REVIEW DRAFT 10/15/99

DREDGE MATERIAL MANAGEMENT PLAN (DMMP)

DRAFT ENVIRONMENTAL IMPACT REPORT (DEIR)

FOR SALEM HARBOR

MASSACHUSETTS OFFICE OF
COASTAL ZONE MANAGEMENT (CZM)

CZM

PREPARED BY: MAGUIRE GROUP INC.

MAGUIRE GROUP

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DMMP CONSULTANT TEAM:

Maguire Group Inc.

The BSC Group

CoastalVision

GEI Consultants

SAIC

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LIST OF ACRONYMS

ACEC Areas of Critical Environmental Concern

ALF Active MSW Landfills and Active Demolition Landfills

APEG Alkaline Polyethylene Glycol

ARCS U.S. EPA's Alternative Contract Strategy Program

ATC Adjacent to Channel

BCD Base-Catalyzed Decomposition

BHNIP Boston Harbor Navigation Improvement Project

BNL Brookhaven National Laboratory

CA/THT Central Artery/Third Harbor Tunnel Project

CAD Confined Aquatic Disposal Site

CAD/OD Confined Aquatic Disposal Sites for Overdredge

CAP Capped Disposal Site

CCDS Cape Cod Disposal Site

CDF Confined Disposal Facility

CDF/TH Confined Disposal Facility/Tidal Habitat Creation

CERCLA Comprehensive Environmental Response, Compensation and Liability Act of 1976

CMR Code of Massachusetts Regulations

CPUE Catch Per Unit Effort

CWA Federal Clean Water Act

DCAM Massachusetts Division of Capital Asset Management (Formerly Division of Capital Planning Operations)

DEIR Draft Environmental Impact Report

DEM Massachusetts Department of Environmental Management

DEP Massachusetts Department of Environmental Protection

DMF Massachusetts Division of Marine Fisheries

DMMP Dredged Material Management Plan

DOD U.S. Department of Defense

DPA Designated Port Area

EDTA Ethylenediaminetetraacetic Acid

EMAP Environmental Management and Assessment Program

EOEA Executive Office of Environmental Affairs

FEIR Final Environmental Impact Report

FEMA Federal Emergency Management Agency

GIS Geographic Information System: Massachusetts National Resources

HDPE High Density Polyethylene

ILF Inactive or Closed Solid Waste Landfills in Massachusetts

KPEG Potassium Ethylene Glycol

LEDPA Least Environmentally Damaging Practicable Alternative

MBDS Massachusetts Bay Disposal Site

MCP Massachusetts Contingency Plan

MCZM Massachusetts Coastal Zone Management

mcy Million Cubic Yards

MEPA Massachusetts Environmental Policy Act

MHD Massachusetts Highway Department

M.G.L. Massachusetts General Law

MLW Mean Low Water

MPA Massachusetts Port Authority

MPRSA Marine Protection Research and Sanctuaries Act

MSW Municipal Solid Waste

MWRA Massachusetts Water Resource Authority

NAD83 North American Datum 1983

NEPA National Environmental Policy Act

NFIP National Flood Insurance Program

NHA Massachusetts Natural Heritage Atlas

NMFS National Marine Fisheries Service

NOAA National Oceanic and Atmospheric Administration

NWI National Wetlands Inventory

OSI Organism Sediment Index

PAH Polycyclic Aromatic Hydrocarbon

PCB Polychlorinated Biphenyl

PG&E Pacific Gas and Electric

POSW Dutch Development Program of Treatment Processes

RCRA Resource Conservation and Recovery Act

RMFP MWRA Residual Management Facilities Plan

SARA Superfund Amendments and Reauthorization Act of 1986

SAV Submerged Aquatic Vegetation

SSA Site Screening Analysis

TCLP EPA Toxic Characteristic Leaching Potential

TSCA Toxic Substances Control Act

TPH Total Petroleum Hydrocarbons

UDM Unsuitable Dredge Material

UR MHD Uneconomic Remainder Parcels

USACE U. S. Army Corps of Engineers

USEPA U. S. Environmental Protection Agency

USFWS U. S. Fish and Wildlife Service

USGS United States Geological Survey

VOC Volatile Organic Chemicals

SECRETARY'S CERTIFICATE

The Commonwealth of Massachusetts
Executive Office of Environmental Affairs
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April 24, 1998

CERTIFICATE OF THE SECRETARY OF ENVIRONMENTAL AFFAIRS
ON THE
ENVIRONMENTAL NOTIFICATION FORM

PROJECT NAME	: Salem Harbor Dredge Material Management Plan
PROJECT MUNICIPALITY	: Salem
PROJECT WATERSHED	: North Coastal
EOEA NUMBER	: 11538
PROJECT PROPONENT	: Massachusetts Coastal Zone Management
DATE NOTICED IN MONITOR	: March 25, 1998

Pursuant to the Massachusetts Environmental Policy Act (G. L. c. 30, ss. 61-62H) and Sections 11.04 and 11.06 of the MEPA regulations (301 CMR 11.00), I hereby determine that this project **requires** the preparation of an Environmental Impact Report.

This project is part of Phase II of a state-wide Dredged Material Management Plan (DMMP) to address the issue of finding environmentally sound disposal sites to accept dredged material that is unsuitable for unconfined ocean disposal from the Commonwealth's eight Designated Port Areas (DPA). Phase I of the project, "Inventory and Analysis of Existing Conditions," has been completed. This phase involved the creation of an inventory of conditions and practices in dredging and dredged material disposal in the Commonwealth.

This Environmental Notification Form is being filed to implement Phase II of the DMMP specifically for the Port of Salem. The focus of this aspect of the project is to complete the necessary environmental studies and complete the harbor-specific surveys of dredged material, natural resources and disposal options.

It is important to note that the project involves the development of disposal options for dredged materials and not dredging specifically. Dredging needs for each DPA will be determined by the local harbor plans that are currently being developed by the participating municipalities. This information will determine the disposal needs for each DPA and is therefore a determining factor in the Phase II studies; however, each individual dredging project will require its own environmental review under MEPA insofar as such individual projects may meet the thresholds for review under MEPA.

The project is categorically included for preparation of an Environmental Impact Report (EIR) pursuant to Section 11.25(2) of the MEPA Regulations since it will involve the dredging of more than 10 acres of land under water and involves the use of public funding through the Seaport Bond Bill (Chapter 28 of the Acts of 1996). Because the proponent is an agency of the Commonwealth and is providing financial assistance for the project, MEPA jurisdiction extends to all aspects of the project that might result in adverse environmental impacts.

The required EIR should follow the outline contained at Section 11.07 of the MEPA Regulations and should address the following specific issues as well as the issues raised in the attached letters of comments, listed below.

Project Description, Purpose and Need

The EIR should contain a full description of the project that includes a description of the purpose and need for the DMMP in Salem Harbor.

Sediment Quality and Quantity

The EIR should contain an analysis of the quality and quantity of dredged material for DMMP dredging projects. It should summarize dredge sampling and testing programs (I understand that the sampling plan has been pre-approved by the regulatory agencies) and discuss conformance with the Department of Environmental Protection (DEP) and Army Corps/EPA requirements, including physical, bulk chemistry and any required biological testing. It should identify low, medium and high volume dredge volume estimates in consultation with Salem Working Group and Harbor Plan Committee. For overdredge and adjacent to channel aquatic disposal alternatives, it should provide a summary of results of subsurface investigations.

Identification of Disposal Alternatives

The EIR should identify the full range of practicable disposal alternatives considered under DMMP Phases, including:

a. Alternative Technologies and Methodologies

Identify potential alternative technologies, and discuss operational requirements, regulatory feasibility, and characteristics of output and sidestream flows and associated environmental impacts. Based on these factors, identify potentially practicable technologies.

b. Upland Reuse/Disposal

Identify potential upland alternatives within the Zone of Siting Feasibility Suitability relating to Salem, consistent with existing DEP regulations and policy. The EIR should also consider the use of brownfield sites consistent with DEP policy and the Massachusetts Contingency Plan.

c. Aquatic Disposal

Identify all potential aquatic disposal alternatives as defined under DMMP Phase I within the Salem Zone of Siting Feasibility, consistent with Army Corps operational policies and Clean Water Act, Section 404 provisions.

Screening of Disposal Alternatives

1. Perform a first order screen of disposal alternatives for impacts to natural resources, permitting feasibility, engineering characteristics, capacity, cost, logistics, and users conflicts, based on existing information. Screening criteria used in the analysis should be developed in consultation with local interests and state and federal resource agencies. Identify potentially practicable alternatives resulting from the screening.

2. Fisheries Investigation and Monitoring

   The proposed fisheries studies are intended to fill information voids relative to the present status of marine resources in specific areas so that the potential impacts from dredging and in-water disposal can be determined.

These studies will complement other resource investigations either currently underway or recently completed by the Division of Marine Fisheries (DMF).

The important marine fisheries resources in Salem Sound are shellfish (soft shell clams), lobster, and finfish. Detailed assessments of the resources are underway in Salem Sound in connection with the Salem 2000 study.

DMF will direct the Contractor to the sites to be sampled for finfish and lobster sea sampling, the data from which shall be transferrable within the DMMP survey area. Juvenile lobster and shellfish surveys shall be site specific, and shall be conducted at the areas identified within each study site, subject to final direction from DMF and MCZM.

With one exception, no studies or assessments are proposed in Salem Harbor. DMF is currently conducting a one year estuarine study in the Beverly - Salem Harbor complex in connection with the Salem Sound 2000 Program. Finfish monitoring and shellfish stock assessment are under way and field work will be completed by December 1997. Lobster sea sampling was conducted from May through November in 1997 in Salem Sound and may have occurred within the proposed dredge and potential spoil areas. This material should be included in the EIR.

Juvenile lobster surveys will be conducted at the aquatic sites identified on DMMP project maps as federal maintenance and improvement dredging areas, the proposed Salem pier project areas, and ATC CAD sites in Salem Sound. Information obtained will be analyzed in relation to other juvenile surveys. Juvenile lobsters (carapace length <40mm) will be surveyed in August in both the proposed dredge area and the aquatic sites identified on DMMP project maps as ATC, CAD and the Fish Pier CDF. A diver- operated suction device will be utilized to obtain quantitative information on juvenile lobsters. Twelve randomly placed 0.5 m^2 quadrats will be sampled in each site. Samples will be enumerated and compared to other similar investigations in state waters. It is noted that while this method of EBP lobster assessment is experimental, it is rapidly becoming the standard for evaluating juvenile lobster habitat.

3. Analyze the effects of disposal activities on shore birds and the impacts of these activities on shore bird habitat.

Additionally, provide the results of a cultural investigation to identify any resources that might be affected by disposal options. I suggest consultation with the Board of Underwater Archaeology in preparing this information.

4. Characterize identified potentially practicable sites in terms of: engineering, physical, chemical, and meteorological characteristics; quantify natural resource impacts; identify permitting requirements; cost; capacity; and operational requirements, based on site specific conditions.

5. Identify, in consultation with Salem officials and other interested organizations and individuals, a preferred alternative(s)and/or methodology(s). Identify mitigation requirements and identify the parties responsible for implementation of mitigation measures.

Disposal Site Management Plan

The EIR should contain a draft disposal site management plan detailing measures to be taken to ensure protection of the public health and welfare and to properly manage the construction and operation of the preferred disposal alternative. It should also identify parties responsible for implementation of the plan.

Draft Section 61 Findings

The EIR should contain a draft Section 61 Finding for the preferred alternative. This finding should set out what mitigation is available to minimize or eliminate environmental impacts.

Federal permitting requirements

The EIR should contain, as appropriate, the draft federal Endangered Species Act Section 7 consultation and draft Clean Water Act Section 404(b)(1) analysis.

April 24, 1998
Date

Trudy Coxe, Secretary

Comments received :

Department of Environmental Protection
Massachusetts Historical Commission
Board of Underwater Archaeological Resources
Coastal Zone Management
Mayor Usovicz
Salem Planning Department
Michel, Frank
Bergen, Doris
Montague, Anne
Evans, Lisa
Pitman, Jack
Osgood, Jack
Freedman, Harvey
Stevenson, Marcie

SECTION 1.0 - EXECUTIVE SUMMARY

1.0 EXECUTIVE SUMMARY

This section of the Salem Dredged Material Management Plan (DMMP) Draft Environmental Impact Report (DEIR) summarizes the report contents, lists the principal environmental impacts of the alternatives to the project and identifies mitigation measures to be implemented to mitigate unavoidable environmental impacts.

1.1 Name and Location of Project

The project described in this DEIR is the Salem Harbor DMMP, in Salem, Massachusetts. An Environmental Notification Form (ENF) was filed for the Salem Harbor DMMP on March 16, 1998, by CZM, the project proponent.

The Executive Office of Environmental Affairs (EOEA) file number for the Salem Harbor DMMP is 11538.

1.2 Project Description

This Draft Environmental Impact Report (DEIR) includes an analysis of alternative aquatic and upland dredged material disposal sites and alternative technologies to treat sediments that are unsuitable for unconfined open water disposal (a.k.a. unsuitable dredge material or UDM) for eventual upland disposal or beneficial reuse. The DEIR identifies three Potential Preferred Alternatives for disposal of UDM, including one aquatic Confined Aquatic Disposal/Channel Overdredge (CAD/OD) site in Salem Harbor and two upland sites, an existing rock quarry on the border of Salem and Swampscott and located in both municipalities, and an existing commercial lined solid waste landfill in Westminster, Massachusetts.

At this time, Massachusetts Coastal Zone Management (MCZM) is not designating a single Preferred Alternative disposal site. Selection of the final Preferred Alternative will be made by MCZM after the public review of this DEIR and after due consideration of public and regulatory agency comments on the DEIR. The final Preferred Alternative will be identified in the Final EIR, and public comment will be invited on this DEIR, in full compliance with the regulations implementing the Massachusetts Environmental Policy Act (MEPA)

1.2.1 Purpose and Need

The purpose of the Dredged Material Management Plan for the Port of Salem is to identify, evaluate and permit, within the Zone of Siting Feasibility (ZSF) for the Port of Salem, a dredge material disposal site for the disposal, over the next twenty (20) years, of dredge material unsuitable for unconfined ocean disposal. The lack of a practicable, cost-effective method for the disposal of dredged material unsuitable for unconfined ocean disposal in an environmentally sound manner has been a long standing obstacle to the successful completion of dredging projects in the Port of Salem and other ports throughout the Commonwealth and elsewhere in the United States.

Salem Harbor contains several marinas, a significant recreational fleet, harbor side historical attractions, and a large fuel terminal. Salem Harbor is a significant recreational boating destination due to the large number of historical and cultural attractions of the city, largely located adjacent to or in close proximity to the harbor. A total of five marinas and yacht clubs, one electrical power plant (Salem Station), seven public projects (including the New Salem Wharf) and five future development sites have been identified as existing facilities and potential future sites requiring maintenance and improvement dredging in the next twenty years.

Maintenance dredging of existing navigation channels and marine facilities is required in order to maintain the competitive position of the port. In addition, the City of Salem has developed preliminary plans for the development of a New Salem Wharf, including marine facilities to accommodate whale watch boats, lobster boats, passenger ferries and water taxis, cruise ships up to 800-feet long, and provision of a fuel dock.

Maintenance and improvement dredging needs in Salem Harbor include maintenance of the existing 32-foot, 10-foot, and 8-foot federal channels, the federal South Channel leading to the South River, the PG&E Generating Salem Station power plant and the state navigation channel into Palmers Cove. The major improvement dredging project is the proposed New Salem Wharf project, adjacent to the PG&E Generating Salem Station property.

1.2.2 Alternative Disposal Sites

Aquatic Sites

Two general types of aquatic disposal sites were evaluated for the Salem Harbor DMMP, confined aquatic disposal (CAD) and confined disposal facilities (CDF). A CAD is an aquatic site where unsuitable dredged material is deposited in the marine environment and then covered with a clean capping material. There are three general types of CADs evaluated in this DEIR. A Confined Aquatic Disposal/Over Dredge (CAD/OD) site, is where an existing navigation channel is over dredged to a depth sufficient to accommodate a volume of unsuitable dredged material and a cap of clean material without interfering with navigation. The advantage of the CAD/OD type is that the disturbance to the ocean bottom is confined to an area of previous disturbance. An Adjacent to Channel (ATC) site is a CAD cell constructed in an area immediately adjacent to a navigation channel, where the ocean bottom may be previously disturbed or degraded due to the proximity of the navigation channel and channel dredging activities. The third type is a CAD cell constructed in an existing depression on the ocean bottom, or in an existing depression in the ocean floor. Figures 1-1 through 1-4 illustrate the aquatic disposal types.

A total universe of forty (40) aquatic disposal sites within the Salem Zone of Siting Feasibility (ZSF) were subjected to a preliminary physical screening, including criteria based on size (or capacity), water depth, confinement potential, location and navigational restrictions. The location of the 40 disposal sites is illustrated in Figure 1-5. An additional screening of the universe of aquatic disposal sites within the context

