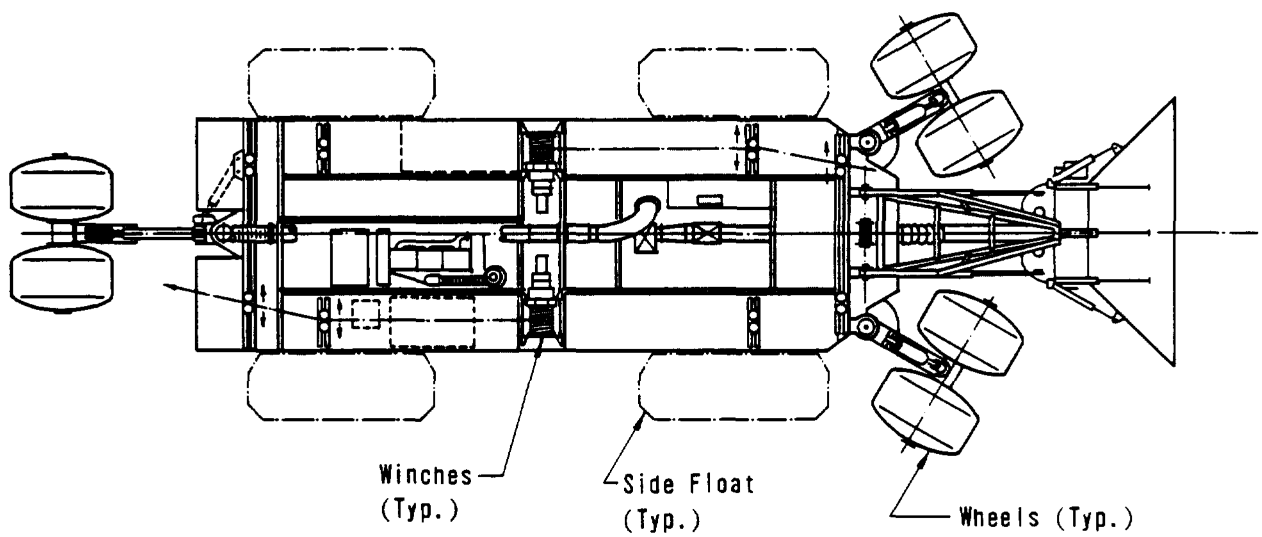
Disadvantages

- Availability may be a problem, since this dredge is manufactured in Europe, and none are in operation in the United States at this time.
- The production rate is small for the size projects which are being investigated in this report.
- These dredges will not work efficiently under conditions where the sediment contains a substantial amount of debris or heavy vegetative growth.
- The mechanical dredging units disturb the bottom, resuspending fines and generating turbidity.

Terra Marine Scoop - This system consists of a 3.2 cu yd scoop which is ferried on steel cables from a truck mounted winch to a deadman anchorage. As the bucket is pulled along, it is filled by scraping along the bottom. A built-in baffle



IHC AMPHIDREDGE
TYPE S170



SOURCE: IHC HOLLAND

plate prevents overfilling. When the bucket arrives at the dumping site the return line is pulled, rotating the scoop 90 degrees. This action empties the bucket and the scoop is pulled back to the dredging point. Built-in vents allow water and aquatic life to escape from the bucket. The truck which carries the scoop and winching mechanisms is equipped with flotation tires allowing operation in wet and marshy terrain. The system is highly mobile and can be set up or dismantled in a very short time.

Advantages

- Portable and highly mobile.
- Able to dredge in a wide variety of conditions: from swamps to 100 ft depths.
- The scoop can dredge up to 2,000 ft from shore.

Disadvantages

- Substantial resuspension of fines.
- Dredge control imprecise.
- Slow and tedious operation.

Delta - The Delta dredge is a new dredging system developed for the removal of fines and silts from shallow or confined areas. The dredging operation is similar to that of a conventional cutterhead hydraulic dredge with the exception that the Delta uses small anchors rather than stern spuds to maneuver. This is possible because of the low crowding power required by the special cutterhead. The Delta cutterhead design consists of two counter rotating cutters providing a 7.5 ft wide swath to a water depth of 16 ft. A 12-in. submersible dredge pump transports the slurry to a pipeline and, ultimately, to a disposal site.

Advantages

- Portable, shallow draft machine (32 in.).

- o Cleans out silted lakes, industrial settling tanks, sewage lagoons, boat harbors, and other shallow or confined areas.

Disadvantages

- o Not generally available, only limited number have been manufactured.
- o Does not efficiently dredge coarse sand and gravel.
- o Method of operation results in a resuspension of fines and increases the turbidity of the water column.

Types of Transport Systems

Pipeline - Material dredged as a slurry is generally transported by pipeline to a disposal site. The pipeline may link the dredging and disposal operation or may be used to transfer material from an unloading site, through a barge pumpout mechanism, to the disposal site. In some hydraulic dredging techniques, the pipeline is very short and is used to return the dredged material to adjacent waters (eg: sidecasting dredge). Large quantities of material may be moved through this system.