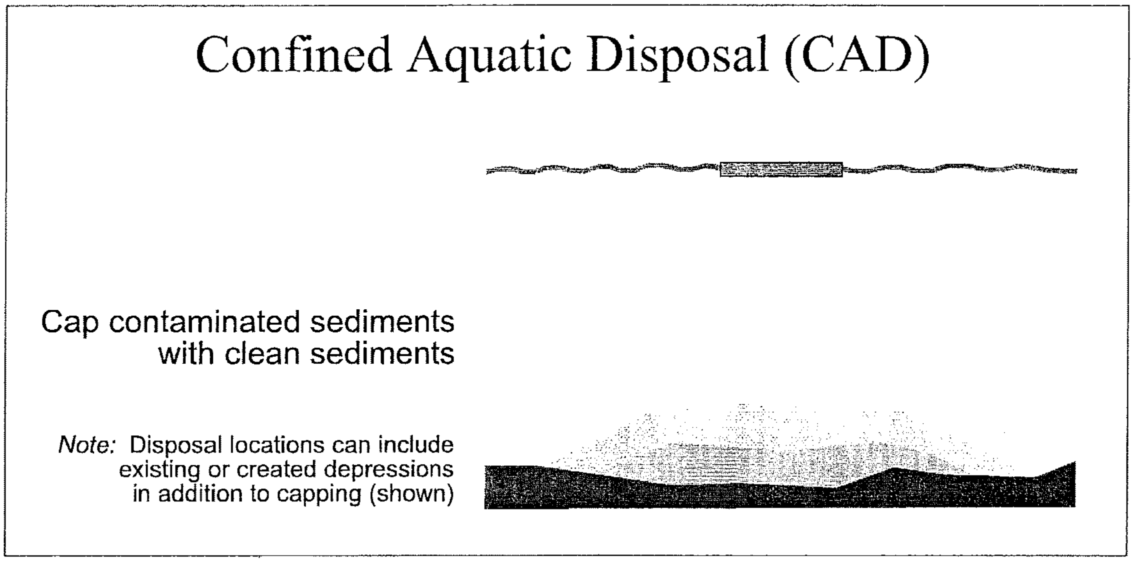


Figure 1-1: Schematic of Confined Aquatic Disposal (CAD) Method

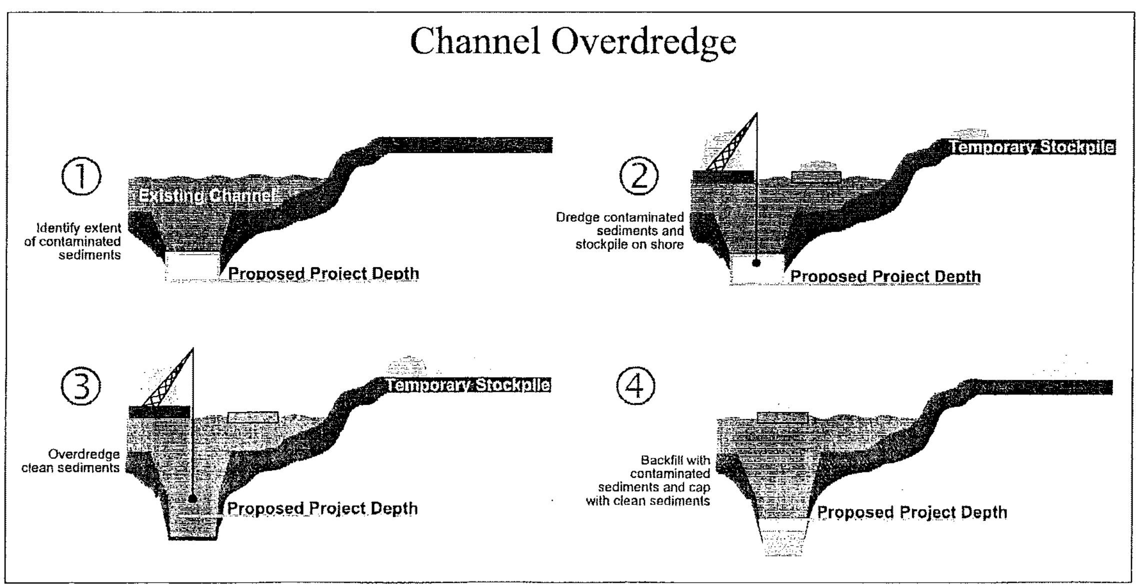


Figure 1-2: Schematic of Channel Overdredge (OD) method

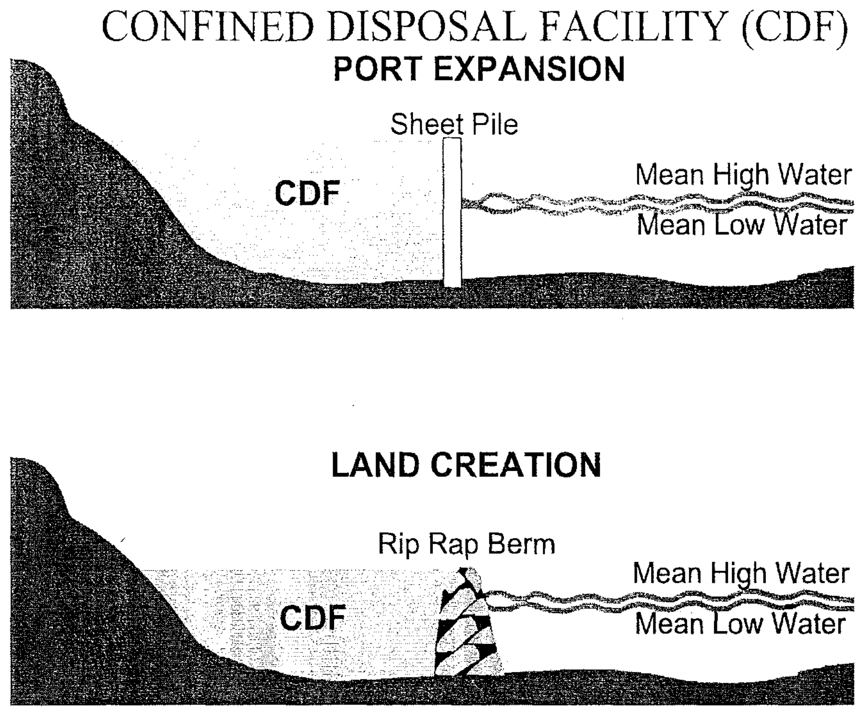


Figure 1-3: Schematic of the Confined Disposal Facility (CDF) Method

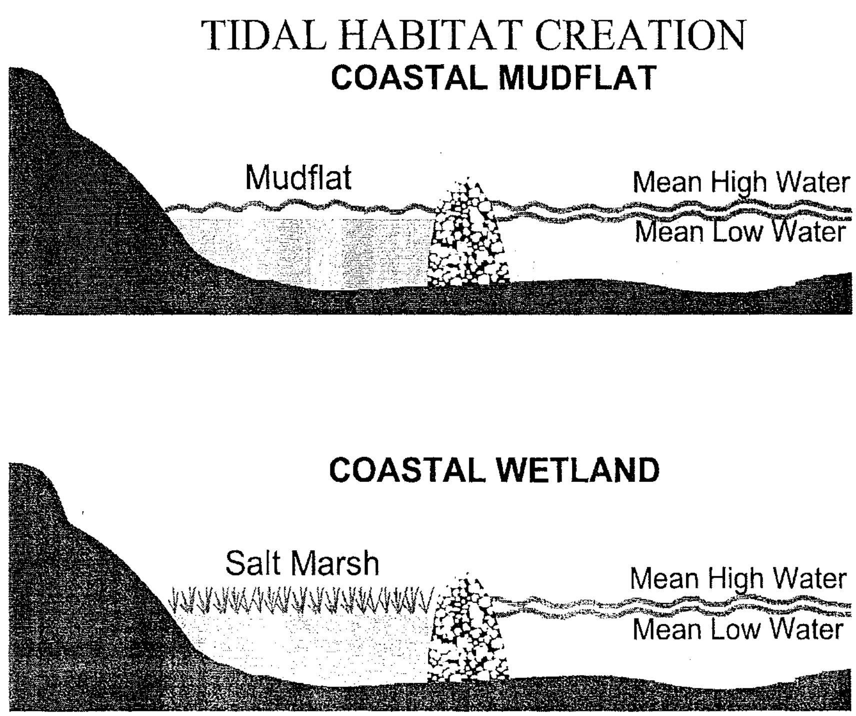


Figure 1-4: Schematic of the Tidal Habitat (TH) creation method.

of the sedimentary environment of Salem Sound evaluated the potential stability and confinement potential of the aquatic sites.

As a result of this preliminary screening, a total of twenty-six (26) candidate aquatic disposal sites were identified and evaluated in detail in this DEIR. The locations of the 26 candidate sites is illustrated on Figure 1-6. These 26 candidate disposal sites were subject to the detailed environmental screening process described in detail in Section 4.6 of this DEIR. Screening and evaluation factors considered site capacity, location, confinement potential, water quality, the presence of threatened and endangered species, finfish and shellfish habitat, benthic organisms, wetlands and floodplains, historic and archaeological resources, Marine Sanctuaries and Areas of Critical Environmental Concern, consistency with the Salem Harbor Plan, and permitting feasibility, and the mitigation potential at the site.

The results of the environmental analysis of the 26 candidate aquatic disposal sites resulted in the selection of a single Proposed Preferred Alternative Aquatic Disposal Site in Salem Harbor, identified as S6-CAD/OD. The site location is illustrated in Figure 1-5. The site is located within the turning basin at the southern end of the existing federal navigation channel, adjacent to the PG&E Generating Salem Station electrical generating facility dock. As a CAD/OD site, the site is located in an area of previous disturbance of the harbor bottom, and can be sited without additional impact to bottom resources in the area. The site contains natural resources and fisheries and benthic organism habitat of marginal value, compared to other locations in Salem Harbor and Salem Sound.

Upland Sites

Upland reuse and disposal alternatives involve the placement of unsuitable dredged material on land. The site can be an existing active or inactive landfill, or a raw parcel of land. Dredged material can be used as daily cover or final cover for landfills, provided the material meets the physical and chemical specifications for such use. Dredged material placed on a raw parcel of land could be managed as a landfill, or could be used as a grading material that has some end use (e.g. ball fields, golf course), provided the physical and chemical properties of the dredged material permit such use. There are currently no regulations in Massachusetts which specifically apply to the disposal of dredged material in the upland environment, therefore the disposal of the material is regulated under the Commonwealth's Solid Waste Management Regulations (310 CMR 16.00 and 19.000). Dredged material, when amended with other material such as portland cement, can also be used as structural fill in construction projects.

As with the aquatic sites, a siting universe within an upland ZSF was developed. A universe of 1,123 potential upland sites were identified within a ZSF encompassing a 50-mile radius from Salem. The 50-mile radius was based on the time it would take for a truck to load at an upland dewatering site, travel to the disposal site and unload, and return to Salem within an 8-hour working day. Figure 1-8 illustrates the Salem upland ZSF.

The total universe of upland sites was initially subjected to a feasibility screen, evaluating the site capacity to accommodate a minimum of 10,000 cubic yards of UDM and to comply with setback requirements specified in the Solid Waste Regulations, resulting in a minimum site size of twenty-five (25) acres. A total of 270 sites in the upland universe were smaller than 25 acres and were eliminated, leaving a total of 853 candidate disposal sites.

These remaining 853 sites were then subjected to an exclusionary screening, based on factors that would essentially prohibit disposal of UDM based on state or federal laws, including the presence of: rare or endangered species; historic or archaeological sites or districts; and drinking water supplies. A total of eleven (11) upland sites within the Salem upland ZSF survived the exclusionary screening process. These sites are illustrated on Figure 1-9.

Additional discretionary screening factors were also applied to the remaining 11 sites, including the presence of: groundwater and surface water quality, including wetlands; accessibility; area of impact; duration of potential adverse impacts; habitat types; terrain; floodplains; agricultural use; risk of failure; potential for odor/dust/noise impacts; consistency with local, regional and state plans; ability to obtain permits; and cost. As a result of the discretionary screening, two Potential Preferred Alternative Upland Disposal sites were identified: an existing rock quarry located on the Salem/Swampscott border, and an existing commercial solid waste landfill in Westminster, MA. A locus map for the Salem/Swampscott site is provided in Figure 1-10, the Westminster site locus is illustrated on Figure 1-11.

Alternative Technology Assessment

Alternative treatment technologies involve the treatment of contaminated sediment, using one or more processes, to allow for reuse of the sediment in a safe manner in the upland environment or for unconfined open water disposal. There are four general types of treatment technologies, categorized based on their effect on the contaminants of concern within the sediment: *Destruction*; the removal of contaminants from the sediment via physical, chemical or biological agents; *Separation*; the process of removing contaminants from the sediment resulting in a concentrated residual of contaminated sediment of significantly smaller volume; *Reduction*; the process of reducing the amount of contaminated dredged material that requires treatment by screening sediments into various particle sizes; and, *Immobilization*; the fixing of contaminants in the dredged material which keeps the contaminants from being released to the environment.

Fourteen (14) classes of treatment technologies were evaluated within the four broad categories listed above, involving a comprehensive survey of technology vendors. The results of the alternative technology assessment indicate that, at this time, alternative treatment technologies are not a practicable solution to the management of UDM from Salem Harbor. This is due to several factors, most notably cost. But the costs for some technologies such as solidification and landfarming, even though comparable to the cost of CAD disposal, do not overcome the fact that there needs to be a permanent receiving site for the treated sediment.

It is not known at this time, whether treatment of the UDM would be required for disposal at the proposed preferred upland sites; more tests need to be conducted. Solidification/Stabilization and soil washing are the only forms of treatment that could be practicably used on Salem Harbor UDM, but a receiving site, such as an industrial or commercial development that requires large quantities of construction fill would need to identified, and the treated UDM must be competitively priced with upland sources of fill material to be a practicable solution for the DMMP. Currently, the supply of upland fill material exceeds the demand for construction fill, and at a much lower price (approximately $20/cy) than that of even the lowest-priced treatment technology. Therefore, alternative treatment technologies are not a viable solution to the management of UDM from Salem Harbor. The DMMP will reevaluate, on a five year cycle, the feasibility of alternative treatment technologies for UDM in Salem Harbor and other harbors throughout the Commonwealth.

Dewatering Sites

In order to be practicable, use of an upland disposal/reuse site or an alternative treatment technology, a shore-front site of adequate size and availability must be identified so that the UDM may be dewatered prior to transport to an upland site. A total of eighty-one (81) potential dewatering sites were identified along the shoreline from Lynn Harbor north to Manchester-by-the-Sea, including shore front areas of Danvers. The universe of dewatering sites is illustrated in Figure 1-12.

As with the aquatic and upland sites, the 81 candidate dewatering sites were subjected to a two tier process involving the initial screening of exclusionary site factors and a second tier screening of discretionary factors. The exclusionary factors only apply to the harbor side site requirements, all other criteria are discretionary. The harbor side requirements are exclusionary because they are the first link in the "dewatering process train", if a harbor side site meeting the minimum requirements can not be located, upland disposal and alternative technology options can not be considered. None of the 81 potential dewatering sites survived the exclusionary screening process, mainly due to site size and availability factors.

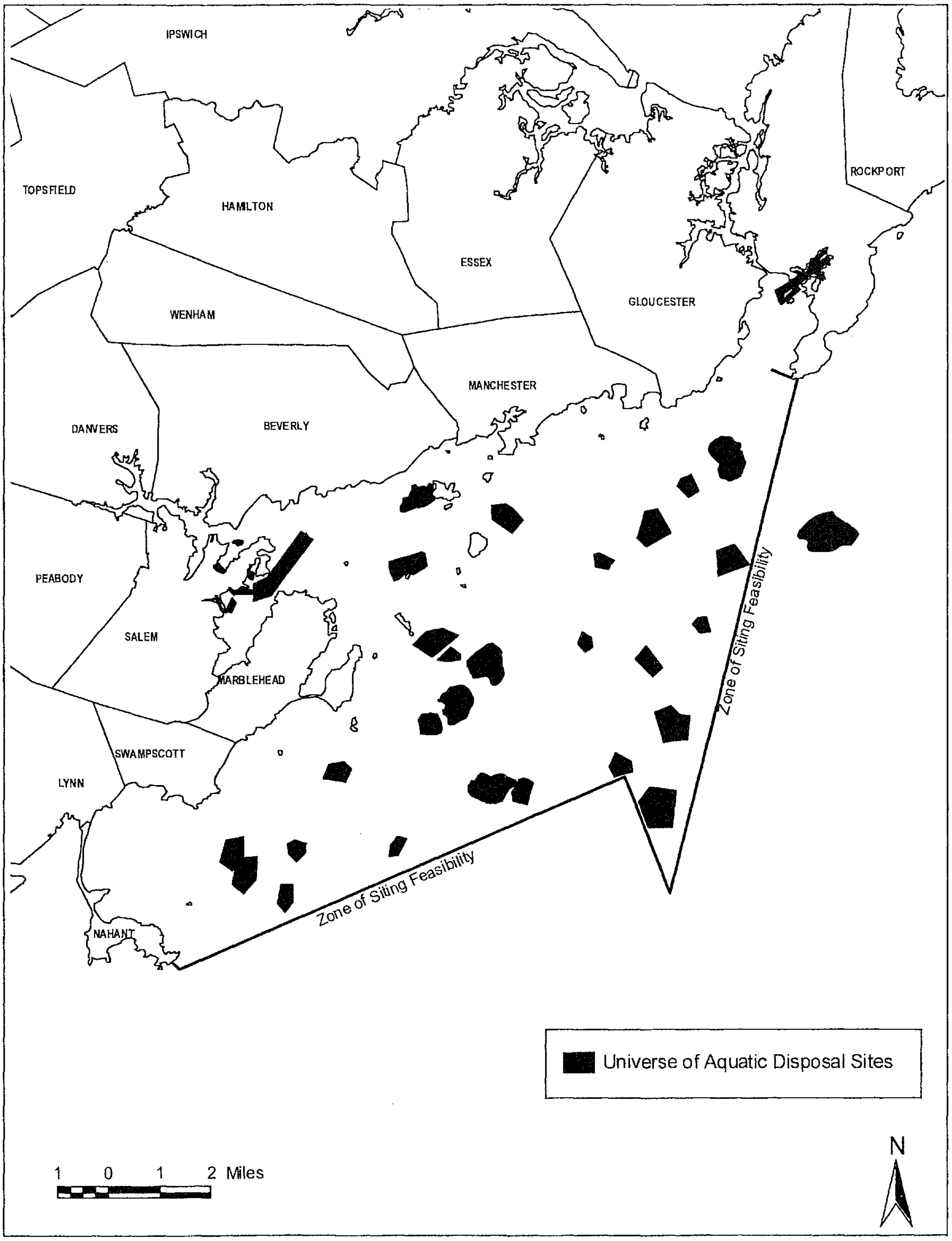


Figure 1-5: Salem Harbor Universe of Aquatic Disposal Sites

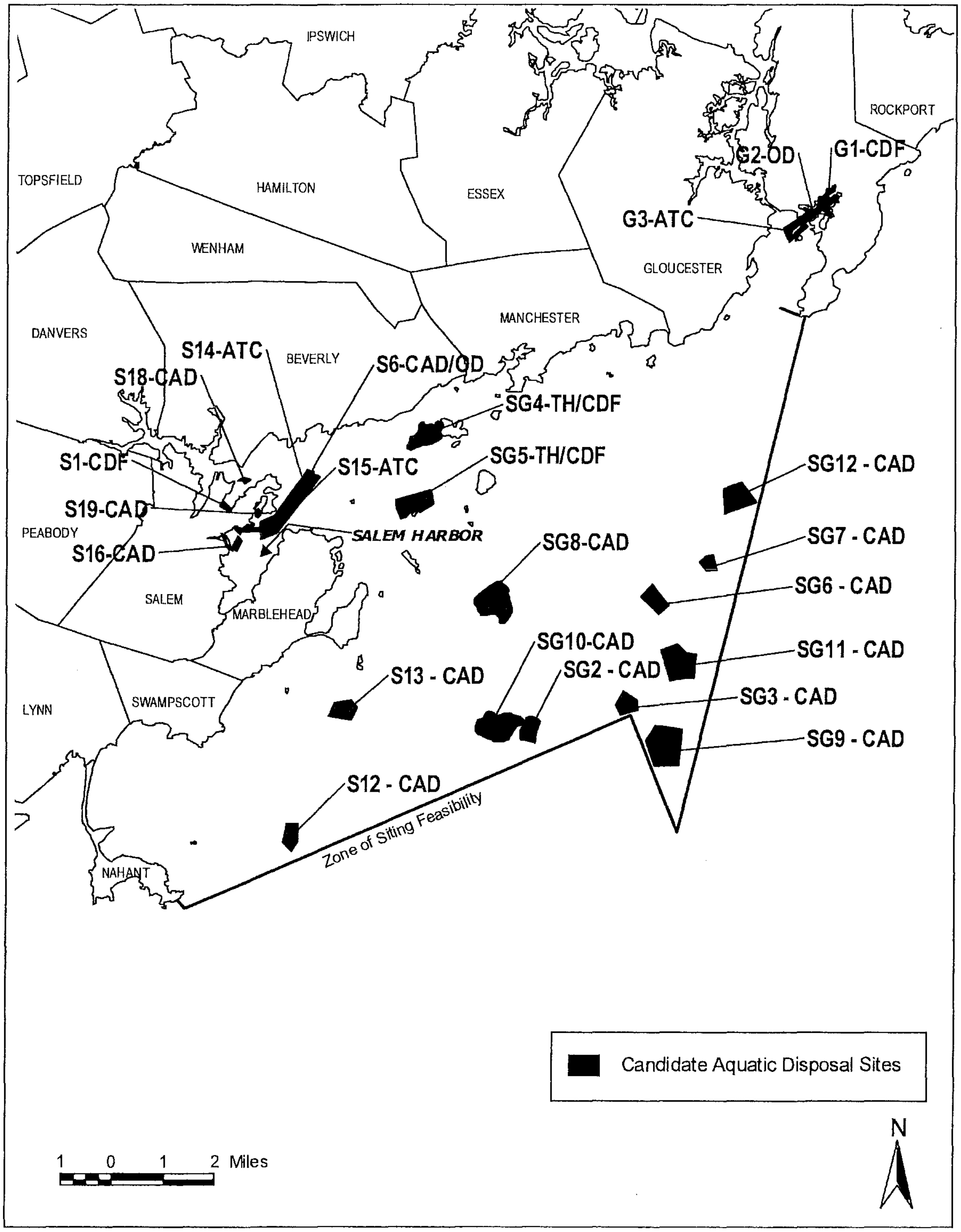


Figure 1-6: Salem Candidate Disposal Sites

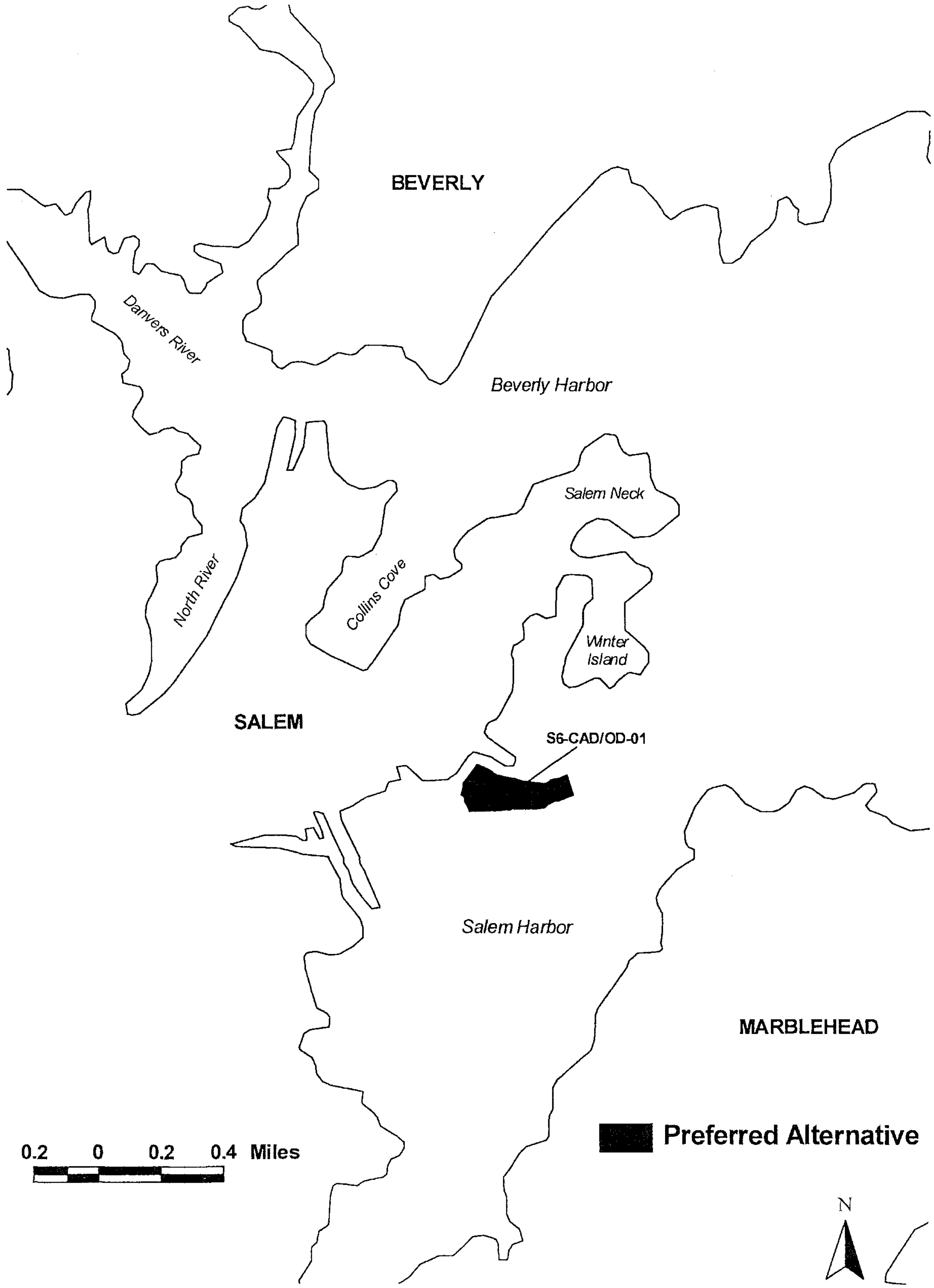


Figure 1-7: Proposed Preferred Alternative Aquatic Disposal Site

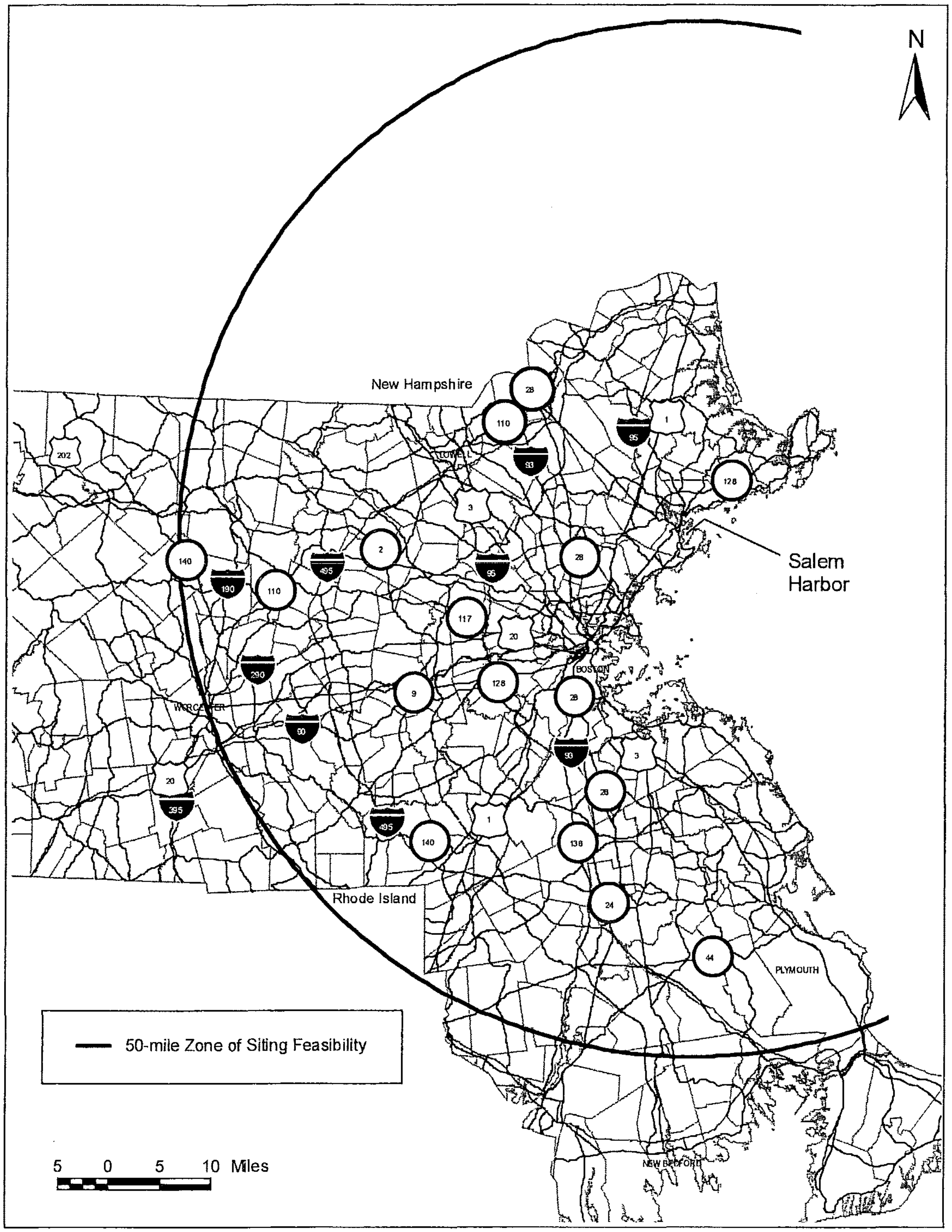


Figure 1-8: Salem Upland Zone of Siting Feasibility

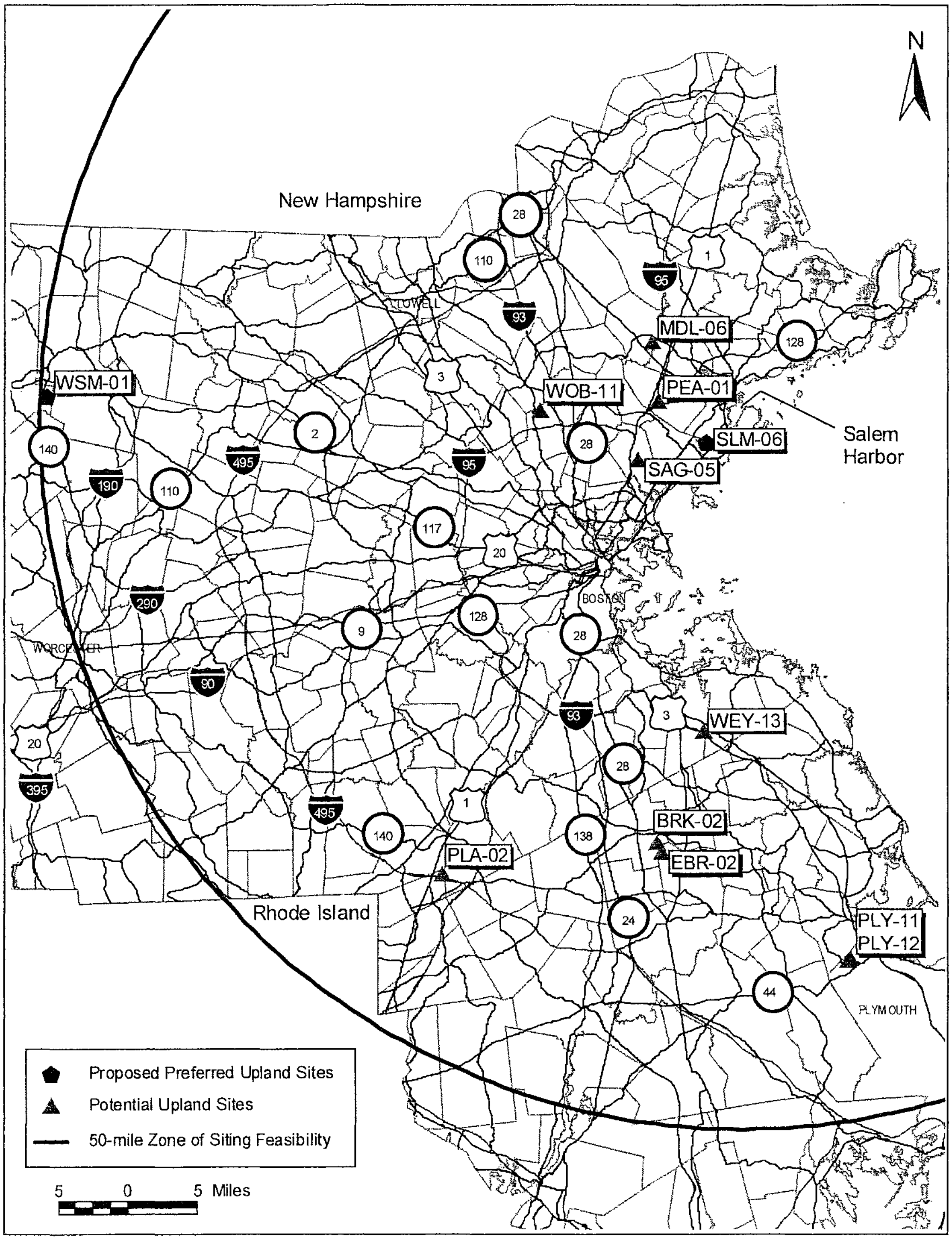


Figure 1-9: Salem Harbor Candidate Upland Disposal Sites

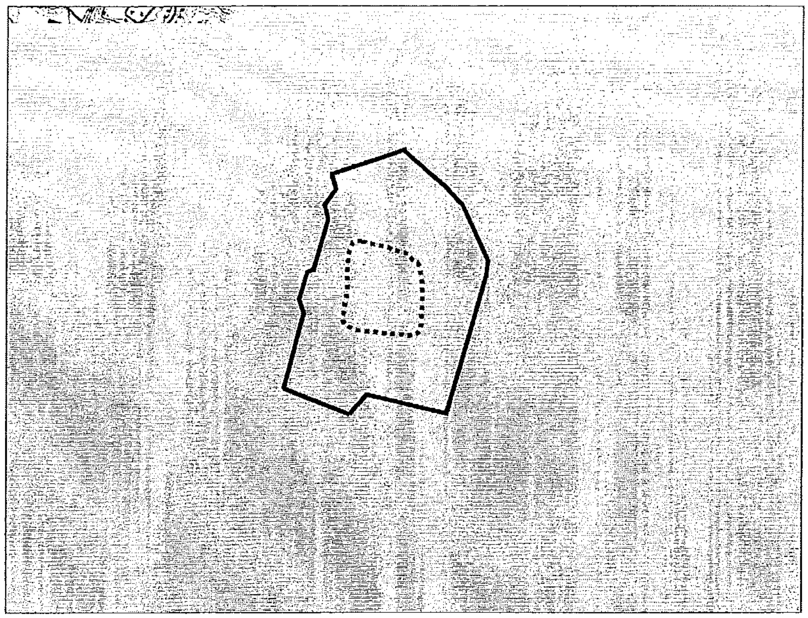


Figure 1-10: Preferred Upland Alternative #2 - SLM- 06- Bardon Trimount Quarry

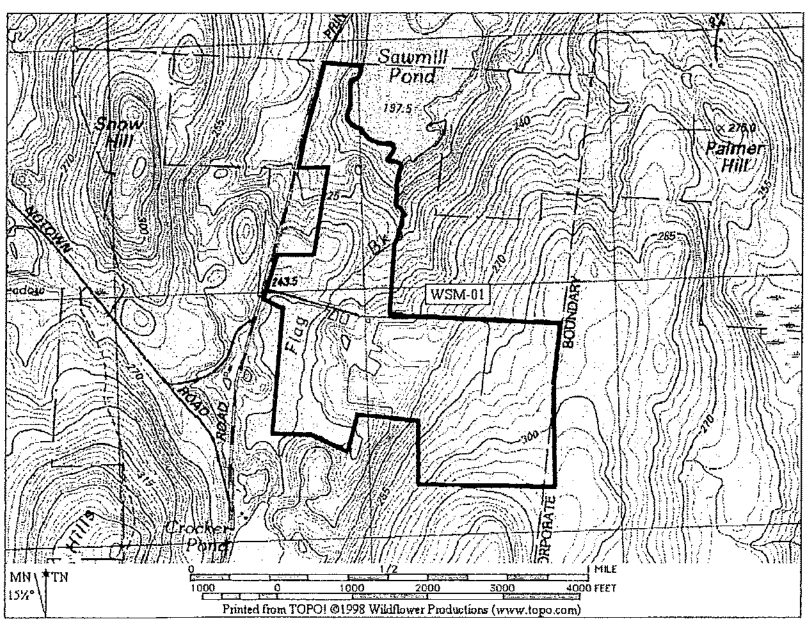
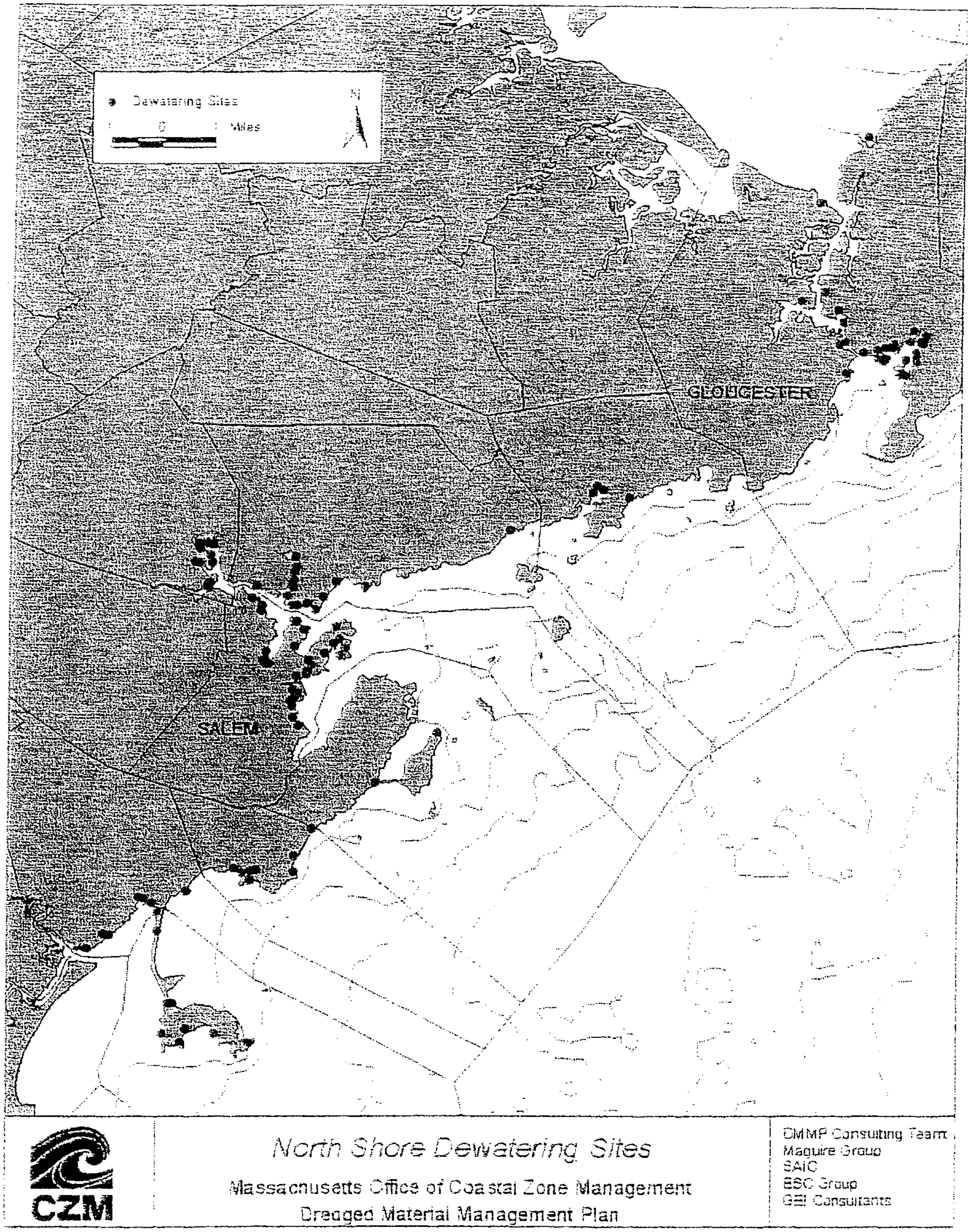


Figure 1-11: Preferred Upland Alternative #1 - WSM- 01- Westminster-Fitchburg Landfill

Figure 1-12: Universe of Potential Dewatering Sites for Salem Harbor



1.3 Required Permits and Approvals

Development of any of the Potential Preferred Alternative disposal sites will require permits and approvals from local, state and federal environmental regulatory agencies. Table 1-1 provides a listing of the required permits and approvals for each of the three Potential Preferred Alternatives. A complete analysis of the permitting requirements and specific regulatory standards for each of the permitting and approval programs is included in Section 7 of this DEIR.

Table 1-1: Potential Local, State and Federal Permits and Approvals

	Federal		State							Local
Administrating Agency	Corps of Engineers	Environmental Protection Agency	Coastal Zone Management	Mass. Environmental Policy Act	DEP: Division of Water Pollution Control	DEP: Division of Wetlands & Waterways	DEP: Division of Wetlands & Waterways	DEP: Bureau of Waste Site Cleanup	DEP: Division of Solid Waste Management	Local Conservation Commissions
Permit/ Approval	Section 10, 404 & 103 Permits	NPDES Permits	CZM Consistency Concurrence	MEPA Certification on DEIR and FEIR	Surface Water Discharge Permits	Chapter 91 License	Water Quality Certification	Mass. Contingency Plan Approval	Permit and Plan Approval	Wetlands Order of COnditions
Aquatic Disposal Sites										
S6 - CAD/OD	✔		✔	✔		✔	✔			✔
Upland Disposal Sites										
SLM-06 Salem/ Swampscott	✔	✔		✔	✔		✔	✔	✔	✔
WSM-01 Westminster	✔	✔		✔	✔		✔	✔	✔	✔

1.4 Summary of Potential Environmental Impacts and Mitigation Measures

This section summarizes the potential environmental impacts and proposed mitigation measures for each of the Proposed Preferred Alternative aquatic and upland disposal sites for the Salem Harbor DMMP. A detailed analysis of project impacts is included in Section 6 of this document, Sections 8 and 9 include a discussion of potential mitigation measures for the Proposed Preferred Alternatives. Potential environmental impacts and proposed mitigation measures are presented in Tables 1-2, 1-3, and 1-4.