In general, abrasion resistant steel pipe is used in the construction of a pipeline. The slurry is pumped at a velocity in the range of 14 to 20 ft per second; this is to assure that the suspended material does not settle out in the pipe. Higher velocities are undesirable because of the large head losses generated.

Advantages

- o Pipe is readily available.
- o For short and medium distances, the pipeline system of transportation is the most cost-effective.

Disadvantages

- o For long distances over rough terrain many booster pump stations are required to move the slurry to the disposal site.

- The pipeline requires a right-of-way.

- The hydraulic system generates large quantities of wastewater which must be treated. This significantly increases the cost of a project.

Barge Transport - Barge transport of dredged material is generally associated with mechanical dredging systems. The dredge excavates the sediment and places it on an adjacent barge, which, when filled, is towed by a tug to an unloading site. At the unloading site the material is removed and transferred to the disposal site. The transfer from the barge to the disposal site may be performed either mechanically by clamshell buckets or hydraulically by a pumpout system.

In the latter case, the pump suction is lowered into the barge, water is added, a slurry formed, and the material pumped to the disposal site. The costs and operations from the unloading site to the disposal site are similar to the costs and operations of a pipeline system. The treatment costs are comparable to those experienced in the hydraulic dredging systems.

Advantages

- Barge transportation is less expensive than pipeline in conveying material from one point to another over long distances.

Disadvantages

- This system involves much equipment: tugs, tenders, unloading facilities, and transportation facilities from the unloading area to the final disposal site.

- The dredged material is rehandled several times. With each rehandling, material may be lost or spilled.

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Terra Marine Scoop Co. Inc., "Terra Marine Scoop," Geneva, New York.

Toyo Construction Co. Inc., "Oozer Pump," Tokyo, Japan.

Amtec Development Company, "Amtec Development Company, Pneumatic Pump System and Slurry Transfer System".

Telephone Conservations:

Telephone conversation between Mr. Ray Wilson, Amtec Development Company and J. Bedard, MPI, September 10, 1982.

Telephone conversation between Mr. Naito, Marubini America Corporation and J. Bedard, MPI, September 10, 1982.