Table 1-2: Potential Environmental Impacts and Mitigation Measures for the Aquatic Disposal Preferred Alternative - S6-CAD/OD-1 - Salem Harbor DMMP

AQUATIC SITE - S6-CAD/OD-1		
Environmental Feature	**No Build**	**Impact/Mitigation Measures**
Sediments	No Impact	Impact: Temporary disturbance to existing bottom conditions Mitigation: Recess final cap material compared to existing elevation to encourage active sedimentation over cap
Sediment Transport	No Impact	Impact: Reduced water circulation and water column mixing at site Mitigation:
Water Quality	No Impact	Impact: Short term localized, degradation due to dredged material disposal. Monitoring to ensure compliance with water quality standards. Mitigation: Disposal only during favorable tidal conditions to minimize impacts
Benthos	No Impact	Impact: Temporary disturbance to existing resources Mitigation:
Shellfish	No Impact	Impact: No impact to known shellfish beds Mitigation: None Required
Lobsters	No Impact	Impact: No known resources at disposal site Mitigation: None Required
Submerged Aquatic Vegetation	No Impact	Impact: No resources within disposal site Mitigation: None Required
Finfish	No Impact	Impact: Navigation channel provides suitable spawning habitat for several commercial species, but disposal site area habitat conditions are less favorable than outer channel Mitigation: Timing of disposal activities to avoid peak spawning periods
Wetlands	No Impact	Impact: Land Under Ocean impacts from cell construction and disposal activities required to verify Mitigation: None required
Wildlife	No Impact	Impact: No impact to shorebird, marine mammal and sea turtle habitat Mitigation: None Required

Table 1-2: Potential Environmental Impacts and Mitigation Measures for the Aquatic Disposal Preferred Alternative - S6-CAD/OD-1 - Salem Harbor DMMP (continued)

AQUATIC SITE - S6-CAD/OD-1 (continued)		
Environmental Feature	**No Build**	**Impact/Mitigation Measures**
Endangered Species	No Impact	Impact: No impact to habitat at disposal site Mitigation: None Required
Navigation and Shipping	Lack of disposal site may lead to shallower water depths, affecting safe navigation and reducing moorings	Impact: Potential interference with oil and coal vessel navigation to PG&E Generating dock Mitigation: Timing of disposal and cell construction activities to avoid ship movements
Land Use	Lack of disposal site may lead to loss of water-dependent uses, changing land use patterns	Impact: No direct impacts; Positive indirect impacts resulting from maintenance of existing land use patterns Mitigation: None Required
Consistency with Salem Harbor Plan	Lack of disposal site is not consistent with Harbor Plan	Impact: Positive; disposal site is consistent with Harbor Plan Mitigation: None Required
Air Quality/Noise/Odor	No Impact	Impact: AQ - temporary diesel emissions; potential volatilization of organic compounds; Noise - temporary increase in disposal site noise levels, no increase expected at nearby land side receptors; Odor- potential odor impact at temporary stockpile area Mitigation: AQ - use of properly operating mufflered equipment, cover UDM at stockpile to prevent volatilization; Noise- use of properly operating mufflered equipment, operation during daylight hours; Odor- use lime to control objectionable odors
Historic/Archaeological Resources	No Impact	Impact: Potential historic and archaeological resources to be further investigated; impacts to potential historic shipwrecks unlikely due to previous dredging activities. Mitigation: Possible recovery and recordation.
Recreation	No Impact	Impact: Recreational boaters temporarily diverted from area during cell construction and disposal operations, cell construction and disposal activities may drive fish from nearby recreational fishing areas Mitigation: None required

Table 1-3: Potential Environmental Impacts and Mitigation Measures for the Upland Disposal Preferred Alternative - SLM-06 - Salem Harbor DMMP

UPLAND SITE - SLM-06		
Environmental Feature	**No Build**	**Impact/Mitigation Measures**
Soils/Groundwater	No impact to groundwater due to filling with clean soils	Impact: Soil - No impact due to existing presence of contaminated soils at site; Groundwater - Potential for contamination to existing groundwater resources Mitigation: Soil - Disposal of UDM below grade; Groundwater - Installation of liner and leachate collection system
Wetlands	No impact	Impact: None expected, no resources present within quarry pit, site survey required Mitigation: None required
Wildlife	No Impact	Impact: None, little habitat value at existing quarry Mitigation: None Required
Endangered Species	No Impact	Impact: None, small habitat area on site removed from quarry portion of site Mitigation: None required
Land Use	No Impact	Impact: Quarry would be closed, changing use of site Mitigation: No measures identified
Consistency With Harbor Plan	No Impact	Impact: No inconsistency with plan; indirectly supports the plan goals of support for dredging projects in harbor Mitigation: None required
Air Quality/Odor/Noise	No Impact	Impact: AQ - No net increase in VOC, CO and NO_x emissions from trucks delivering UDM and moving material on site; Odor - Potential for objectionable odors; Noise - No net increase in existing noise levels Mitigation: AQ - None required; Odor - Use lime to control objectionable odors; Noise - None required

Table 1-3: Potential Environmental Impacts and Mitigation Measures for the Upland Disposal Preferred Alternative - SLM-06 - Salem Harbor DMMP (continued)

UPLAND SITE - SLM-06 (continued)		
Environmental Feature	**No Build**	**Impact/Mitigation Measures**
Historic/Archaeological	No Impact	Impact: Historic - Loss of historic quarry site due to filling of quarry; Archaeological - No impact, nearest known site is 0.5 miles Mitigation: Historic - Documentation of quarry resources; Archaeological - None required
Recreation	No Impact	Impact: Potential negative impact to abutting open space due to noise, dust and odors from truck traffic and disposal operations Mitigation: None identified
Economic Environment	No Impact	Impact: Not identified, but potential for negative impacts due to truck traffic through tourist/recreational areas from dewatering site Mitigation: Use of major highways to avoid tourist/recreational areas

Table 1-4: Potential Environmental Impacts and Mitigation Measures for the Upland Disposal Preferred Alternative - WSM-01 - Salem Harbor DMMP

UPLAND SITE - WSM-01		
Environmental Feature	**No Build**	**Impact/Mitigation**
Soils/Groundwater	No impact to groundwater due to filling with clean soils	Impact: Soil - Potential for disturbance to undisturbed soils due to transport and unloading operations; Groundwater - None expected due to use of landfill liner at site Mitigation: Soil - transport on existing landfill roads and careful unloading operations; Groundwater - Continuing maintenance of liner and leachate collection system
Wetlands	No impact	Impact: None expected, no resources present within existing landfill area, site survey required for expansion areas Mitigation: None required
Wildlife	No Impact	Impact: None, little habitat value at existing landfill site Mitigation: None Required
Endangered Species	No Impact	Impact: No known habitat within 0.5 miles Mitigation: None required
Land Use	No Impact	Impact: None, use of site continues Mitigation: None required
Consistency With Harbor Plan	No Impact	Impact: No inconsistency with plan; indirectly supports the plan goals of support for dredging projects in harbor Mitigation: None required
Air Quality/Odor/Noise	No Impact	Impact: AQ - No net increase in VOC, CO and NO_x emissions from trucks delivering UDM and moving material on site; Odor - Potential for objectionable odors; Noise - No net increase in existing noise levels Mitigation: AQ - None required; Odor - Use lime to control objectionable odors; Noise - None required

Table 1-4: Potential Environmental Impacts and Mitigation Measures for the Upland Disposal Preferred Alternative - WSM-01 - Salem Harbor DMMP (continued)

Upland Site - WSM-01 (continued)		
Environmental Feature	**No Build**	**Impact/Mitigation**
Historic/Archaeological	No Impact	Impact: Historic -No impact expected as no historic sites within 0.5 miles; Archaeological - Nearest known site is 0.5 miles, expansion of landfill towards this area may cause increased truck vibrations and noise Mitigation: Historic - None required Archaeological - None identified
Recreation	No Impact	Impact: Potential negative impact to abutting open space due to noise, dust and odors from truck traffic and disposal operations Mitigation: None identified
Economic Environment	No Impact	Impact: Not identified, but potential for negative impacts due to truck traffic through tourist/recreational areas from dewatering site Mitigation: Use of major highways to avoid tourist/recreational areas

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SECTION 2.0 - INTRODUCTION

2.0 INTRODUCTION

2.1 Background of the MA CZM DMMP

The Executive Office of Environmental Affairs (EOEA), through its office of Coastal Zone Management (CZM), has developed a draft Dredged Material Management Plan (DMMP) for Salem Harbor. The development of this Salem Harbor DMMP Draft Environmental Impact Report (DEIR) involved two project phases to address the critical issue of finding environmentally sound disposal sites for dredged material unsuitable for unconfined ocean disposal. The DMMP developed by CZM has a twenty year planning horizon.

To develop the DMMP, CZM needed to do the following:

- Collect and analyze information on dredging needs, characteristics of the sediment, and available alternatives for treatment, reuse, and disposal of dredged material from the Salem Harbor Area to be used in subsequent port planning initiatives

- Identify and characterize the range of reasonable alternatives for dredged material reuse/disposal and establish a framework for comparison of the alternatives as guidance for compliance with the Massachusetts Environmental Policy Act (MEPA).

Phase I of the DMMP, conducted in 1996 and 1997, included several discrete tasks, the purpose of which was to provide a baseline assessment of existing conditions related to dredging and dredged material disposal in the port of Salem. DMMP Phase I tasks were documented in a report (Maguire Group Inc., 1997a and b.) and included:

- Summary Report - a synopsis of dredging volumes, sediment quality and potential disposal alternatives for Salem, Gloucester, New Bedford and Fall River Harbors;
- Dredging Inventory - an update of the US Army Corps of Engineers inventory of dredging demand for Salem, Gloucester, New Bedford and Fall River Harbors;
- Bathymetric Surveys - a review and compilation of existing bathymetric survey information in Salem, Gloucester, New Bedford and Fall River Harbors;
- Alternative Technologies - an inventory and assessment of available treatment technologies for contaminated dredged material;
- Natural Resource Inventory - an inventory of all known fish, shellfish and wildlife resources within Salem Sound and Gloucester, New Bedford and Fall River Harbors;
- Aquatic and Near-Shore Disposal Site Analysis - an identification and description of potential confined aquatic disposal (CAD), confined disposal facility (CDF) and tidal habitat restoration sites within Salem, Gloucester, New Bedford and Fall River Harbors;
- Upland Disposal Site Inventory - an examination of upland and reuse options for contaminated dredged sediments;
- Due Diligence - an inventory and data description of pollution sources and historic sediment quality information in Salem, Gloucester, New Bedford and Fall River Harbors;
- Preliminary Geotechnical Investigations - an inventory and assessment of existing geotechnical information within Salem, Gloucester, New Bedford and Fall River Harbors; and
- Sampling Plans - sediment sampling and testing plan for Salem Harbor dredging projects.

The DMMP Phase I information provided the basis for the preparation of the Environmental Notification Form (ENF) for the Salem Harbor DMMP.

Phase II of the DMMP has focused on the review of the potential environmental impacts associated with the dredged material disposal alternative(s) identified through the DMMP process.

The purpose of the DMMP for Salem Harbor is to identify, evaluate and ***permit,*** within the Zone of Siting Feasibility (ZSF) for Salem Harbor, a dredged material disposal site(s) with sufficient capacity over the next 20 years to accept dredged material unsuitable for unconfined ocean disposal from public and private dredging projects.

The lack of a practicable cost-effective method for the disposal of unsuitable dredged material in an environmentally sound manner has been a long standing obstacle to the successful completion of dredging projects in Salem Harbor. The disposal alternative siting process has been closely coordinated with the City of Salem, including the Dredged Material Disposal Working Group (the dredging subcommittee of the Salem Harbor Planning Committee),and with the public at large.

Reflecting the reality that a solution to the problem of dredged material disposal will potentially affect <u>all</u> communities abutting greater Salem Sound, the City of Salem, through the Dredged Material Working Group, has consciously involved abutting communities in the development of the Salem Harbor DMMP, inviting representatives from Marblehead, Peabody, Danvers, Beverly and Manchester-by-the-Sea to participate as full members of the Working Group.

Coordination with local port planning interests has also been a critical component of the development of the Salem Harbor DMMP DEIR. The simultaneous development of both the DMMP and the Salem Harbor Plan has aided the identification of the future dredging needs for the maintenance and improvement in navigation within Salem Harbor and with the identification of potential sites for the disposal of dredged material unsuitable for unconfined open ocean disposal. Public input has been coordinated thorough the presentation of several dredging workshops, mailings, and presentations to interested parties.

This Salem Harbor DMMP DEIR identifies disposal alternatives with sufficient capacity to accept dredged material unsuitable for unconfined ocean disposal from public and private dredging projects.

2.2 Massachusetts Environmental Policy Act (MEPA) Procedural History

The submission of the Environmental Notification Form (ENF) for the Salem DMMP on March 16, 1998, inaugurated the official MEPA review process for the DMMP (a copy of the ENF is included in Appendix A). On April 24, 1998, pursuant to the Massachusetts Environmental Policy Act (M.G.L. c. 30, ss. 61-62H) and the MEPA Regulations (301 CMR 11.00), the Secretary of the Executive Office of Environmental Affairs (EOEA) made the determination that the Salem Harbor DMMP require the preparation of an Environmental Impact Report (EIR). Because the project involves the potential alteration of more than 10 acres of Land Under the Ocean (a resource area regulated under the Massachusetts Wetlands Protection Act, M.G.L. c. 131, s. 40) and involves the use of state agency funding through the Seaport Bond Bill (Chapter 28 of the Acts of 1996), the Salem Harbor DMMPs exceeded the "categorical inclusion" threshold at Section 11.25(2) of the MEPA regulations in effect in June 1998, requiring by regulation the preparation of an EIR. (Under the current MEPA Regulations, promulgated in July 1998, the Salem Harbor DMMP exceeds the 10-acre wetland resource area alteration "Mandatory EIR" threshold at 301 CMR 11.03(a)b. The Mandatory EIR thresholds contained in the July 1998 MEPA Regulations have replaced the Categorical Inclusion thresholds from previous versions of the MEPA regulations.)

2.3 Scoping and Coordination Summary

The MEPA public "scoping" meetings was held at Salem City Hall on April 7, 1998. The meeting was conducted by a representative of the MEPA Unit of the EOEA. At the meeting, the Salem Harbor DMMP, as described in the ENF, was presented and public comments were received by the MEPA Unit. (Copies of the meeting attendance lists are included in Appendix A)

The Secretary's ENF Certificate of July 24, 1998 (included in the front matter of this DEIR) establishes the scope for this DEIR. In addition to the DEIR subject matter outline contained in Section 11.07 of the MEPA regulations, several major issues were emphasized as subjects to be addressed in this DEIR:

- Sediment quality and quantity analysis;
- Identification of disposal alternatives, including: alternative technologies and methodologies; upland reuse/disposal; and aquatic disposal;
- A complete description of the screening of disposal alternatives:
- Results of fisheries investigations and monitoring program;
- Effects on shore bird habitat;
- Results of cultural/historical/archaeological investigations;
- Characterization of proposed disposal sites;
- A description of the Preferred Alternative; and
- A proposed disposal site management plan;

2.3.1 Coordination with Port Planning Process

CZM and the City of Salem sponsored a local workshop series with topics related to dredging and dredged material management. The purpose of the workshop series was to provide a mechanism for citizens in communities abutting Salem Harbor to provide input into the process of developing a preferred disposal alternative. CZM also conducted a series of workshops and meetings with the Salem Dredged Material Disposal Working Group. The proposed disposal sites included in the ENF were a starting point, and the continuing input from the Salem Working Group was crucial in assisting CZM in identifying dredging projects and disposal sites that needed to be added, subtracted, or modified from the ENF listing of potential disposal sites.

The workshops also served the function of disseminating DMMP technical information as it became available, so that information could be reviewed as this DEIR was developed. Salem's participation in the workshop series should facilitate review of this DEIR. Public workshops conducted included the following topics, as listed in Table 2-1 and described below.

Table 2-1: Salem Harbor DMMP Workshops/Meetings

Workshop	Date
Dredging and Disposal Technologies	June 19, 1998
Siting Criteria and Process for Dredged Material Disposal	July 24, 1998
Regulations Governing Dredged Material Disposal/Reuse	August 20, 1998
Sediment Quality	September 18, 1998
Municipal Working Meeting #1	January 22, 1999
Municipal Working Meeting #2	April 16, 1999
Municipal Working Meeting #3	April 30, 1999
Municipal Working Meeting #4	May 14, 1999
Municipal Working Meeting #5	May 21, 1999
Screening of Potential Disposal Sites Working Meeting	June 11, 1999
Preferred Alternative(s) Public Workshop #1	July 28, 1999
Preferred Alternative(s) Public Workshop #2	September 7, 1999

Dredging and Disposal Technologies - This workshop presented information on the basic elements of dredging, including potential dredging technologies that could be employed in Salem projects, and dredged material disposal. Issues covered included: probable characteristics of dredged material; types of disposal options for dredged material; and management practices to minimize and mitigate environmental impacts. The goal of the workshop was to inform citizens of the linkage between minimizing environmental impacts with the proper planning of dredged material disposal.

Siting Criteria and Process for Dredged Material Disposal - In this workshop, various criteria were discussed, such as avoidance of environmentally sensitive areas, compatibility with adjacent uses and minimizing exposure to important physical features. The linkage between developing comprehensive siting criteria and understanding regulatory requirements with potential locations for siting dredged material disposal within the harbor was developed. This workshop also focused on the idea that the selecting potential sites for dredged material disposal should follow a logical process of using important features of the natural and built environment as a means of screening and, finally, choosing the best location to create a dredged material disposal site. This workshop provided an opportunity for local input on screening criteria and the development of harbor specific site screening factors.

Regulations Governing Dredged Material Disposal and Reuse - This workshop included the presentation of information on state and federal regulations covering dredging, dredged material disposal and dredge material reuse. The primary federal regulatory agency is the US Army Corps of Engineers (USACE) with the US Environmental Protection Agency (USEPA), US Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) having cooperative involvement. At the state level, the Department of Environmental Protection (DEP), Office of Coastal Zone Management, and the Executive Office of Environmental Affairs (EOEA) in accordance with the requirements of the Massachusetts Environmental Policy Act, have regulatory oversight of dredging and dredged material disposal projects in the Commonwealth. The intent of the workshop was to provide information on the types of data required by federal and state regulatory agencies as well as an explanation of the importance of the regulatory process in selecting appropriate disposal options for contaminated dredged material.

Sediment Quality - The results of recently collected and tested samples of marine sediment from proposed dredging areas within the harbor were presented. The results of the testing portrayed the level of contamination that determine the volume of dredged material that must be managed. Sediment quality data were compared with criteria mandated by the USACE and USEPA. Dredged material that the federal agencies deem suitable for unconfined aquatic disposal and the probable location of disposal sites and cost of disposal were addressed. Probable dredged material contaminants and degrees of unsuitability of sediment in the harbor were presented. The linkage between the volume of contaminated dredged material and options for selecting prudent disposal sites was developed in this workshop.

Municipal Working Meeting - To finalize data collection related to Candidates Sites for upland disposal/reuse and dewatering sites, CZM met with municipal officials to verify that information collected was valid. A goal of this meeting was to gain insight into Candidates Sites from the local municipalities that may not have been apparent to CZM.

Screening of Potential Disposal Sites / Proposed Preferred Alternatives - Proposed Preferred Alternatives were presented to the subcommittee for review. The workshop was a hands-on session, working with maps of the harbor and its various natural features. The Consulting Team facilitated the discussion at the workshop through the use of computer overlays depicting fisheries habitat, water depths, wind/wave exposure, areas of navigation and other data collected and compared it with the siting criteria developed in the Siting Criteria workshop. The intent of the session was to presents results of the screening process to find a disposal site(s) of sufficient size, with minimal environmental impacts, for unsuitable dredged material. The subcommittee provided input on the Proposed Preferred Alternatives presented.

Preferred Alternative(s) Public Workshop - After the presentation of screening results to the Dredged Material Subcommittee, and incorporating comments, from the Subcommittee and the federal agencies, Preferred Alternatives were presented to the public-at-large. The workshop goal was to develop a consensus and broad based community support on a location(s) suitable to use as the long term disposal site for dredged material.

Additional coordination with the Port Planning process involved attendance at public milestone meetings and inter-action with the project coordinator and consultants. Documentation of this public process can be found in Appendix B. The documentation includes meeting notes, presentation handouts and other items.

2.3.2 Coordination with Federal Agencies

Rooted in the highway project planning and permitting process, the Army Corps of Engineers has developed a method of coordinating the review and approval time lines of the various federal resource agencies charged with reviewing major projects involving discharges of dredged or fill material in Waters of the United States, regulated under Section 404 of the Clean Water Act or activities in tidal waters regulated under Section 10 of the Rivers and Harbors Act of 1899. Based upon the mapping overlay planning methodology developed by noted landscape architect Ian McHarg in the 1960s, the Corps of Engineers "Highway Methodology" provides a useful tool for decision making in a coordinated fashion. This methodology is a useful way to integrate the planning and design of a project with the requirements of the Corps permit regulations. The Corps serves as the coordinator of comments from the Federal agencies, including the US Environmental Protection Agency (USEPA), the US Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS).

Participation by the Corps in the earliest stages of project planning is a key provision of the Highway Methodology. The evaluation of alternatives to the project is key to the successful completion of the methodology. Alternatives analysis are based upon the determination of the project "purpose and need" (developed under the National Environmental Policy Act (NEPA)) and the "overall/basic project purpose" required under the EPA 404(b)(1) guidelines and used by the Corps in project permitting.

The 404(b)(1) guidelines establish pass/fail environmental tests, to be completed before a determination is made on the balancing of overall project benefits versus detriments. An USEPA/USACEs Memorandum of Agreement, signed in February 1990, mandates a three-step iterative process of avoidance, minimization and mitigation of adverse impacts to wetlands functions and values. (Army Corps of Engineers, New England Division, 1993)

Application of the Highway Methodology to the Salem Harbor DMMP DEIR involved several key milestones including the USACE's concurrence with the DEIR Outline, Basic Project Purpose (BPP), and Aquatic and Upland Zones of Siting Feasibility (ZSFs). Documentation of the Corps' implementation of the Highway Methodology is presented in Appendix B which contains letters presenting the coordinated federal comments.

As part of the effort to coordinate closely with the Federal Agencies, two meetings to present draft screening results were held. The first presentation was to representatives of the USACE-NED on April 9, 1999, and a second meeting to all reviewing federal agencies, including representatives from Army Corps, Environmental Protection Agency (USEPA), National Marine Fisheries Service (NMFS) and Fish and Wildlife Service (USFWS). The results of the two meeting was a letter from the USACE dated June 8, 1999, (see Appendix B), indicating concurrence with the screening process conducted and the proposed preferred disposal alternatives put forward. The letter also indicated that upland disposal was not considered a feasible disposal option.

SECTION 3.0 - PURPOSE AND NEED

3.0 PURPOSE AND NEED

3.1 Project Purpose

3.1.1 Basic Project Purpose

The purpose of the Salem Harbor Dredged Material Management Plan (DMMP), is to identify, evaluate and permit, within the Zone of Siting Feasibility (ZSF) a site (or sites) or alternative technology, for the disposal of dredged material unsuitable for unconfined ocean disposal over the next twenty years. The lack of a practicable, environmentally sound, cost-effective method for disposal of contaminated dredged material has been a long-standing obstacle to the successful completion of major dredging projects in the port of Salem. The harbor is in need of maintenance and / or improvement dredging in order to maintain and improve their competitive position in the maritime industries while maintaining environmental quality.

Salem Harbor contains several marinas, a significant recreational fleet, numerous harbor side historical attractions, and a large fuel terminal. Salem Harbor is a significant recreational boating destination due to the large number of historical and cultural attractions of the city, largely located adjacent to or in close proximity to the harbor.

A total of five marinas and yacht clubs, one electrical generating plant (Salem Station), seven public projects (including the Salem Port Development Plan), and five future development sites have been identified as existing facilities and potential future sites requiring maintenance and improvement dredging in the next twenty years.

3.2 Port Planning Context

The February 1996, passage of the Seaport Bond Bill, included a provision for funding assistance to the state's major commercial ports to conduct comprehensive harbor development and management plans. This "Four Ports Initiative," undertaken by CZM on behalf of the EOEA Secretary, is being closely coordinated with the DMMP. As part of the local port planning process, Salem has developed a Harbor Plan to guide the development of the harbor for the five and twenty year planning horizons, providing a framework for future decisions related to port development.

A port plan, approved by the secretary of EOEA, is a legal document having significant impact upon the viability of planning initiatives in the port. The plan allows Salem to have greater flexibility in implementing a development strategy tailored to its port's needs and the City's visions of economic development and environmental quality. The plans also identifies fiscal infrastructure needs which are critical to the plan's implementation. The preferred alternative put forward in the plan represents the City's harbor planning goals and vision for the next twenty years.

The development of the Salem Harbor DMMP, also funded through the Seaport Bond Bill, has been coordinated with local planning efforts. Coordination with local port planning interests has been a critical component of the development of this DEIR. The simultaneous development of the port plan and the DMMP has helped with the identification of Salem Harbor's future dredging needs for maintenance and improvement in navigation and potential sites for the disposal of dredged material unsuitable for unconfined open ocean disposal. Public input has been coordinated thorough local workshops sponsored by CZM, mailings, a project web page, and presentations to interested parties. The development of a preferred alternative through the local port planning process has been considered in the DEIR DMMP.

To date, Salem has prepared a draft of the Harbor Plan, which has been submitted to CZM for review and ultimate approval. The development of the Harbor Plan has been guided by the following mission statement:

> *Reclaim Salem's identity as a vibrant seaport, which makes use of its waterfront for a variety of commercial and recreational waterfront activities, and has high quality landside facilities necessary to support these activities at an environmentally beneficial, and economically sustainable level. Such waterside activities and landside facilities should preserve the City's distinguishing historic character and ultimately enhance the quality of life in the city for residents, visitors and businesses.*

Eight planning goals have been developed to guide the evaluation of alternative development scenarios for the plan:

- To re-establish the identity of Salem as an active seaport by developing new and improved facilities serving many types of vessels on the waterside, and by enhancing access to, and visibility of the Harbor on the landside for residents and visitors alike. This should be done by defining a specific program of activities to intensify use of the Harbor, as well as funding to implement priority projects;

- To maximize the economic potential of the Harbor in the context of the economic development goals of the City as a whole, while enhancing the quality of life for residents in adjacent areas.

- To promote the waterfront as a focal point for Salem's visitor economy, emphasizing cultural tourism, high quality recreational experiences and longer visitor stays.

- To protect and enhance access to the waterfront, and on the water, for the Salem community, for passive and active recreation; reconnect the community to its waterfront where the connection currently does not exist;

- To identify and preserve those aspects of Salem's waterfront experience which should be preserved and protected from change;

- To protect and preserve those aspects of Salem's waterfront experience which can beneficially link the City to its historic past;

- To ensure that public investment in waterfront infrastructure will support and encourage private investment, and to develop long term capital maintenance/management strategies to ensure that public investment will result in infrastructure which is sustainable over the long term; and

- To protect and enhance the environmental quality of the harbor and its environs as an integral component of any proposed development or revitalization efforts.

One of the key projects identified in the Port Plan is the new cruise terminal pier proposed near Hawthorne Cove Marina and the PG&E power station. The project referred to as the Salem Port Development (Salem PD) Plan, calls for the erection of an L-shaped pier to accommodate cruise ships.

Dredged material disposal alternatives for Salem Harbor identified in this Draft Environmental Impact Report (DEIR) have been screened for their consistency with the Salem Harbor Plan mission statements and planning goals listed above, to ensure that the Preferred Alternative assists in the achievement of the goals of the plans.

Throughout the MEPA process and the development of this DEIR, CZM provided the technical information necessary to identify disposal sites and will make recommendations based upon that information; however, is the responsibility of the City of Salem to determine the appropriateness of any site selected. The identification of the preferred alternative disposal site(s) has been coordinated with Salem throughout the port planning process.

3.3 Sediment Quality and Quantity

3.3.1 Dredging Inventory

The volume of sediment to be dredged from Salem Harbor has been estimated through various surveys conducted by the ACE (1996), Maguire (1997) and Massachusetts Department of Environmental Management (DEM). The dredged material volumes were used to identify, plan and permit a disposal site(s) to accomodate the volumes under the regional and municipal scenarios. For planning purposes, a twenty percent contingency was added to the volumes to cover any additional volume that may be unaccounted for in the dredging inventory.

The total volume of sediment to be dredged from Salem Harbor is estimated at 978,533 million cy (815,444 plus 163,089 (20%) contingency). A contingency of 20% has been added to the dredging inventory figures to account for any uncertainty in the volumes provided by the marine users. The volumes presented in the sub-sections below are *without* the 20% contingency.

In order to determine the volume of sediment that would be dredged from Salem Harbor over the next 20 years, an inventory of marine users in and near Salem Harbor was conducted by the ACE (1996) and updated by Maguire (1997). All shoreline marina owners, municipalities, utilities, state and federal agencies were surveyed via a mail-back questionnaire, with follow-up telephone calls to non-respondents. Marine users were asked to complete a questionnaire, denoting dredging footprints, volumes, and anticipated time schedule over the next 20 years.

There were eighteen facilities who responded (Table 3-1): 5 marinas, 1 utility, 7 public projects and 5 future development projects or sites. The total dredge volume for these projects is 815,000 cy. The largest of these is the proposed Salem Port Development (PD) Project, with an estimated volume of 550,000 cy (Figure 3-2). The main federal channel (110,000 cy) and the south channel (53,000 cy) maintenance projects total 163,000 cy.

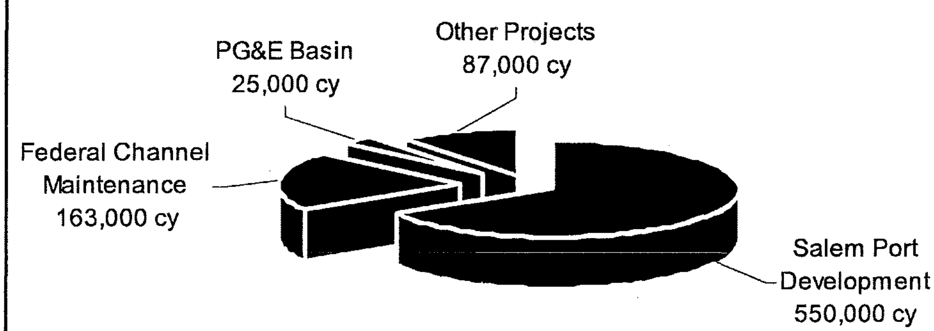

Figure 3-1: Twenty-year dredging volume (cy) breakdown for Salem Harbor

Table 3-1: Projected Twenty-Year Dredging Volumes for Salem Harbor

Inventory ID	Project Name	Volume (cy)	M or I 1	Volume Suitable 2	Volume Unsuitable 2	Dredging Year
S1	Federal Channel	110,000	M	110,000	0	5
S2	Federal Channel South	53,000	M		53,000	10
S3	South River Redevelopment	14,000	I		14,000	5
S4	Pickering Wharf	3,000	M		3,000	10
S5	Salem Maritime Nat. Hist. Site	5,000	M		5,000	5
S6	House of Seven Gables	5,000	I		5,000	10
S7	Hawthorne Cove Marina	5,000	M		5,000	5
S8	Salem Port Dev. Plan	540,000	I	466,000	74,000	5
S9	PG&E	25,300	M		25,300	5
S10	Winter Island Yacht Yard	1,000	M		1,000	5
S11	Winter Island Municipal Launch	8,000	M		8,000	10
S12	Winter Island Municipal Pier	8,000	I		8,000	15
S13	Keny Playground	5,000	I		5,000	10
S14	Village Street Landing	5,000	M		5,000	5
S15	House of Seven Gables	0				0
S16	Fred Dion Yacht Yard	0				0
S17	Palmer's Cove Yacht Club	3,700	M		3,700	5
S17	Palmer's Cove Yacht Club	4,444	I		4,444	5
S18	State Channel	20,000	M		20,000	20
SUBTOTAL		815,444		576,000	239,444	
CONTINGENCY (20%)					47,889	
TOTAL					**287,333**	

Notes:

1 Maintenance or Improvement (deepening)

2 Assessment of suitability for ocean disposal at MBDS is based on existing chemistry data alone. Final determination will be made by USACE and EPA following biological testing.

This data was developed from USACE and MCZM surveys conducted in 1995 and 1997, respectively.

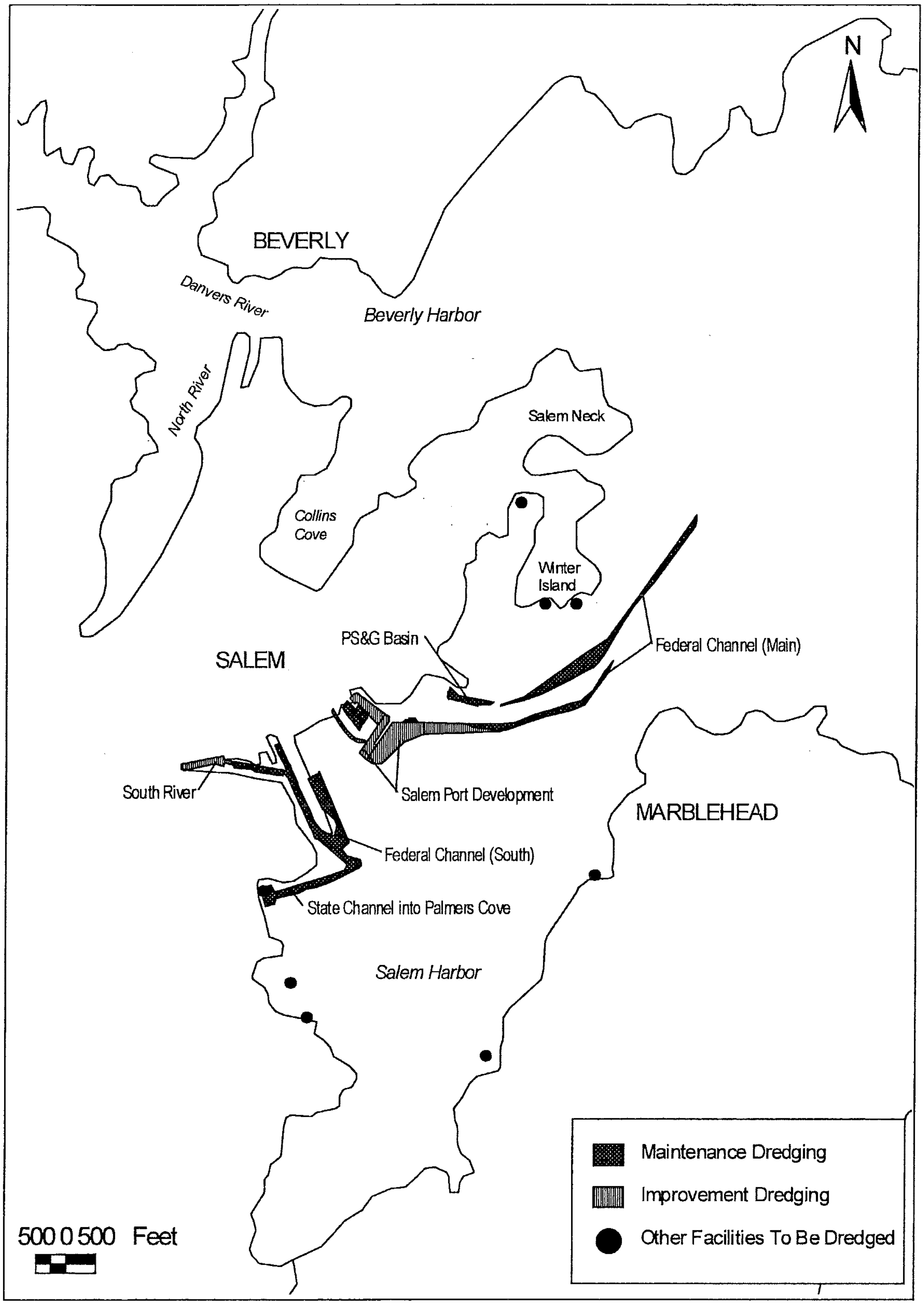

Figure 3-2: Dredging Areas and Facilities in Salem Harbor

3.3.2 Sediment Quality - Conformance with Regulatory Requirements

EPA Protocol

The evaluation of sediments proposed for dredging is conducted by federal and state regulatory agencies. The USEPA, USACE, NMFS, USFWS, DEP, and CZM, through an inter-agency agreement, are responsible for development and review of all sampling and testing for dredging and dredged material disposal in Massachusetts.

The first step of Tier II involves the physical analysis of samples (grain size, organic carbon content). These results are reported to the USACE, which, in turn determines which samples are to be composited for chemical analysis. The only sediments that would not require further testing are those that consist of greaater than 90% sand and/or are in areas of high currents and no major pollution sources. In Salem, there are no sediments that meet this "exclusionary" criteria. The entire harbor is primarily a depositional area because of relatively slow currents and tidal action.

After the bulk chemical analysis, results are presented to the federal agencies for their review and evaluation. According to USEPA, if a substance is detected in sediments above "trace amounts", biological-effects testing (Tier III) is required. USEPA interprets "trace amount" as being any concentration that is above laboratory detection levels. If all substances are below trace levels, then no additional testing is required and sediments are deemed suitable for ocean disposal.

An inventory of potential pollution sources and historic sediment quality data in and near Salem Harbor was conducted as part of the DMMP Phase 1 (Maguire 1997). This information was used by the regulatory agencies to develop site-specific sampling and testing plans for the Salem Port Development, Federal Channel, South Channel, and PG&E Basin projects. These projects were chosen for site-specific study because in total, they account for nearly 90% of the total anticipated dredged volume in Salem Harbor.

Sampling and testing plans are developed in a coordinated effort by EPA, ACE, NMFS and USFWS with input from DEP. The plans for Salem Harbor were completed in the winter of 1998. Sampling and testing was conducted in the spring/summer of 1998. A summary of the results is presented below. Detailed results appear in Appendix E.

Physical Testing

Surficial sediments in the main channel, south channel, PG&E Basin, and at the Salem PD sites are fine-grained, generally grey to black in color and anoxic, with some sulfur odor. Organic carbon content is moderate to high.

Deeper sediments at the Salem PD site are quite varied, but lenses of clayey sand are most common. Some organic silt, peat, and clay sediment layers exist at varying depths.

Bulk Chemistry

Sediments were analyzed to determine metals, polycyclic aromatic hydrocarbon (PAH), pesticides and polychlorinated biphenyl (PCB) content. All these classes of chemical have been detected in previous samples in the harbor and have the potential to occur in the sediments due to the presence of several point and non-point pollution sources in the area.

Although a direct comparison of test results to ocean disposal site reference values is not used to determine sediment suitability for ocean disposal, chemistry results are compared to the MBDS reference site guidelines so that the nature of the sediments in Salem Harbor can be viewed in a useful context.

Table 3-2 summarizes the mean (average) concentrations of selected substances found in measurable quantities in the sediments from the major dredging projects.

Table 3-2: Mean Sediment Chemical Concentrations for Major Dredging Projects in Salem Harbor

Analyte	Main Channel	South Channel	PG&E Basin	Salem PD Surface	Salem PD Subsurface	MBDS Reference
Arsenic	10	7	13	6	7	28.7
Cadmium	2	1	2	0.4	0	2.74
Chromium	**762**	**336**	**800**	116	36	152
Copper	**36**	**47**	**59**	13	12	31.7
Mercury	**0.28**	**0.52**	**0.48**	0.09	0.03	0.277
Nickel	21	21	31	15	22	40.5
Lead	**65**	**126**	**89**	26	11	66.3
Zinc	91	116	117	40	44	146
Total PAH	1,732	**17,186**	**5,289**	699	24	2,996
Total PCBs	38	75	96	15	10	ng

Bold denotes values greater than MBDS Reference
MBDS Reference values are mean plus 2 standard deviations
Metals in parts per million (ppm) and PAH/PCB in parts per billion (ppb)
ng = no guideline

Of the eight metals studied, chromium is the most prevalent in Salem Harbor. Mean concentrations in main channel, south channel and PG&E basin sediments are 2 to 5 times the MBDS reference level. Copper, mercury and lead concentrations from these sites also exceed the MBDS reference levels. Metals occur naturally in sediment at low concentrations, but point and non-point discharge sources contribute significant amounts of metals to the water and sediment. Most metals have a tendency, once

entering the water, to adsorb to suspended sediment particles which then settle to the harbor bottom. Potential sources of elevated chromium in the harbor are tanneries,wastewater treatment outfalls and combined sewer outfalls.

Total PAH concentrations in the south channel and U.S. Generating basin exceed the MBDS reference level by 2 to 5 times. South channel PAH concentrations are particularly high. Sediments in the main channel and at the Salem PD contain mean concentrations well below the MBDS reference levels, however, PAH levels in one of four surficial samples at the Salem PD site exceeded the MBDS reference levels (Figure 3-4).

Polycyclic aromatic hydrocarbons (PAH) are a class of chemicals that are formed by the incomplete combustion of fuel. Sources of PAH include power generation, stormwater runoff, industrial discharge and dry deposition from the atmosphere.

There appears to be no harbor-wide pesticide contamination as most compounds analyzed were not detected in the sediments. Small concentrations of DDT and DDT-derivatives were detected in sediments at a few sites.

There are no MBDS reference numbers for pesticides, but there are some numerical guidelines that have been developed by NOAA and the NERBC. Pesticide concentrations harbor-wide are generally low compared to these guidelines, however, elevated DDT and DDT-derivative compounds were found in the South Channel and PG&E basin samples. This is consistent with the spatial distribution of other contaminants such as metals and PAHs within the harbor. Pesticides, as the name implies, are used to control weeds, fungi, rodents and other undesirable organisms. While many chlorinated pesticides have been banned from use in the United States, their historic production and chemical stability have allowed them to persist in the environment.

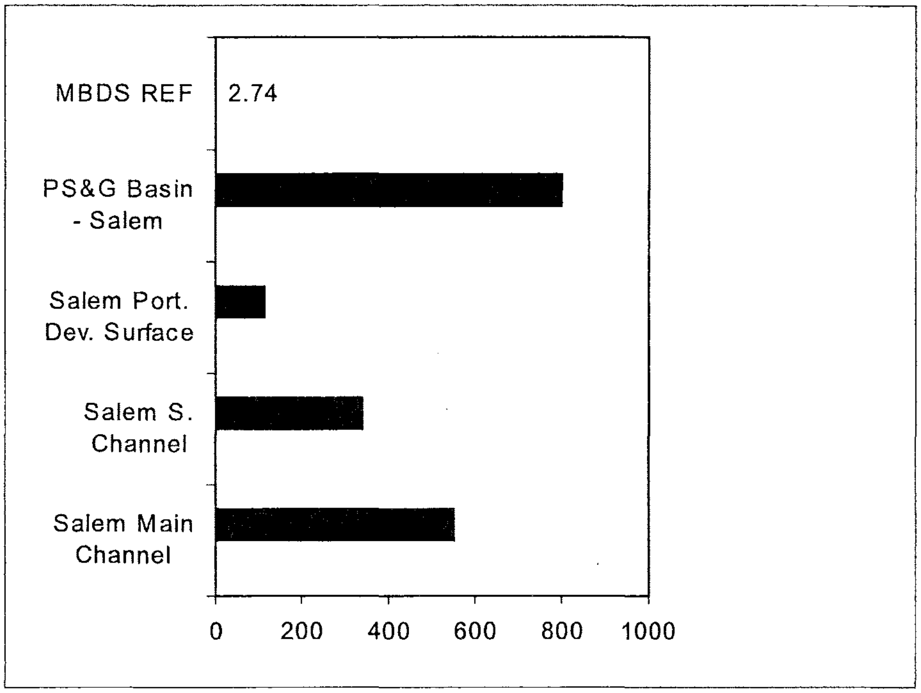

Figure 3-3: Mean Chromium Concentrations (ppm) for Salem Harbor Sediments

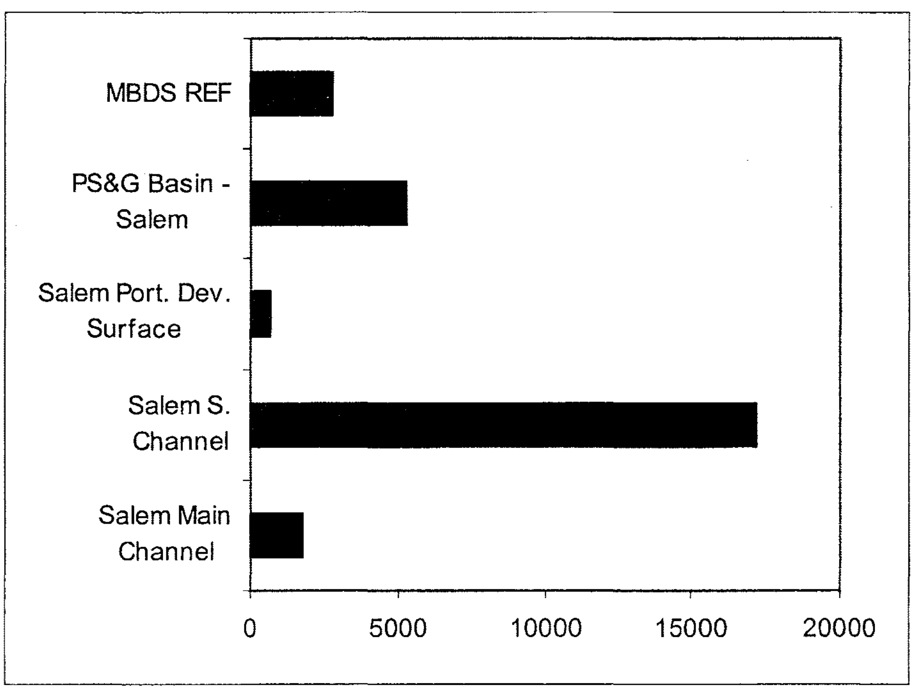

Figure 3-4: Mean PAH Concentrations (ppm) in Salem Harbor Sediments

Polychlorinated biphenyls (PCBs) concentrations were also highest in the South Channel and PG&E basin sediments. There are no sediment quality guidelines for PCBs (congener-specific) so the toxicological and ecological significance of the concentrations in Salem Harbor sediments cannot be assessed without bioaccumulation testing.