APPENDIX C

DREDGING COST ESTIMATE

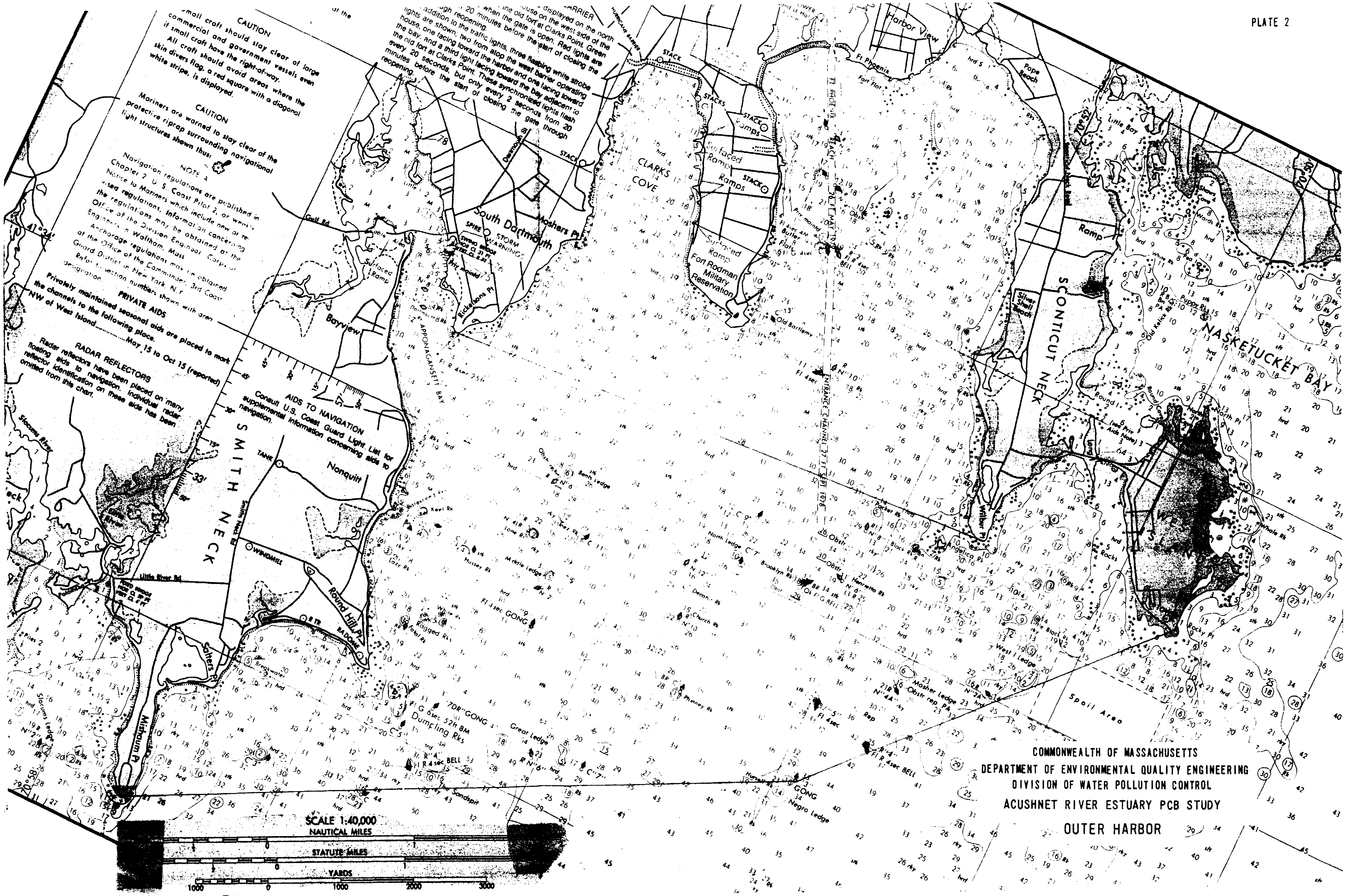
PLATES

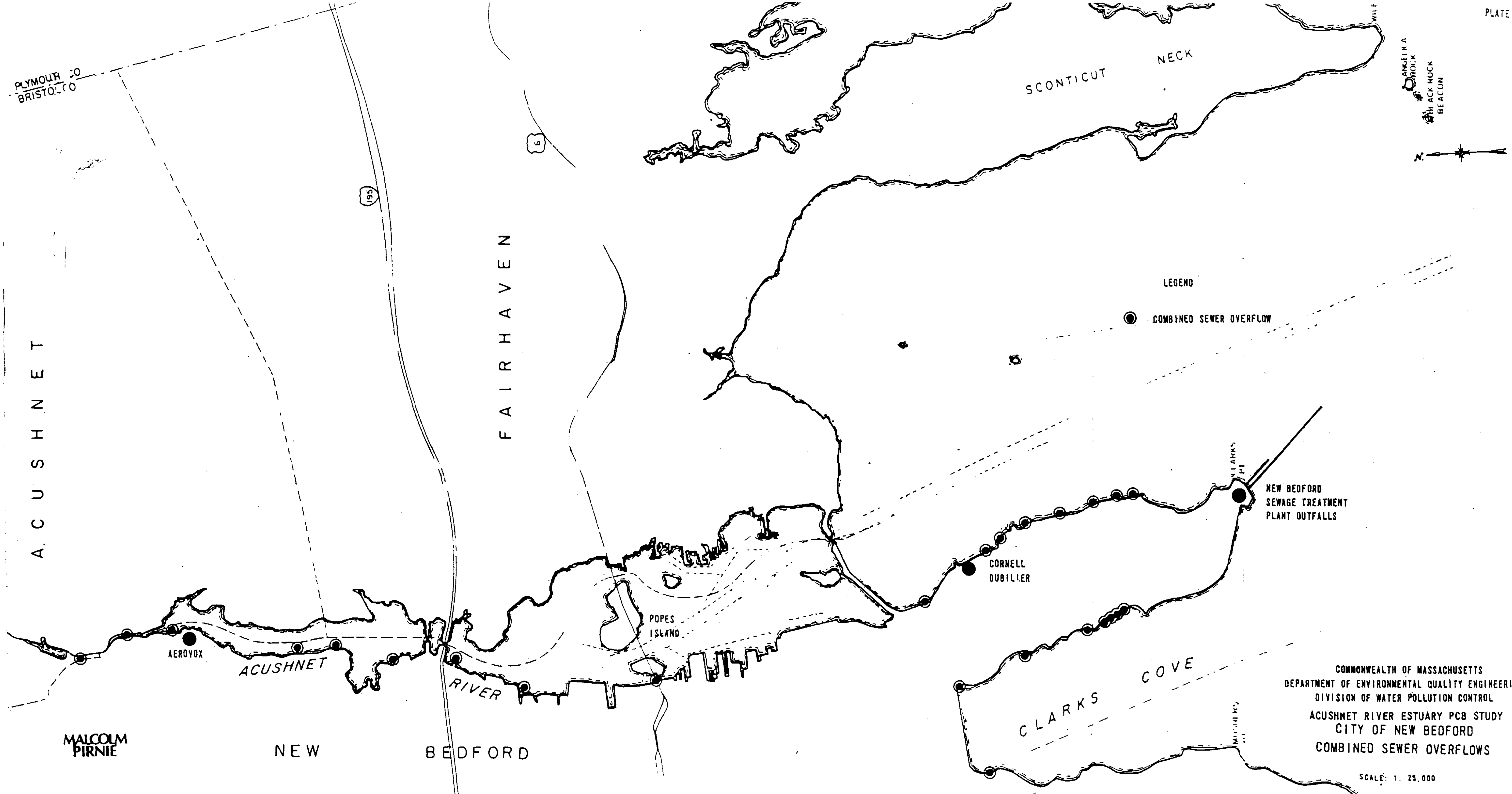
COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF ENVIRONMENTAL QUALITY ENGINEERING
DIVISION OF WATER POLLUTION CONTROL