PCBs were once used as cooling fluids in transformers and other electrical equipment. Since, 1976, they have been banned from manufacturing and use in the United States due to their potential acute and chronic effect on the environment. But before their discontinuance, PCBs were widely used and their chemical stability, has allowed them to remain in the environment.

Biological Testing

In accordance with the EPA protocol discussed in the above section, Tier III biological-effects testing is required before a suitability determination can be made for all dredging projects (except those that meet MPRSA exclusionary criteria). The Salem PD project is the largest project anticipated within the north shore region, accounting for almost one-third of the total dredge volume for the next 20 years. Therefore, for the purpose of the DMMP, biological testing of these sediments will be conducted in the summer of 1999. A sampling and testing plan has been drafted by the USACE and this appears in Appendix E. The results will be presented in the FEIR. A similar biological testing plan is currently being carried out by the ACE for the main federal channel and south channel maintenance dredging projects.

The testing will consist of the following:

1) Suspended particulate phase bioassays;

This test is used to determine the short-term effect of dredging and disposal on sensitive water column organisms. If significant short-term effects are anticipated, then dredging and disposal management restrictions can be employed to minimize impacts.

2) Solid phase toxicity test;

Over a 10-day period, sensitive marine amphipods are exposed to test sediments to determine the acute toxicity (lethality) of the sediment.

3) Solid phase bioaccumulation test;

Sediment dwelling organisms are exposed to test sediments over a 28-day period to determine acute and chronic effects of the sediment. The tissues of surviving organisms are then analyzed for the chemicals of concern.

The results of the above tests are evaluated in accordance with the procedures in the Green Book. This includes a human and ecological risk is assessment that will be conducted by USEPA.

3.3.2 Sediment Quantity - Suitable versus Unsuitable Volumes

It is important to remember that the determination of the suitability for sediments for ocean disposal is made by the federal agencies. The agencies have stated that biological-effects testing would be required to make such a determination, nevertheless, a reasonable assessment to determine if sediments are suitable for ocean disposal can be made by by comparing sediment chemistry values to various sediment quality guidelines, particularly the MBDS reference levels.

The sediment chemistry data presented in this section for the major dredging projects in Salem Harbor were used to evaluate those specific project areas, but this data is also useful in assessing the suitability of sediments at nearby facilities that have expressed an interest in dredging. Those facilities that are distant from any sampling locations were assessed based on: historic sediment quality data (if any); proximity to pollution sources; and, general oceanographic conditions, i.e. is the site within a high or low energy environment.

Given the sediment chemistry data presented above, it is likely that sediments from the South Channel and PG & E basin would be unsuitable for ocean disposal at MBDS. Also, the surficial sediments (0-2 ft. Or 0-4 ft.) from the Salem PD site could also be unsuitable due to elevated chromium and PAH levels.

Sites within and near the confined South Channel area would likely exhibit similar characteristics as the South Channel sediments, i.e. elevated organics and metals, and, therefore, would likely be unsuitable for ocean disposal.

Maintenance material from areas near the SPD site will likely contain elevated chromium and PAH due to proximity to the U.S. Generator Power Plant and, therefore, would likely be unsuitable for ocean disposal.

Sediments at sites further into the harbor, near Winter Island are likely similar in chemical content to the federal channel sediments, which are generally clean and probably suitable for disposal at MBDS.

Facilities from Palmers Cove south are likely to contain sediments that would be suitable for ocean disposal, given their distance from pollution sources.

Given the assumptions presented above, it is estimated that approximately 239,000 cy of the 815,000 cy of sediment to be dredged from Salem Harbor over the next 20 years would be unsuitable for ocean disposal. For planning purposes a 20% contingency has been added to the unsuitable volume to arrive at a volume of approximately 287,000 cy.

Table 3-3: Dredged Material Volumes (cy) for Salem Harbor for Next 20 Years

Inventory Total	Inventory Total with Contingency[1]	Suitable Dredged Material[2] with Contingency	Unsuitable Dredged Material[3] with Contingency
815,444	978,533	691,200	287,333

[1] Contingency is 20%
[2] Suitable for disposal at MBDS
[3] Not suitable for disposal at MBDS

As part of the dredging inventory, marine users were asked to estimate the timeframe for their anticipated dredging projects. Five-year increments were used as a temporal framework and the results for the unsuitable dredged material volumes are presented in Table 3-4. As shown, the majority of the UDM would be dredged in the first 5 years. These projects include the Salem PD and the federal channel dredging. With the ensuing years, it is thought that the reliability of predicting the dredged material volumes and the actual timeframes for dredging lessens, hence another justification for adding a 20% contingency to the original dredged material volume estimates.

Table 3-4: Twenty Year Dredged Material Volume[1] (cy) Breakdown in 5-Year Increments

Years 1-5	Years 6-10	Years 11-15	Years 16-20	Total
164,933	88,800	9,600	24,000	287,333

[1] Includes 20% contingency

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SECTION 4.0 - ALTERNATIVES ANALYSIS

4.0 ALTERNATIVES ANALYSIS

4.1 Introduction

This section of the Salem Harbor DMMP DEIR presents the alternatives for the disposal of unsuitable dredged material and the comparative environmental impacts between each alternative. Both state and federal laws guide the development of the alternatives analysis contained in this section of the DEIR. The two principal statutes are:

Massachusetts Environmental Policy Act (MEPA), Massachusetts General Laws (MGL) Chapter 30, Sections 61 and 62A-H. MEPA is the environmental review statute of the Commonwealth, and is the law under which this DEIR is being prepared. MEPA provides an opportunity for public review of potential environmental impacts of projects for which state agency actions (e.g., permits, funding, or agency-sponsored projects) are required. Most important, MEPA functions as a vehicle to assist state agencies in using: "... all feasible means to avoid damage to the environment or, to the extent damage to the environment cannot be avoided, to minimize and mitigate damage to the environment to the maximum extent practicable." (MEPA, 1998)

MEPA requires an analysis of "reasonable alternatives and methods to avoid or minimize potential environmental impacts" (301 CMR 11.07(6)) and that all "feasible" alternatives be analyzed in an EIR. Feasible alternatives means those alternatives considered: "... in light of the objectives of the Proponent and the Mission of the any Participating Agency, including relevant statutes, regulations, executive orders and other policy directives, and any applicable Federal, municipal, or regional plan formally adopted by an Agency or any Federal, municipal or regional governmental entity." (301 CMR 11.07(6)(f))

Clean Water Act (CWA), in particular the Section 404(b)(1) guidelines of the US Environmental Protection Agency (Title 40, Code of Federal Regulations (CFR), Part 230) require that "practicable" alternatives to a proposed discharge to "waters of the United States" be considered, including avoiding such discharges, and considering alternative aquatic sites that are potentially less damaging to the aquatic environment. The term "practicable" means "available and capable of being done after taking into consideration cost, existing technology, and logistics in light of overall project purposes."

In consideration of the above, the alternatives for the North Shore DMMP included in this section of the DEIR are those alternatives for the disposal and/or reuse of unsuitable dredged material.

4.2 No Action Alternative

The No Action Alternative for the North Shore DMMP is required to be included in this DEIR under the MEPA Regulations at 301 CMR 11.07(6)(f). The No Action alternative is used to provide a future baseline against which the impact of the Preferred Alternative(s) is (are) measured, compared and contrasted. It is representative of future conditions in Salem Harbor, without the changes or activities that would result from the implementation of the Preferred Alternative(s) for disposal of contaminated dredged material.

The No Action alternative for the North Shore DMMP assumes that no maintenance or improvement dredging activities which require the confined aquatic or upland disposal of a volume of unsuitable dredge material will occur. Existing sedimentation rates in Salem Harbor will continue unabated and the navigation channels will slowly fill in. Dredging projects and activities which have been identified as preferable by the city of Salem in their harbor plan will not occur. More importantly for the Salem Harbor DMMP, no aquatic or upland disposal sites for unsuitable dredged material will be constructed and future environmental impacts which would result from their construction and use would be avoided.

4.3 Description of Disposal Alternatives

4.3.1 Aquatic Disposal Alternatives

The following describes several types of aquatic disposal methods considered for the disposal of dredged material. The primary advantages of open water disposal over other disposal alternatives are the large disposal capacity, relatively short-term environmental impacts, and its low relative cost (Carey et al., 1999).

Confined Aquatic Disposal

Confined aquatic disposal (CAD) is the process where dredged material that is unsuitable for unconfined open-water aquatic disposal is deposited into the marine environment within a confined area, and then covered with suitable material (Figure 4-1). There are basically two methods of constructing a CAD site. Most commonly, CAD sites are created by placing unsuitable material on the seabed, and then covered with clean dredged material which is considered "suitable" for open-water disposal. The overlying layer is commonly referred to as a cap, and has been constructed using both dredged silt and sand. This method has been used in offshore disposal sites in New England (e.g., DAMOS 1994), New York (SAIC 1998), and elsewhere, and requires that sufficient suitable material be available to provide complete coverage of the unsuitable material. In exposed offshore regions in Massachusetts Bay, sites with topography that would enhance potential for confinement were preferred, in water depths of at least 20 meters to maximize protection against storm-driven waves (Section 4.5.1).

The second method of constructing a CAD site is to excavate a confined area, or pit, which then is filled with unsuitable dredged material and capped. In general, these sites can be created in shallower water, but require water depths in excess of 20 feet, to enable placement and capping of dredged material. Two types of CAD pits are presented for possible use:

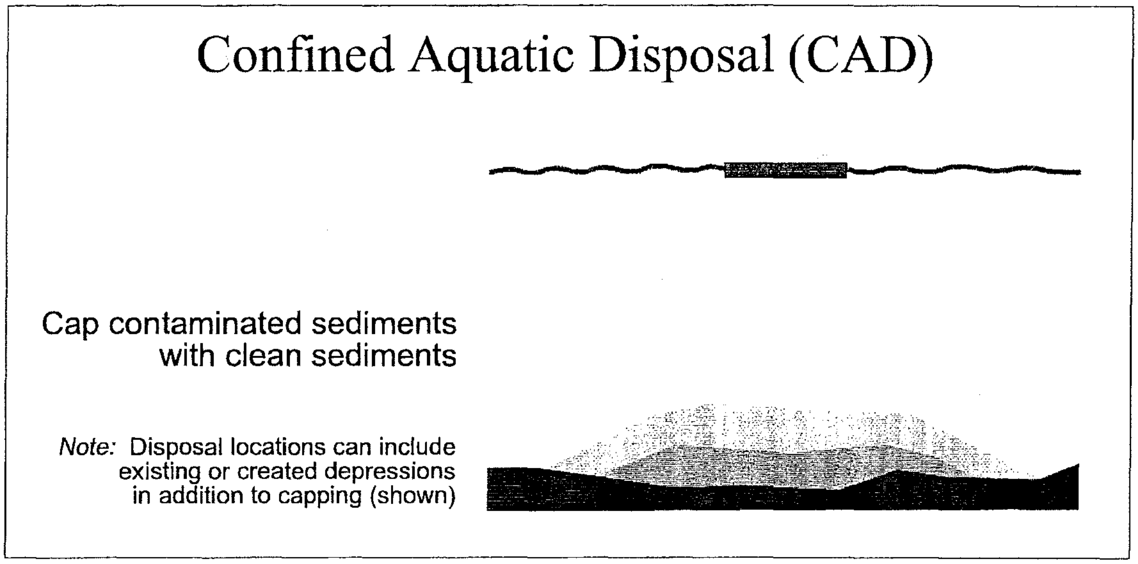


Figure 4-1: Schematic of Confined Aquatic Disposal (CAD) Method

Overdredge (OD) - CAD sites located within an existing channel that are dredged below the proposed navigational depth, then filled with dredged material and capped to proposed navigational depth (Figure 4-2);

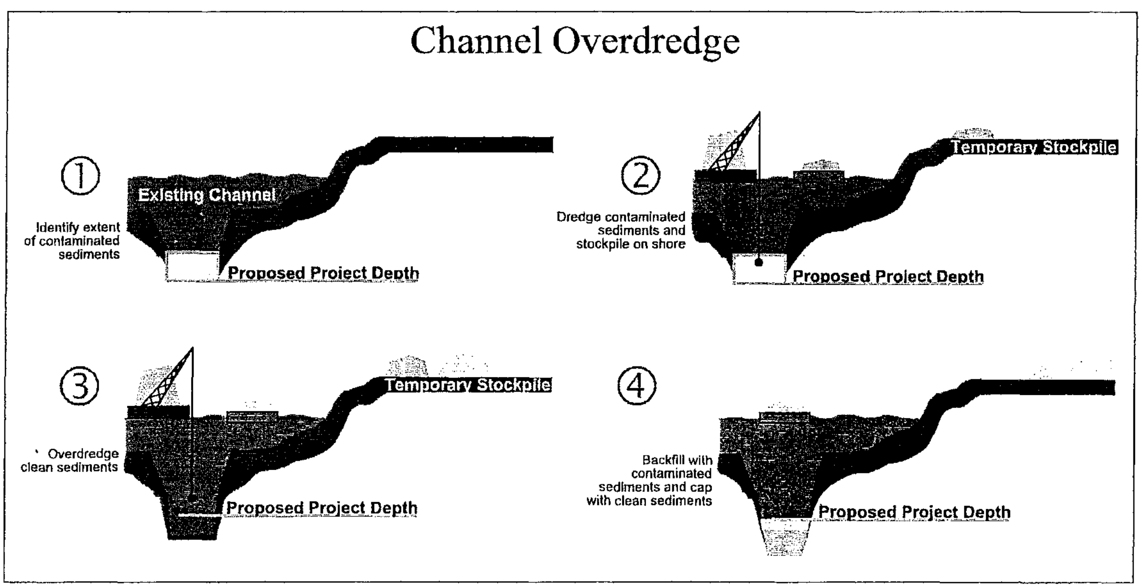


Figure 4-2: Schematic of Channel Overdredge (OD) method

Adjacent-to-Channel (ATC) - CAD sites that are dredged in industrialized areas considered already impacted in harbors near navigational channels.

The **OD** method is presently being employed for the Boston Harbor Navigation Improvement Project (BHNIP).

(BHNIP; NAE and Massport 1995; DAMOS 1999). In this method, the pits are excavated in the channel, and then filled and capped up to or below the existing maintenance depth. If the overlying sediments in the channel are unsuitable, these are first are removed and stockpiled. Dredging then continues into underlying suitable sediments, creating a pit below the designed channel depth. Suitable material is disposed of in an approved offshore disposal site (e.g., the Massachusetts Bay Disposal Site-MBDS). Unsuitable dredged material (including the stockpiled channel cover) is then deposited in the pit and covered with suitable material. In the BHNIP, the cap design was for three feet of sand, although alternative cap material can be considered. The selection of an appropriate cap material is dependent upon the environmental objectives of the CAD design, as well as the geotechnical properties of the sediment to be capped.

The **ATC** method is similar, except that the pits are excavated in areas near, but outside, of the project dredging area. The ATC can be dredged into existing bottom, but is limited only by the existing water depth rather than the maintenance depth of the channel. As with OD sites, if the overlying sediments prove to be unsuitable, the removed material also needs to be stockpiled for eventual deposition into the ATC pit.

The OD and ATC CAD alternatives have the advantages of locating the disposal site near an existing dredged area (the channel), causing only temporary disturbance of the bottom resulting in rapid biological recovery of the sea floor, and disposing of the material in an inner harbor area that is already impacted by human activity. When the OD site is located near to the area being dredged, the additional advantages include (NAE and Massport 1995):

1) confinement of the disposal impacts to areas impacted by dredging,

2) sequestering the material near the point of origin, and

3) compartmentalizing dredging and disposal operations.

Relative to the first type of CAD site in which no pre-dredging is required, the OD and ATC methods have the disadvantages of requiring additional dredging, longer project duration, greater material handling, larger disposal volumes (the material removed to create the pits), and thereby increased costs. In addition, for OD sites, the method precludes future dredging to deeper design depths, so that the project cap design must include a contingency thickness for any future navigational improvement projects. One advantage of the ATC design is that there is no concern that the material will be disturbed by future navigational dredging projects.

Confined Disposal Facility

Unsuitable dredged material may also be disposed in confined disposal facilities (CDFs), illustrated in Figure 4-3. Creation of a CDF requires construction of confinement walls, typically steel sheet pile, or a confinement berm of earth or stone. Stone reinforcement (rip-rap) may be required on the seaward side of confinement walls and berms to protect them from wave action and tidal scouring. An impermeable liner and cap may also be required, depending on the chemical characteristics of the dredged material. The liner and cap may be made of impermeable soils, such as clay, synthetic materials such as high density polyethylene (HDPE), or some combination of these two. Leachate collection, treatment and disposal may be necessary for lined cells during the construction period to control rainwater infiltration until the cap can be placed over the cell.

CDFs have the advantage of isolating the unsuitable material from the environment, while at the same time creating new land which can be put to constructive uses, such as port expansion, development, open space, parkland, or upland wildlife habitat. Alternatively, the CDF can be left as a subaqueous area, creating additional wetlands , as discussed in the section on Tidal Habitat, below. CDFs have the disadvantages of: permanently displacing existing tidal and subtidal habitat; being relatively expensive to construct; and, requiring periodic maintenance to ensure the long-term structural integrity of the CDF.

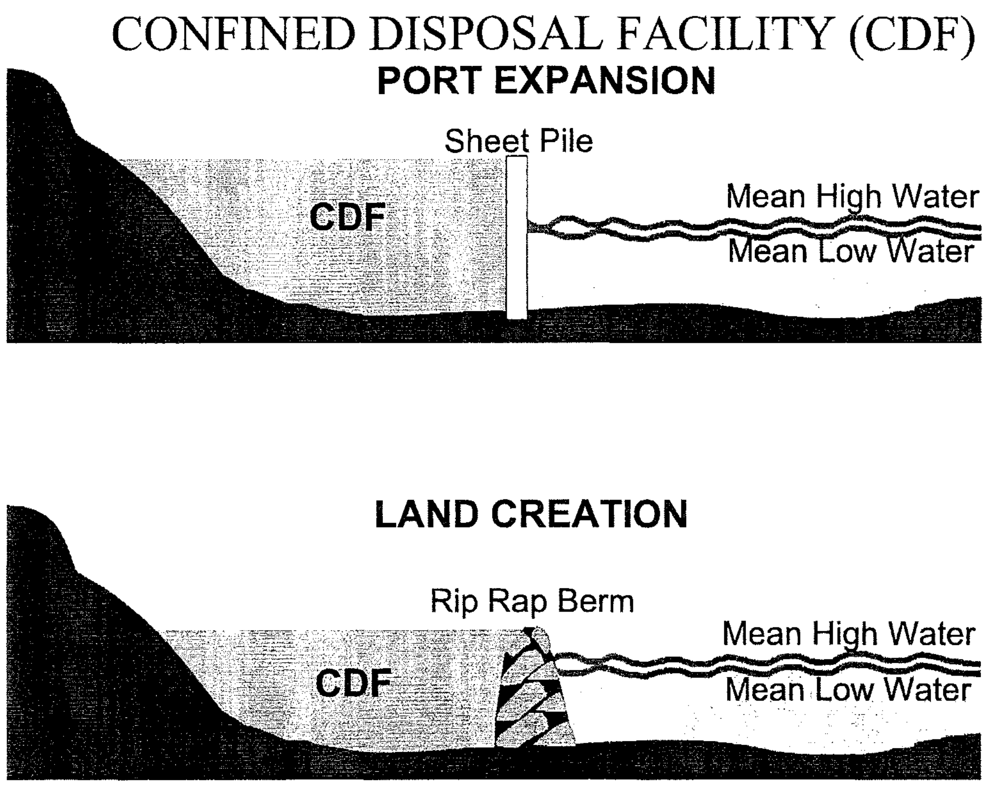


Figure 4-3: Schematic of the Confined Disposal Facility (CDF) Method

Tidal Habitat

A tidal habitat site is a special type of CDF, developed specifically for creation of tidal habitats such as mudflats and coastal wetlands (Figure 4-4). The tidal habitat method requires a cap of material that is chemically and physically able to support biological activity. The tidal habitat method requires creation of an impoundment to retain the dredged material and protect the newly created habitat from scouring currents and wave action. This is typically accomplished by building a berm or breakwater of stone, or of soil armored with stone, up to an elevation above high water. The berm would be penetrated by one or more culverts, enabling sea water to flow through the berm and equalize tide elevations on both sides. The area inside the berm can then be filled with dredged material. The surficial sediments that will be exposed to biological activity must be suitable material to prevent bioaccumulation of contaminants, similar to a CAD cap.