ACUSHNET RIVER ESTUARY PCB STUDY

HARBOR AREA

PLATE 2

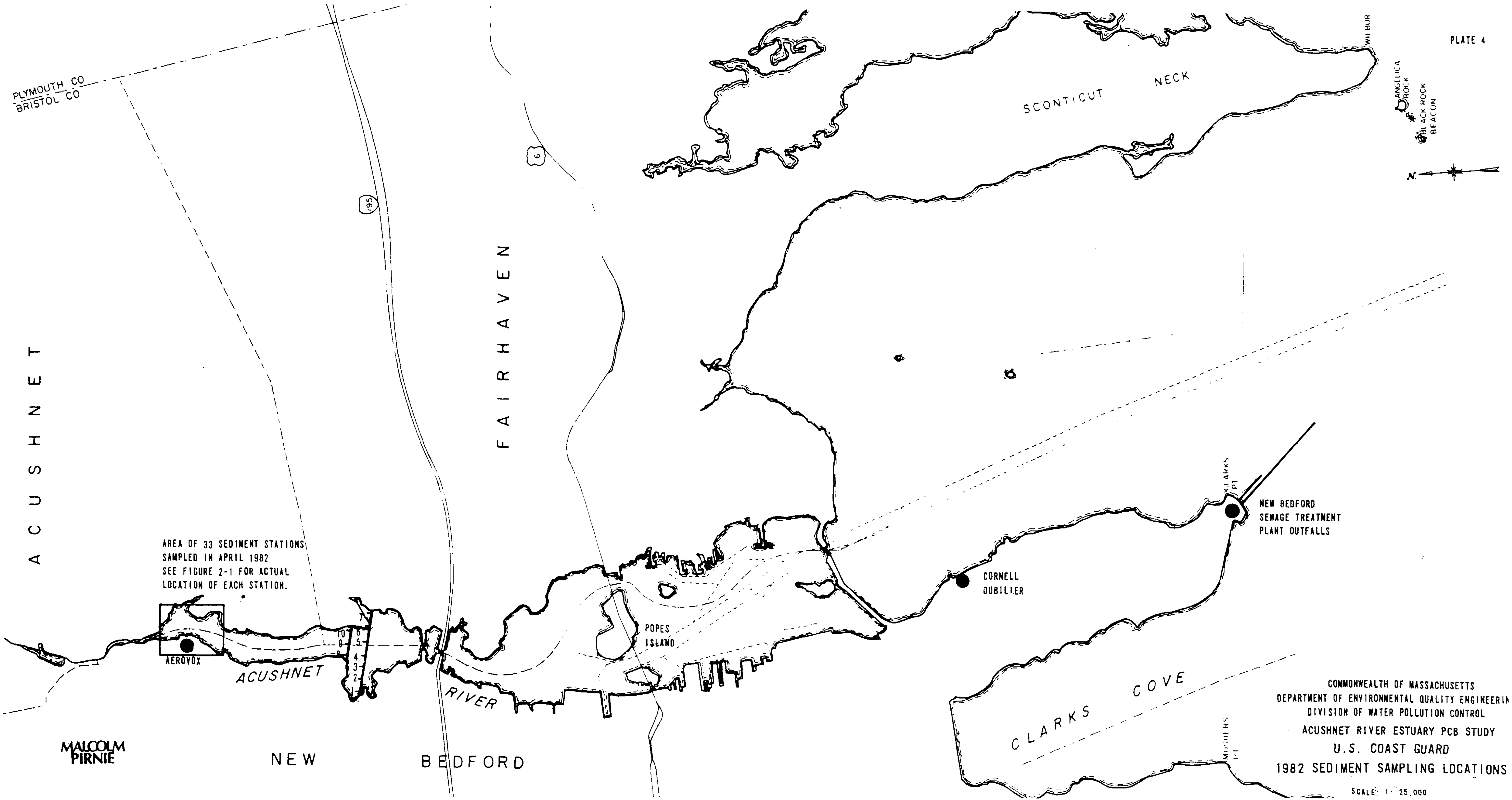

CAUTION
Small craft should stay clear of large commercial and government vessels even if small craft have the right-of-way.
All craft should avoid areas where the skin divers flag, a red square with a diagonal white stripe, is displayed.
CAUTION
Mariners are warned to stay clear of the protective riprap surrounding navigational light structures shown thus:
NOTE A
Navigation regulations are published in Chapter 2, U. S. Coast Pilot 2, or weekly Notice to Mariners which include new or revised regulations. Information concerning the regulations may be obtained at the Office of the Division Engineer, Corps of Engineers in Waltham, Mass.
Anchorage regulations may be obtained at the Office of the Commander, 3rd Coast Guard District in New York, N.Y.
Refer to section numbers shown with area designation.
PRIVATE AIDS
Privately maintained seasonal aids are placed to mark the channels to the following place.
NW of West Island..........May 15 to Oct 15 (reported)
RADAR REFLECTORS
Radar reflectors have been placed on many floating aids to navigation. Individual radar reflector identification on these aids has been omitted from this chart.
AIDS TO NAVIGATION
Consult U.S. Coast Guard Light List for supplemental information concerning aids to navigation.
CLARKS COVE
Fort Rodman Military Reservation
South Dartmouth
Moshers Pt
Rickersons Pt
Bayview
APPONAGANSETT BAY
SMITH NECK
Nonquitt
Round Hill Pt
Salters Pt
Mishaum Pt
Slocums River
Slocums Ledge
Little River Rd
Smith Neck Rd
Gulf Rd
Harbor View
Pope Beach
Little Bay
SCONTICUT NECK
Silver Shell Beach
NASKETUCKET BAY
West Island
Wilbur Pt
Spoil Area
Great Ledge
Dumpling Rks
Ragged Rks
Hussey Rk
Negro Ledge
Mosher Ledge
West I Ledge
Rocky Pt
Whale Rk
North Ledge
Brooklyn Rk
Church Rk
Decatur Rk
Old Bartlemy
The Sandspit
Phinney Rk
ENTRANCE CHANNEL
STACK
TANK
WINDMILL
RADOME
SPIRE
STORM WARNINGS
Surfaced Ramp
Ramp
41°34'
70°58'
SCALE 1:40,000
NAUTICAL MILES
STATUTE MILES
YARDS
1000
0
1000
2000
3000
COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF ENVIRONMENTAL QUALITY ENGINEERING
DIVISION OF WATER POLLUTION CONTROL
ACUSHNET RIVER ESTUARY PCB STUDY
OUTER HARBOR



COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF ENVIRONMENTAL QUALITY ENGINEERI
DIVISION OF WATER POLLUTION CONTROL

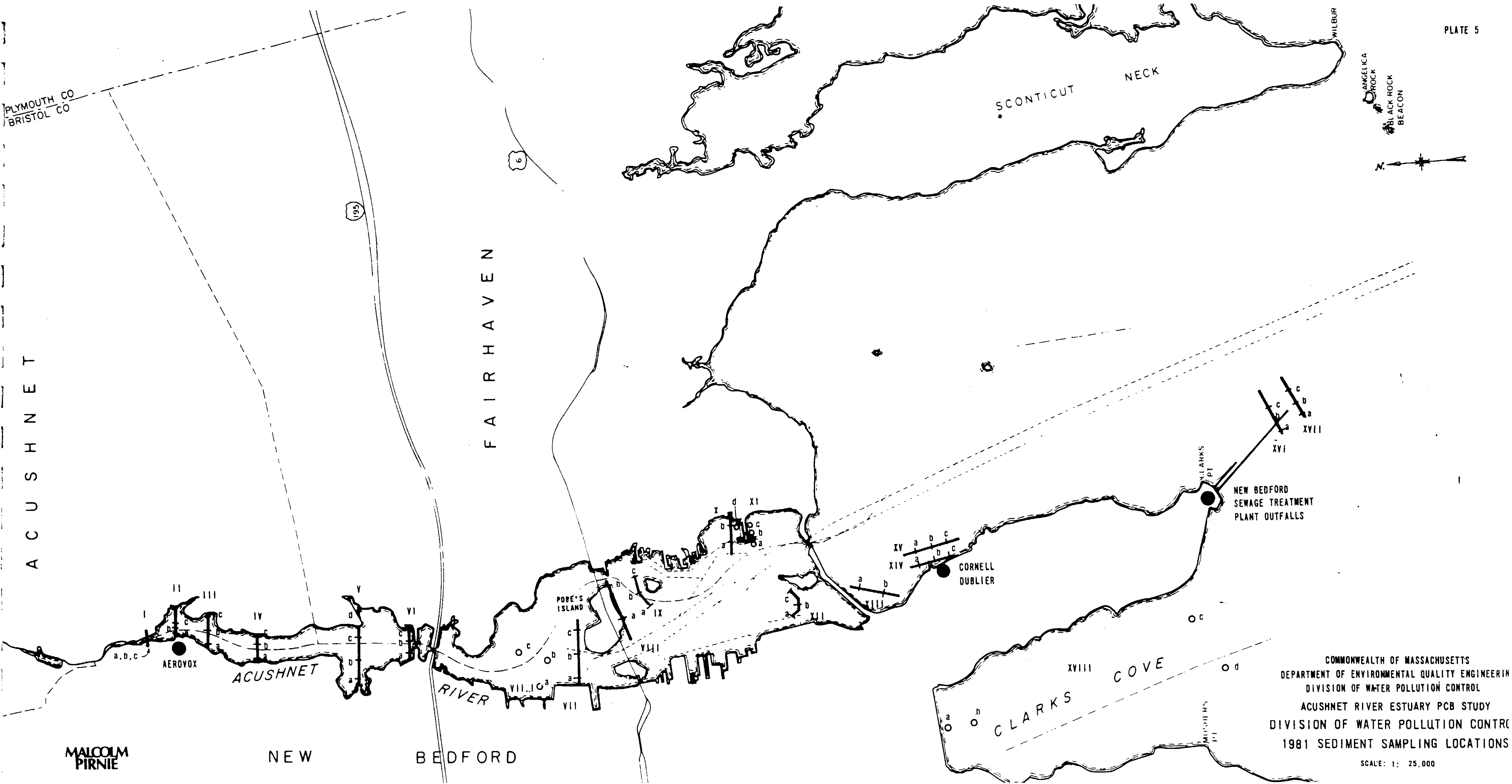
ACUSHNET RIVER ESTUARY PCB STUDY
CITY OF NEW BEDFORD
COMBINED SEWER OVERFLOWS

SCALE: 1: 25,000



COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF ENVIRONMENTAL QUALITY ENGINEERIN
DIVISION OF WATER POLLUTION CONTROL
ACUSHNET RIVER ESTUARY PCB STUDY
U.S. COAST GUARD
1982 SEDIMENT SAMPLING LOCATIONS