To create an intertidal mudflat, the area is filled to the elevation of mean sea level. This ensures that the surface will be covered with water at high tide and will be exposed at low tide. Tidal mudflats provide habitat for a wide range of invertebrate organisms, which, in turn, are an important source of food for shorebirds. To create tidal wetlands, the area is filled to an elevation that ensures that the surface will be flooded periodically, saturated most of the time, and exposed at low tide. Once the surface has stabilized, it is planted with species such as salt marsh cordgrass (*Spartina alterniflora*), salt meadow cordgrass (*Spartina patens*), and big cordgrass (*Spartina cynosuroides*).

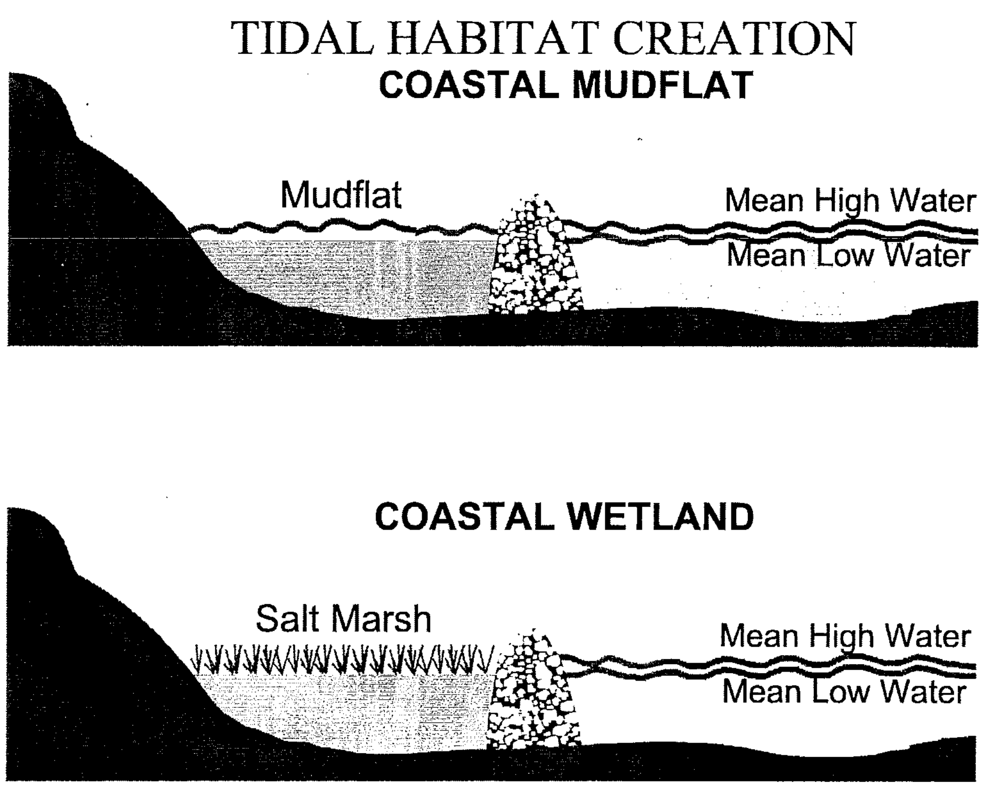


Figure 4-4: Schematic of the Tidal Habitat (TH) creation method.

Tidal habitat alternatives have the advantage of creating additional habitat in, or proximate to, densely developed urban areas. They have the disadvantages of: displacing existing tidal and subtidal habitat; having low capacity relative to the total quantity of material to be dredged; being relatively expensive to construct; and requiring on-going monitoring and maintenance to ensure the integrity of confinement and the success of the created habitats.

4.3.2 Alternative Technologies and Methodologies

Alternative treatment technologies involve the treatment of contaminated sediment, using one or more processes, to allow for reuse of the sediment in a safe manner in the upland environment or for unconfined open water disposal. There are four general types of treatment technologies, categorized based on their effect on the contaminants of concern within the sediment:

1) *Destruction*; the removal of contaminants from the sediment via physical, chemical or biological agents;

2) *Separation*; the process of removing contaminants from the sediment resulting in a concentrated residual of contaminated sediment of significantly smaller volume;

3) *Reduction*; the process of reducing the amount of contaminated dredged material that requires treatment by screening sediments into various particle sizes; and,

4) *Immobilization*; the fixing of contaminants in the dredged material which keeps the contaminants from being released to the environment.

Destructive methods are generally the most complex and expensive forms of treatment. Some of the destructive methods include: incineration, pyrolysis, solvent extraction, thermal desorption and vitrification.

The costs for such technologies range from $161-420/cy (Maguire Group Inc., 1997a).

Separation of contaminants from the sediment can be accomplished by solvent extraction and other techniques. These processes result in a residual material that requires disposal and/or further treatment.

The primary method of reduction used today is soil washing, a process where water is used to separate the sediments by particle size into a reusable bulk fraction, and a smaller fraction containing concentrated contaminants. Because organic contaminants are often sorbed (adhered) to the finer sediment particles such as silts and clays, separation of this fine soil fraction from the coarser, sandy sediments allows for the reuse of the sand and an overall reduction in the volume of unsuitable dredge material.

Immobilization techniques include chelation and solidification/stabilization. Costs for such processes range from $75-$90/cy (Maguire Group Inc., 1997a). Some of these processes, such as solidification/stabilization, can produce a material with sufficient structural bearing strength to allow for use as structural fill in construction projects.

4.3.3 Dewatering Alternatives

In order to implement an upland disposal or alternative treatment option, a shore front site with adequate land area to dewater the dredged material is required. A dewatering site (or sites) is necessary to provide an area to reduce the moisture content of dredged material, allowing it to be processed and transferred to an upland disposal site for final disposal or reuse.

The process to prepare dredged material for final upland disposal or reuse involves the following primary site functions: off-loading; material screening; lime treatment; soil amendment; and transfer to disposal/reuse site.

Off-loading of the dredged material requires that the barge be tied to a pier or seawall along the shore front. Front end loaders or cranes are used to unload the dredged material from the barge and place it on the site or in dump trucks which move the material to a specific location on the site. If the dredged material has a high water content, water tight crane buckets and dump trucks may be required to minimize the uncontrolled discharge of sea water and suspended sediment into the water.

Material screening is often required to screen out large pieces of debris, such as piling fragments, fishing gear, and other debris typically encountered in an urban harbor environment. This material must be removed from the dredged material and disposed of separately.

Lime treatment is often required to reduce the moisture content of the dredged material and to control odors. Dredged sediment with a high organic content has often undergone long term anaerobic decomposition in the marine environment, and anaerobic decomposition (without oxygen) results in a strong, sulfur odor that must be controlled. This also helps reduce the bioavailability of metals. Lime treatment also reduces the moisture content of the dredged material, and results in a material which is easier to handle and spread.

Soil amendment of the dredged material is often required to produce a final product that is suitable for various end uses. Unsuitable dredged material is typically a fine grained, silty material, and mixing or amending of the material with a coarser material such as sand improves the "workability" of the material. DEP has required that any necessary amendment of the dredged material must be performed within the dewatering site, to eliminate the transport of unamended dredged material from the site.

Transport of the dredged material to the final disposal or reuse site is required, and truck transport is the most common method. Water transport via barge or alternative land transport such as trains is also possible, but less common. Space must be available within the dewatering site to allow for the loading of the transport vehicles.

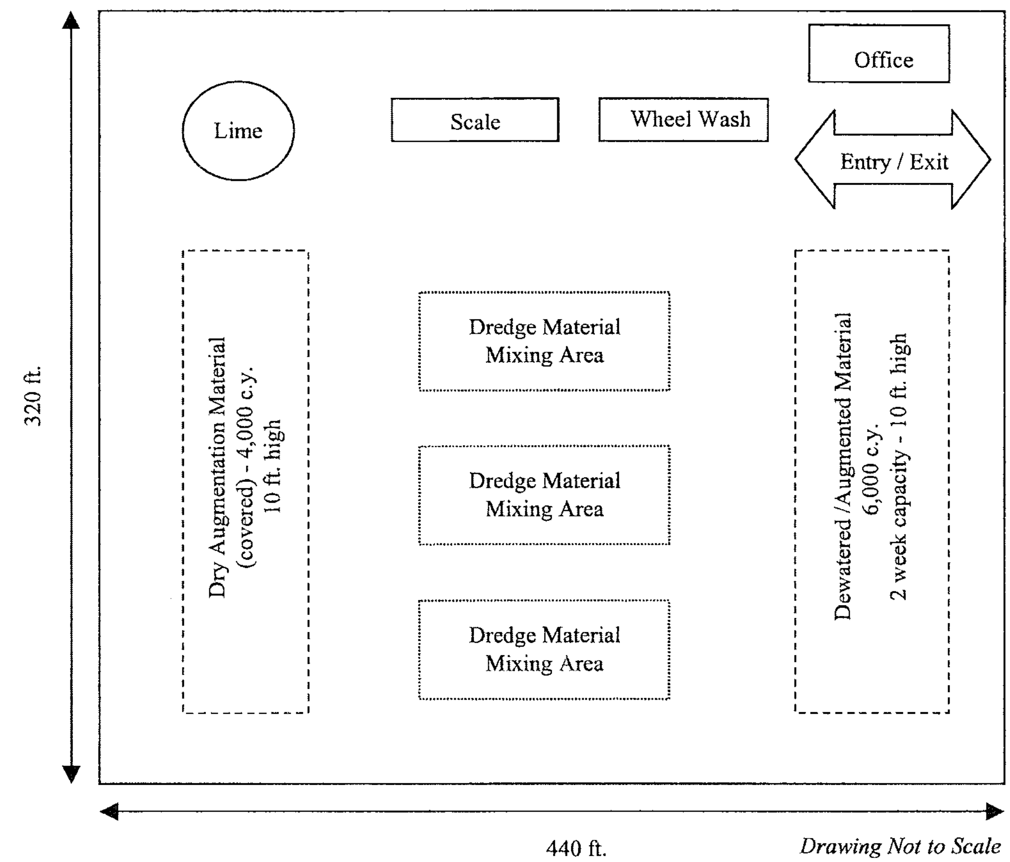
Ideally, the performance of all the above functions to prepare dredged material are conducted at one dewatering site, minimizing the number of times the material is transported and reducing costs.

To determine the minimum site area required for a 10,000 cubic yard (cy) dredging project, site area requirements to process dredged material for upland/reuse disposal including the application of lime to control sulfide reactivity, and to amend the material as per DEP Policy was investigated. Processing the material in this manner helps to reduce the strong odor sometimes associated with dredge material, and increases the ability to handle material, minimizing impacts on surrounding areas and roadways. The typical dewatering site requires adequate area for mixing, lime storage, augmenting material storage, truck scale and wheel wash, and approximately a one week capacity for dewatered material.

Assuming a facility through-put capacity of 400 cy per day, based upon a typical workday (50 cy per hour times 8 hours per day), a 3.2 acre site (approximately 320-feet by 440-feet) is required. Figure 4-5 illustrates a conceptual site layout and requirements for the facility. When mobilization and construction of containment structures (4 weeks), duration of dredging (5 weeks) and restoration of the site (3 weeks) are factored in, the total time required to process 10,000 cy of material is approximately 12 weeks, or 3 months.

The maximum projected volume of unsuitable material to be dredged in Salem Harbor in the first five year planning horizon is 440,000 cy, Assuming 80 percent of the volume of unsuitable dredged material 352,000 cy, is dredged in the five year planning horizon, the 3.2 acre dewatering site could process the material for upland disposal/reuse in 183 weeks (352,000 cy times 5 weeks per 10,000 cy plus 7 weeks mobilization/demobilization). The above numbers represent the best-case scenario, scheduling conflicts and weather delays will extend the processing time. Barring scheduling conflicts and bad weather, the minimum dewatering area of 3.2 acres will satisfy 80% of the volume for upland disposal within the five year planning horizon.

Typical Dewatering Site Layout - Approximately 3.2 Acres



Note:
Augmented material is by product of mixing wet dredged material with a drying agent (quick lime etc.) to create workable material.

Assumptions:
10,000 c.y. to be removed, 50 c.y./hr.dredge production rate, 10 hr. work day, 6 days/week based upon Central Artery Project CO9A8 contract dredge rate using similar augmentation process.

Advantages:
Short schedule
Workable material in short duration

Disadvantages:
Cost of augmenting material to workable consistency
Labor intensive, multiple re-handling.
Smell - hydrogen sulfide escaping material, spray with lime to control odor
Weather dependent.

Figure 4-5: Typical DMMP Dewatering Site Conceptual Layout

By doubling the size of the dewatering facility described above to 6.4 acres, through-put capacity can be doubled to 800 cy per day, increasing the capability to handle the material projected in the five year planning horizon. A dewatering facility of 6.2 acres could handle 80% of the five year volume in approximately one to two years, depending upon the length of dredging season. The larger dewatering site provides greater opportunity to take scheduling conflicts and weather delays into account, greatly increasing the potential to handle 80 % of the material identified within the first five year horizon.

As part of the DMMP DEIR process of exploring potential dewatering site options, the screening process focused on a universe of potential sites to be used for the dewatering process within the municipal boundaries of North Shore communities, from Lynn to Rockport. A total of 118 potential dewatering sites were identified on the North Shore. The sites were identified by examining aerial photographs and a "windshield survey" conducted in 1997, and again in 1999. Through this process, any vacant, open or undeveloped site located adjacent to the shore was identified. Dewatering sites for dredged material require a waterfront location, so that the dredged material may be offloaded from the barge onto the dewatering site.

4.3.4 Upland Reuse Disposal Alternatives

Upland reuse disposal alternatives involve the placement of unsuitable dredged material on land. The site can be an existing active or inactive landfill, or a raw parcel of land. Dredged material can be used as daily cover or final cover for landfills, provided the material meets the physical and chemical specifications for such use. Dredged material placed on a raw parcel of land could be managed as a landfill, or could be used as a grading material that has some end use (e.g. ball fields, golf course, etc.), provided the physical and chemical properties of the dredged material permit such use. There are currently no regulations in Massachusetts which specifically apply to the disposal of dredged material in the upland environment, therefore the disposal of the material is regulated under the Commonwealth's Solid Waste Management Regulations (310 CMR 16.00 and 19.000). Dredged material, when amended with other material such as portland cement, can be used as structural fill in construction projects.

Upland disposal consists of a series of mechanical processes (Figure 4-6). Sediment is dredged from the harbor using a clamshell bucket and placed on scows. The scows are transported to a shoreline area and the sediment is removed from the scows using a front-end loader, backhoe or similar equipment. The sediment is placed in an adjacent area for dewatering (see Section 4.5.3 below). The sediment may require an amendment such as fly ash or lime to control pH and odor. Once the sediment has been amended (if necessary) and dried sufficiently, it is loaded into dump trucks or tractor trailers. The trucks transport the sediment to the ultimate disposal location.

The cost for upland disposal ranges from $117 - $683/cy for silty unsuitable dredged material that is not suitable as final cover for landfills. Clayey sediments that could be used as final cover material would be slightly less expensive to dispose of in a landfill.

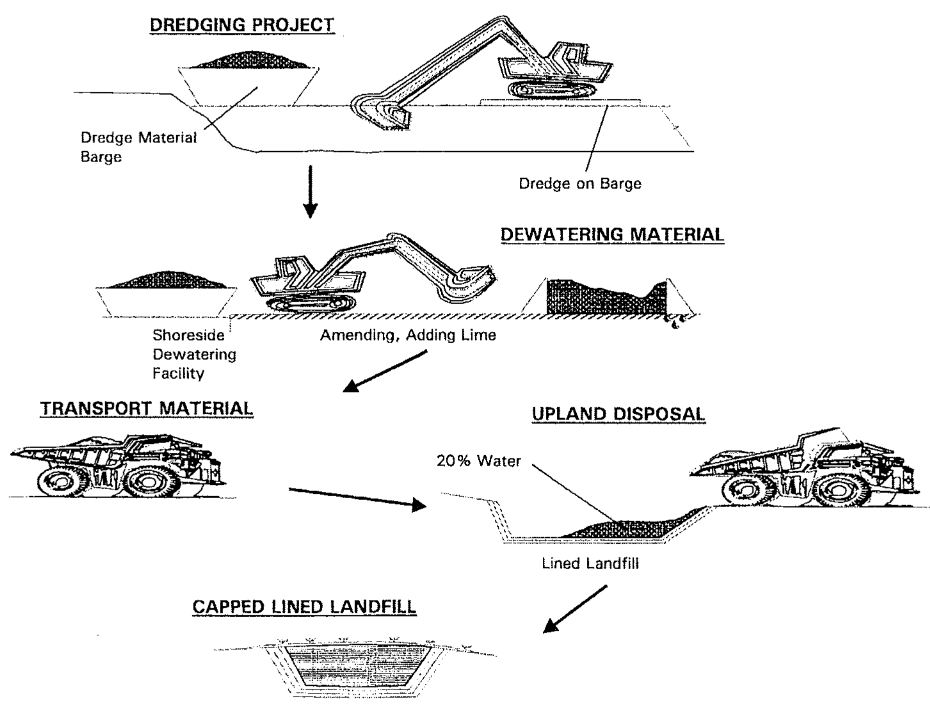


Figure 4-6: Upland Disposal Process

Table 4-1: Disposal Types - General Summary Matrix

Disposal Type	Benefits	Drawbacks	Contaminant Pathways
CDF	Contaminated sediment sequestered from marine environment; creation of new land for port expansion, recreation, commerce, etc..	Permanent loss of subtidal and intertidal habitat; fine sediments may require extensive dewatering time, restricting use of the site for extended period.	Birds and small mammal can be exposed to contaminants in soil and potentially ingest contaminated organisms
CAD - In Channel	Contaminated sediment sequestered from marine environment; impact occurs within already disturbed area; relatively low cost	Technology of capping not perfected; limits potential future dredging depths; short-term water quality impacts; permanent change to bathymetry of disposal site	Suspended particulate matter released during disposal can affect water column larvae
ATC-CAD	Contaminated sediment sequestered from marine environment; relatively low cost; close to channel dredging areas	Technology of capping not perfected; ATC areas may not be degraded, therefore high value bottom habitat can be impacted; short-term water quality impacts	Suspended particulate matter released during disposal can affect water column larvae; potential change in substrate type.
CAD	Contaminated sediment sequestered from marine environment; relatively low cost;	Technology of capping not perfected; CAD areas may not be degraded, therefore bottom habitat can be impacted; short-term water quality impacts; large volume of capping material required to cover mound	Suspended particulate matter released during disposal can affect water column larvae; potential change in substrate type.
TH	Creation of salt marsh or tidal flats beneficial to water quality and wildlife.	Contaminated sediments cannot be used for habitat creation because of potential bioaccumulation of contaminants.	Benthic organism and plants living in contaminated sediments can transfer pollutants up food chain.
Upland	Removal of contaminants from marine environment into a well engineered and monitored situation.	Large dewatering area required; air quality, noise, traffic impacts; high cost; future use of disposal site permanently affected due to classification of material as solid waste	Potential groundwater contamination from leachate; air quality impacts from fugitive dust and odor

4.4 Disposal Site Screening Process

To avoid the unnecessary expenditure of resources on conducting detailed evaluations of sites unlikely to be used as disposal sites, a listing of candidate disposal sites was developed during Phases I and II of the DMMP, including sites recommended by local harbor dredging committees. This universe of candidate disposal sites were evaluated in a tiered process. A result of this process is a list of potential disposal sites representing a range of practicable and reasonable disposal site alternatives. Selected sites on this list are evaluated in detail in this DEIR.

The end result of this process is the selection of a preferred alternative or alternatives to be developed fully in the Final EIR (FEIR). The types of disposal sites and methods identified through this process include: Adjacent to Channel (ATC), Channel Over Dredging, Confined Aquatic Disposal (CAD), Capping (CAP), Confined Disposal Facility (CDF) for land creation, Tidal Habitat Creation (mudflat or marsh), and Upland (reuse or disposal), and alternative treatment technologies.