SCALE: 1:25,000

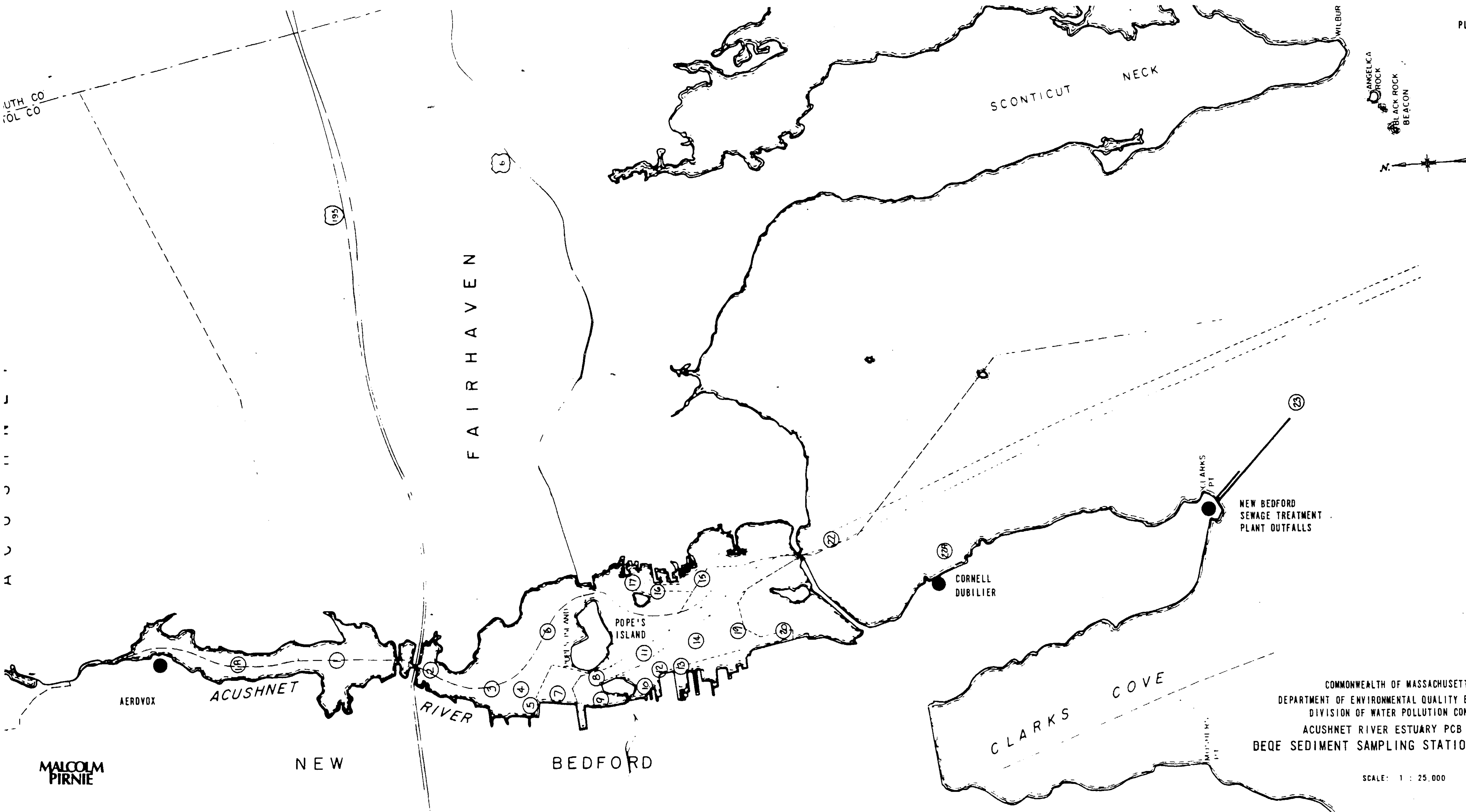
PLATE 5



MALCOLM PIRNIE

COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF ENVIRONMENTAL QUALITY ENGINEERIN
DIVISION OF WATER POLLUTION CONTROL
ACUSHNET RIVER ESTUARY PCB STUDY
DIVISION OF WATER POLLUTION CONTRO
1981 SEDIMENT SAMPLING LOCATIONS
SCALE: 1: 25,000

PLATE 6



COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF ENVIRONMENTAL QUALITY ENGINEERING
DIVISION OF WATER POLLUTION CONTROL
ACUSHNET RIVER ESTUARY PCB STUDY
DEQE SEDIMENT SAMPLING STATIONS 1978-1980

SCALE: 1 : 25,000

MALCOLM PIRNIE

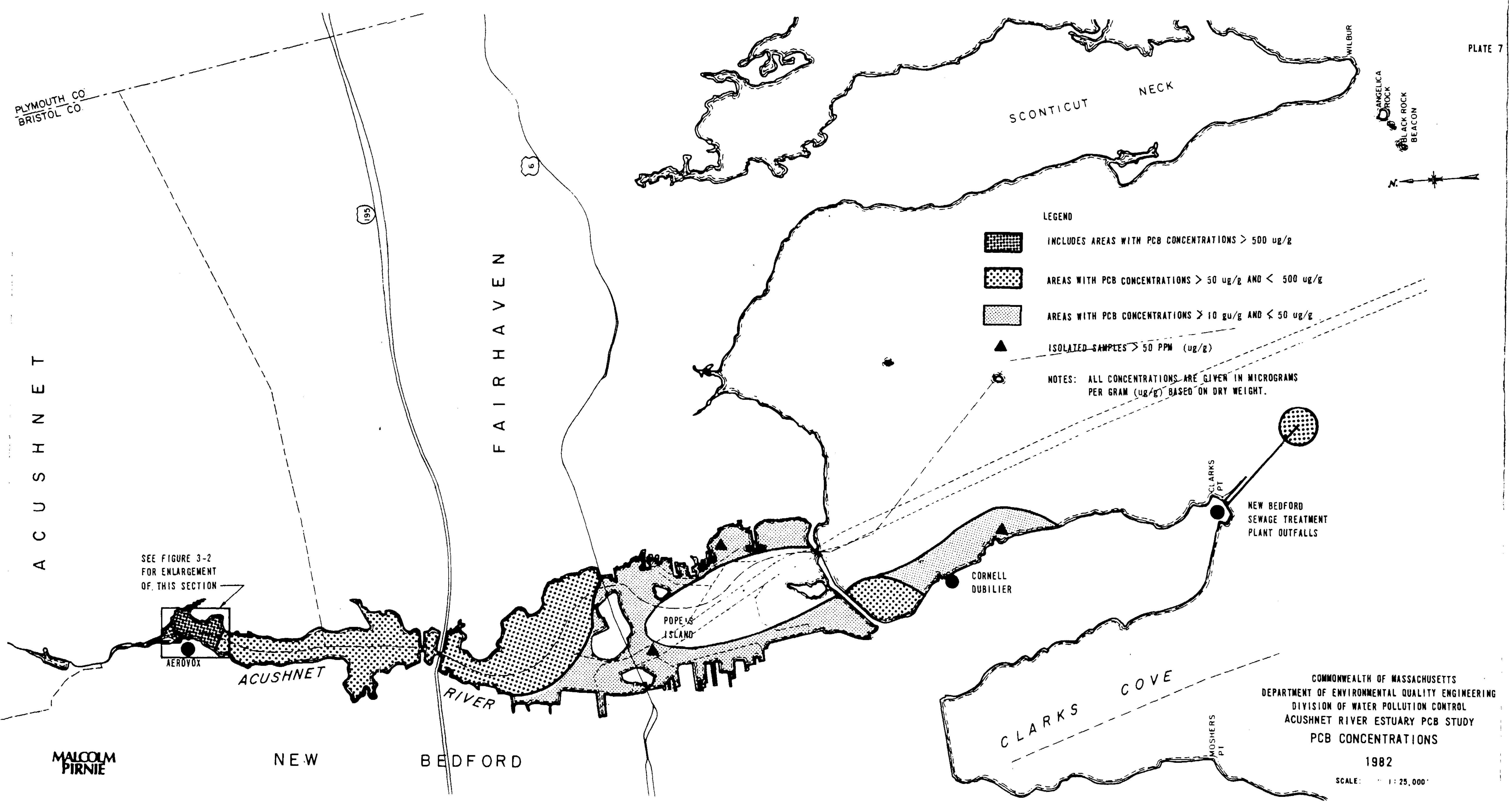
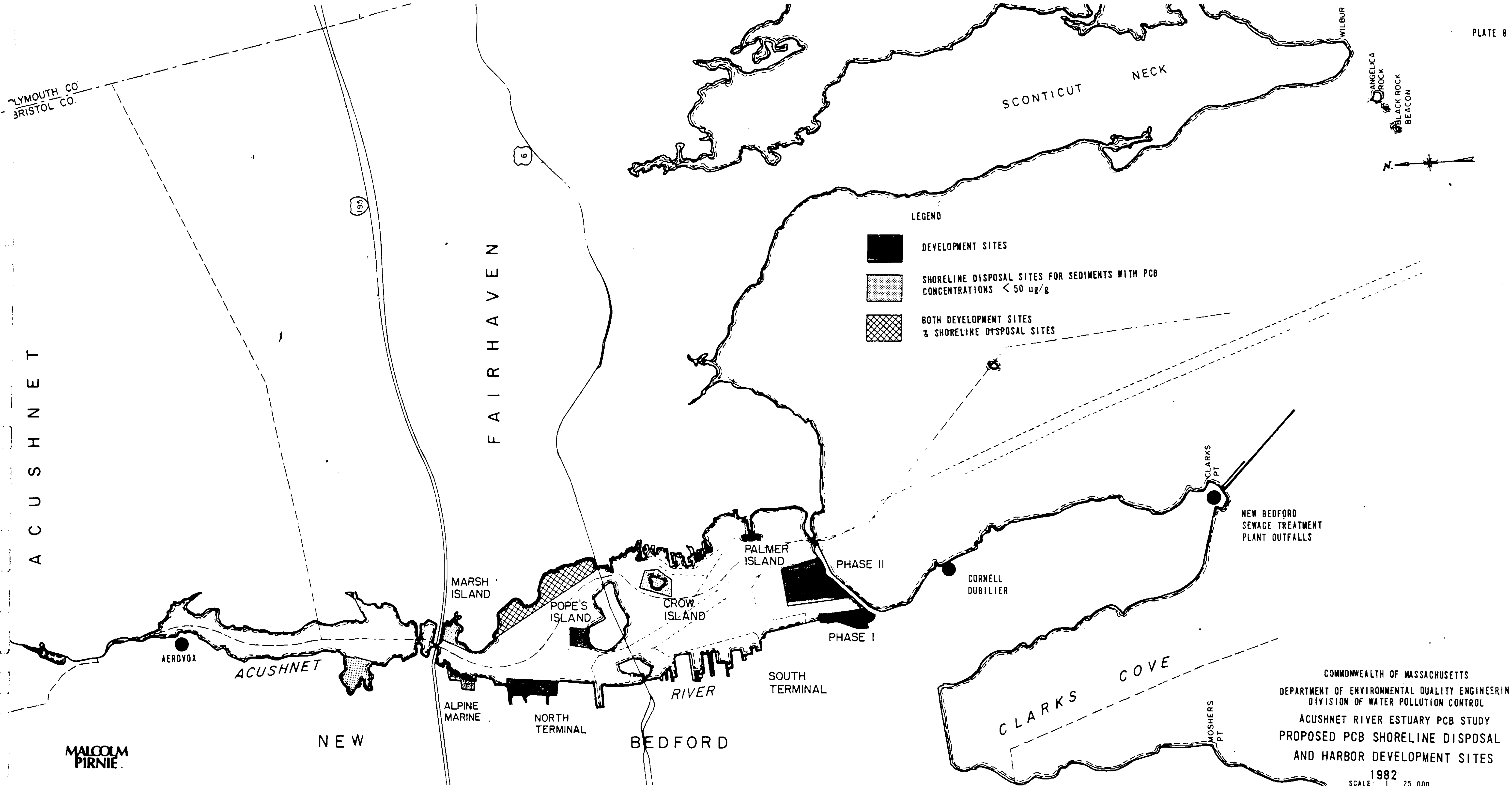


PLATE 7
PLYMOUTH CO
BRISTOL CO
ACUSHNET
FAIRHAVEN
195
6
SCONTICUT NECK
WILBUR
ANGELICA ROCK
BLACK ROCK BEACON
N.
LEGEND
INCLUDES AREAS WITH PCB CONCENTRATIONS > 500 ug/g
AREAS WITH PCB CONCENTRATIONS > 50 ug/g AND < 500 ug/g
AREAS WITH PCB CONCENTRATIONS ≥ 10 ug/g AND ≤ 50 ug/g
ISOLATED SAMPLES > 50 PPM (ug/g)
NOTES: ALL CONCENTRATIONS ARE GIVEN IN MICROGRAMS PER GRAM (ug/g) BASED ON DRY WEIGHT.
SEE FIGURE 3-2 FOR ENLARGEMENT OF THIS SECTION
AEROVOX
ACUSHNET RIVER
POPE'S ISLAND
CORNELL DUBILIER
CLARKS PT
NEW BEDFORD SEWAGE TREATMENT PLANT OUTFALLS
CLARKS COVE
MOSHERS PT
NEW BEDFORD
MALCOLM PIRNIE
COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF ENVIRONMENTAL QUALITY ENGINEERING
DIVISION OF WATER POLLUTION CONTROL
ACUSHNET RIVER ESTUARY PCB STUDY
PCB CONCENTRATIONS
1982
SCALE: 1:25,000

PLATE 8



COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF ENVIRONMENTAL QUALITY ENGINEERIN
DIVISION OF WATER POLLUTION CONTROL
ACUSHNET RIVER ESTUARY PCB STUDY
PROPOSED PCB SHORELINE DISPOSAL AND HARBOR DEVELOPMENT SITES
1982
SCALE: 1 : 25 000

RECEIVED
1983 FEB -3 PM 2:11
DIV. OF WATER
POLLUTION CONTROL