The disposal site screening criteria described in this DEIR were developed independently, based on published federal and Massachusetts disposal siting criteria and conforming with the Providence River and Harbor Maintenance Dredging Project Draft Environmental Impact Statement (USACE, 1998). The evaluation factors used in the Providence River DEIS were reviewed by the US Environmental Protection Agency (USEPA), US Fish and Wildlife Service (USFWS), and National Marine Fisheries Service (NMFS) and Massachusetts regulatory agencies to obtain their concurrence with the criteria that would be the basis for disposal site decisions.

The disposal site screening process includes four categories of evaluation criteria: criteria for all sites, criteria for aquatic disposal sites, criteria for upland disposal sites, and criteria for beneficial use disposal sites. Rather than grouping them with aquatic disposal sites, separate criteria were developed for beneficial use sites, because these alternatives provide a net improvement in habitat, or potential land creation. For example, a beneficial use site including the alteration of salt marsh should not automatically be excluded because potential opportunities for the creation of additional salt marsh at the site may exist. Upland beneficial uses were evaluated using the upland evaluation criteria.

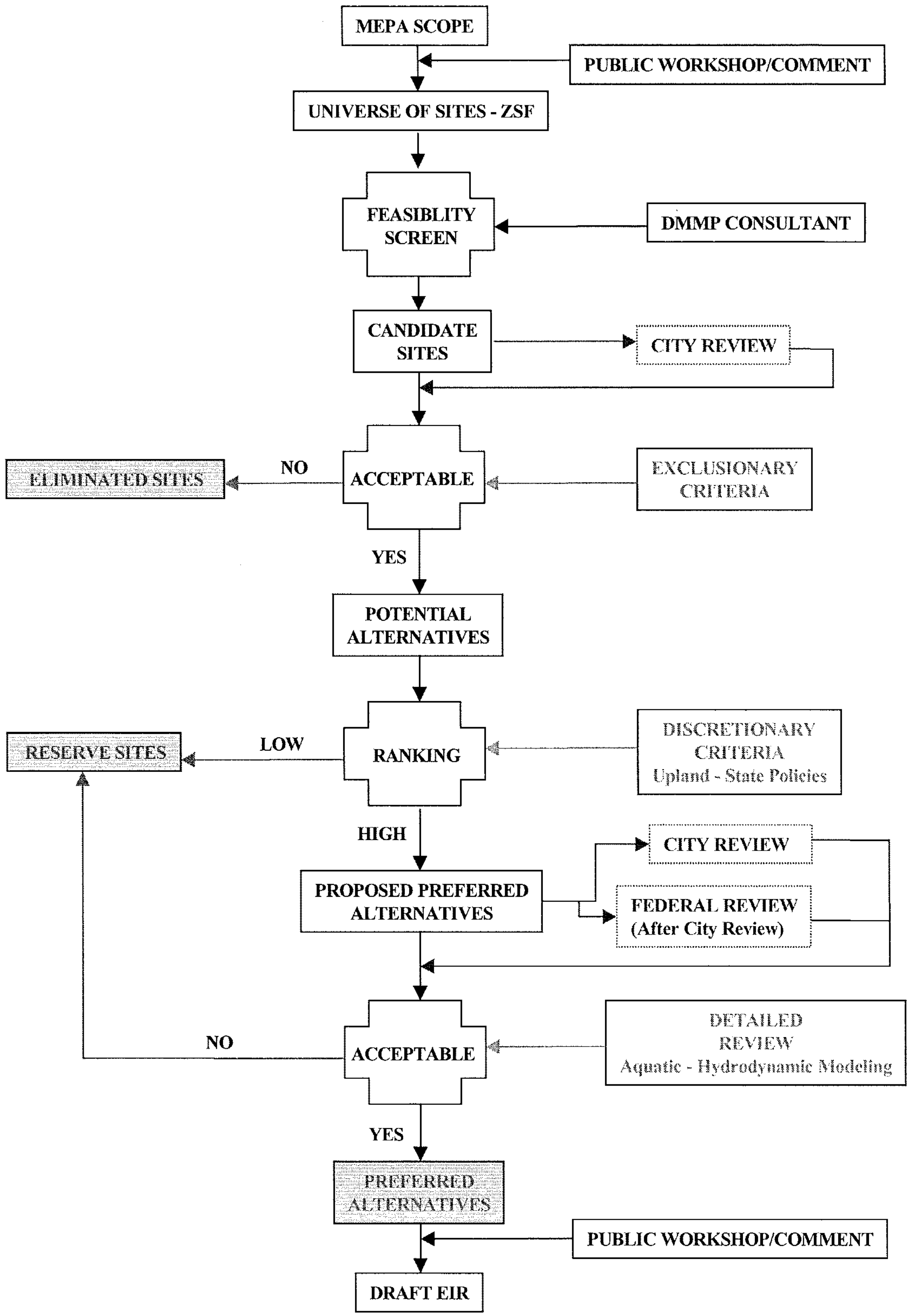
The screening criteria were applied in phases to each of the three disposal site option groups (i.e., aquatic, upland, and beneficial use). The first phase of the screening process is to eliminate sites that are clearly a poor choice for disposal of dredged material because of the surrounding land uses (for upland sites), or because they were not reasonably accessible for the type of disposal proposed, or could not contain a sufficient volume of material. Sites that are not feasible disposal options are permanently eliminated from further consideration from the DMMP.

Sites subject to the full screening process were screened into the following three groups:

1. ***Proposed*** - sites proposed for detailed evaluation in the EIR
2. ***Excluded*** - sites that appear to have significant constraints which suggest that they would not be selected for disposal and are presently excluded from further evaluation
3. ***Eliminated*** - sites that are eliminated from further evaluation

Excluded sites (group 2) could be reconsidered if information generated during the detailed evaluations suggests that they would be better disposal sites than those being evaluated in detail. Sites in Group 1 proposed for detailed evaluation ultimately may or may not be selected as a Preferred Alternative, depending on the results of the detailed evaluations.

Through an interactive workshop series with the local dredging subcommittee in Salem, candidate disposal sites deemed unfavorable to the local community were eliminated from consideration. The workshop series covered the following topics: environmental effects of dredging and disposal technology, regulations



DMMP Disposal Site Screening Process

governing dredged material disposal and reuse, siting criteria and the process for dredged material disposal, level of contamination/sediment quality in the harbor, and the screening of potential disposal sites. Public participation in the workshop series played an integral role in the candidate disposal site screening process.

At the conclusion of the workshop series, carrying forward candidate disposal sites identified through the public process, final site screening was conducted by assembling the interdisciplinary consulting team to review the database information generated for the remaining specific sites. Sites with clearly significant constraints were excluded from detailed study. The Screening of Disposal Alternatives section of the DEIR summarizes the rationale for eliminating specific sites.

The description of the disposal site screening criteria is divided into three sections based on the type of disposal alternative. These sections describe the procedures and results of aquatic, upland and beneficial use disposal site screening. Section 4.5 also contains an assessment of alternative technologies and dewatering site selection process. A chart illustrating the screening process can be found in Figure 4-__.

4.5 Initial Screening of Candidate Disposal Types

Section 4.5 describes: the initial screening process for exclusionary criteria for all disposal options, alternative technology and dewatering sites; the screening process for each, site or option; screening factors; screening results; and the identification of Practicable Alternatives. The Practicable Alternatives developed in this section will be subjected to the detailed screening process by applying discretionary criteria for aquatic sites in Section 4.6, and for upland sites in Section 4.7.

4.5.1 Aquatic Disposal Site Screening

Screening Process

A multi-step siting process was used to identify and screen potential disposal options for dredged material from Salem Harbor. The first stage of the siting process was to refine the range of disposal options by delineating a Zone of Siting Feasibility (ZSF) for Salem Harbor (Figure 4-8). A universe of disposal sites was evaluated in the ZSF, and then narrowed to provide a variety of candidate sites (Figure 4-9) for Salem. The candidate sites were further screened for exclusionary criteria (regulatory criteria that would prohibit a site from being located at a particular place) and additional City review to provide a list of potential alternative sites. These sites were then evaluated for discretionary criteria through a detailed screening process to reach a list of potential alternatives (Figure 4-8). There were no sites eliminated based upon the exclusionary criteria, therefore all candidate sites were considered as potential. The results of this detailed screen are presented in Section 4.6.

Zone of Siting Feasibility

The aquatic ZSF for Salem was defined based on reasonable transit distances from the dredging projects, local jurisdictional boundaries, and evaluation of restricted use areas such as marine sanctuaries. A separate ZSF was delineated for upland sites, as described in Section 4.5.4. Based on the transit distance criteria, the ZSFs were defined by an arc extending 10 nautical miles (nm) from each harbor entrance. Ten nm represented a reasonable distance to permit two round trips for a disposal barge towed at less than 5 knots within a 12-hour period. In addition, the zone south of 10 nm has been extensively screened as a result of the Boston Harbor Navigation Improvement Project (NAE and Massport 1995). The ZSFs also were restricted to the east by the limits of the baseline of the territorial sea based on state jurisdiction and the regulatory oversight of Section 404 of the Clean Water Act (40 CFR Part 230.2[b]). Finally, the ZSFs were also limited to the south by the exclusion of the near-field monitoring area of the Massachusetts Water Resources Authority Deer Island Wastewater Treatment Plant outfall diffuser field.

The ZSF, together with the city boundary for Salem, provided a baseline area over which to continue the search for appropriate disposal sites. The city boundary is provided on Figure 4-7, because of the potential desire by the city of Salem to locate a local disposal site within its jurisdiction.

Preliminary Physical Screening

The second step consisted of preliminary screening of a universe of disposal options within the ZSFs on the basis of physical criteria including size (capacity), water depth, confinement potential, location relative to the areas to be dredged, and navigational restrictions. Maps prepared by the US Geological Survey (7.5 minute topographic quadrangle mapping at 1:24,000 and 1:25,000 scale) and navigation charts prepared by the National Oceanic and Atmospheric Administration (NOAA) of the Department of Commerce (at a variety of scales) were used to identify possible disposal sites. These maps were inspected and all locations within the study area that appeared to be capable of accommodating all or part of the dredged material for each community were marked on them. In addition, previous studies conducted for dredged material disposal were consulted. Other preliminary physical screening for near shore sites (CDFs, Section 4.5.2.1) included media quality, drift patterns, accessibility, use and ownership characteristics, and proximity to water supply sources. Sites that were evaluated as part of those studies, if not identified by the map screening, were added to the universe of potential sites.

Physical Stability/CAD Confinement Potential

In the third stage, the ZSF was evaluated in the context of the sedimentary environments of the area and the physical characteristics of the open-water (CAD) disposal sites. Sedimentary environments, which are based on both the physical characteristics of the substrate and the long-term physical dynamics of the area, were classified into the following three categories: erosional or non-depositional areas; depositional environments; and transitional sediment reworking areas (Knebel and Circé 1995). The results of this analysis allowed identification of candidate sites that had the physical characteristics necessary to ensure confinement and stability of a dredged material deposit.

Following the selection of the candidate disposal sites, illustrated in Figure 4-9, any selected sites that were located in exclusion zones (marine sanctuaries, areas of critical environmental concern, etc.) were removed from the list of candidate sites. The remaining disposal sites after this analysis were the final list of potential alternative disposal sites (Section 4.5.2.3). The results of this preliminary analysis identified those potential alternative sites which are physically capable of accommodating dredged material and which have the least impact on environmentally sensitive areas. Further screening evaluating environmental factors such as the presence of threatened and endangered species, finfish and shellfish habitat, benthic organisms, wetlands and floodplains, and historic and archeological sites, was conducted on these candidate sites (Section 4.6).

Screening Factors

The following briefly describes the physical criteria that were used for the preliminary screening of candidate disposal sites in Salem Harbor. Results of detailed screening, including evaluation of the potential disposal sites using discretionary criteria, is provided in Section 4.6.

Site Capacity

Site capacity was an important consideration in site evaluation as it will determine whether one or multiple sites would be necessary to confine the material requiring dredging (Maguire Group Inc., 1997a). Capacities were evaluated using a range of potential disposal needs, including unsuitable dredged material from Salem Harbor. There were two interdependent elements of site capacity: area and dredged material thickness. For example, 400,000 cy of dredged material would cover 400 acres to 1 foot in depth; 40 acres to 10 feet of depth; or 20 acres to 20 feet of depth. Given the anticipated volumes of dredged material, the use of dredged material for creation of land, wetland, or tidal mudflat would be most practical at water depths of less than 20 feet mean low water (MLW). Bottom disposal in the relatively exposed Massachusetts Bay coastline outside of harbors would typically require depths greater than 20 meters for maximum protection against storm-driven waves.

Site Location

Evaluation of disposal alternatives required consideration of not only the physical and chemical characteristics of alternative sites, but also the location of sites relative to dredging areas. In general, sites closer to dredging were preferred over sites further away to minimize transportation costs. In addition, location of the sites were further considered in the next screening phase, because locating disposal sites near the dredging area is environmentally advantageous (Section 4.6). All sites located within the Salem ZSF remained in the list of potential alternative sites. Finally, the potential for reuse of filled land (CDFs) was considered to evaluate the possible economic and environmental benefits of land creation. Sites that were considered suitable for creation of land consistent with the Salem Harbor plan was preferred. Where land creation was not part of disposal alternatives, sites considered suitable for wetland creation and creation of intertidal habitat were preferred.

Confinement Potential

Approximately one-third of the dredged material from the harbor is considered unsuitable for unconfined open water disposal due to its physical or chemical characteristics. The following confinement characteristics were considered in evaluating the confinement potential of alternative sites:

- *Topography* - Partial confinement may be provided by topographic features such as slopes, ridges and borrow areas. Partial confinement can be provided by placing dredged material against slopes or ridges and by filling in borrow areas, reducing and minimizing capping and cover costs. Offshore CAD sites with topography that facilitates confinement were selected using bathymetric information.

- *Sedimentary Environments* - Sedimentary environments, which are based on both the physical characteristics of the substrate and the long-term physical dynamics of the area, were classified into the following three categories: erosional or non-depositional areas, depositional environments, and transitional sediment reworking areas (Knebel and Circé 1995). Depositional areas were preferred for disposal site locations. In depositional areas, fine-grained sediments accumulate and tend to be stable for long periods of time. Disposal sites located in these areas should effectively contain dredged material in properly designed facilities. In contrast, boulders, outcrops, and coarse-grained sediments have been detected in erosional or non-depositional areas. These erosional forces, due to a combined action of tidal currents and waves, may transport sediment away from disposal sites. Insuring the confinement of sediments over time is difficult in turbulent environments, therefore sites located in erosional or non-depositional areas were rejected. In areas classified as transitional or reworking areas, the sediments ranged from gravel to sand to mud (silt/clay) and have characteristics similar to both erosional and depositional environments. These areas will need further evaluation to determine their suitability as confinement sites.

- *Maintenance* - Certain types of confinement structures require more maintenance than others. Sheet pile bulkheads, for example, may need more frequent repair or replacement than rip-rap slopes. Therefore, the types of confinement suitable for each site was considered with an overall goal of minimizing the need for maintenance of confinement structures at selected sites.

- *Monitoring* - Inspection and monitoring will be required at all selected sites. To minimize costs, sites should be selected to minimize the need for confinement monitoring and inspection, and to facilitate monitoring.

- *Risk of Failure* - The probability of confinement failure can be minimized through proper design, maintenance, and inspection, but it cannot be eliminated. Therefore, the consequences of confinement failure were considered at each alternative site. Sites with more reliable confinement opportunities, and fewer adverse consequences of confinement failure were preferred.

Quality Characteristics

The physical and chemical characteristics of water, sediment, and land at alternative sites, as indicated by the results of the DMMP Phase I Due Diligence Review (Maguire Group Inc., 1997a), were also considered during the site evaluation process. Factors considered as quality criteria include the following:

- *Physical/chemical characteristics of water* - Water quality at, and in the immediate vicinity of, disposal sites was considered. In general, sites with lower water quality were preferred over "pristine" waters. The exception was the selection of sites in offshore Massachusetts Bay.

- *Water quality classification* - The state quality classification for waters at disposal locations was also considered. In general, lower classifications were present in the inner harbors of Salem, but the offshore sites were retained for their other physical characteristics.

Use and Ownership Characteristics

For sites in nearshore areas and dewatering areas, property ownership and land use was considered in evaluating disposal alternatives. This included consideration of current ownership of the site as well as ownership patterns of adjoining and nearby properties. In general, sites with fewer owners were preferred over sites with many owners in order to minimize the number of affected owners. Publicly owned property also was preferred. Candidate sites were not considered in conservation areas or property in ownership by such conservation organizations as the Sierra Club, Audubon Society, Nature Conservancy, etc. Historic sites were excluded. An effort was made to minimize impacts on active agricultural land and agricultural soils subject to protection by the Farmland Protection Policy Act, 7 USC 4201; 43 CFR Title 7, Part 657, 548-551 and related state and local statutes.

Surrounding land use and zoning was evaluated using data provided by the Massachusetts Geographic Information System (MASSGIS) office. Land use and zoning should be compatible with disposal use. Sites which are well buffered from residential areas and which minimize impacts on residential areas were preferred. Therefore, sites abutted by industrial/commercial uses or vacant land were preferred over sites in residential areas.

Environmental Characteristics

Evaluation of siting alternatives also needed to take into account a variety of environmental criteria that are mandated by State or Federal laws, regulations, and policies. These criteria were used for preliminary evaluation of the data only, and were not used to exclude any sites except where mandated (exclusionary zones such as ACECs). The proposed alternative sites were further screened for these environmental characteristics (Section 4.6).

- *Threatened and Endangered Species* - In accordance with the U.S. Endangered Species Act (16 USC 1531), sites were evaluated for critical habitat, presence, or use by threatened and endangered species. This was accomplished through contact with the Massachusetts Natural Heritage Program, the US Fish and Wildlife Service (Fish & Wildlife Coordination Act, 16 USC 661-661c et. seq.), and the National Marine Fisheries Service.

- *Finfish Habitat* - Impacts of disposal alternatives on finfish could range from temporary displacement during disposal operations to chemical effects on eggs, larvae or mature fish.

- *Shellfish Habitat* - In accordance with the stated purpose of 310 CMR 10.01(2), for the "protection of land confining shellfish," the potential impact of disposal on shellfish habitat was evaluated at the sites.

- *Benthic Macroflora* - Benthic macroflora (e.g., eelgrass beds) of the potential alternative sites was investigated, within the limits of available information, to characterize biological impacts of alternatives.

- *Benthic Macrofauna* - Benthic macrofauna data, when available, was evaluated to characterize biological impacts. In general, sites with lower diversity and abundance of benthic macrofauna were preferred over sites with higher diversity and abundance, and sites which increase, or at least do not decrease, available intertidal habitat were preferred.

- *Wetlands* - In accordance with the requirements of the Massachusetts Wetlands Protection Act (M.G.L. Chapter 131, Section 40) and the implementing regulations at 310 CMR 10.00, wetlands in the vicinity of each site were evaluated. Sites that avoid alteration of wetlands and minimize the amount of Bordering Vegetated Wetland, Coastal Beach, or Coastal Bank affected by disposal alternatives were preferred.

- *ACECs* - The vicinity of each site was checked for areas designated by the Secretary of the Executive Office of Environmental Affairs as Areas of Critical Environmental Concern (ACECs) in accordance with the provisions of 301 CMR 12.00. Sites within close proximity to ACECs were excluded from disposal site consideration.

- *Historic and Archaeological Sites* - As required by M.G.L. Chapter 40C; 950 CMR 70 et seq. and by the National Historic Preservation Act (16 USC 470; 36 CFR 61.1 et seq.) sites were evaluated for resources listed on or eligible for listing on the National List of Historic Places. Sites without impacts on historical or archaeological resources were preferred.

- *Marine Sanctuaries* - Sites were also checked for marine sanctuaries, refuges, and national seashores. Areas within the sanctuaries were excluded from consideration for location of disposal sites.

- *Flood plains* - Flood plains in the vicinity of each site were determined from Federal Emergency

Management Agency (FEMA) National Flood Insurance Program mapping. Locations which are outside of the 100 year flood zone, locations outside of velocity zones, and locations which do not decrease flood storage, do not increase the duration or frequency of flooding, and do not increase the potential for flood damage were preferred.

Screening Results

Twenty-six candidate sites in the Salem ZSF, were remaining after the analyses discussed above. Only two sites (offshore CAD sites) were located in the Salem ZSF (Figure 4-10). These two CAD sites were located south of Marblehead (S12-CAD, S13-CAD). The screening results will be presented for each different type of site: the offshore CAD sites, the inshore CAD sites, and the inshore CDF sites. The location of the inner harbor sites relative to the municipal boundaries of Salem are also is shown in this figure.

The physical characteristics of these sites are summarized in Tables 4-2 and 4-3. Detailed screening information was collected for each of the potential alternative sites in preparation for the final selection of preferred alternatives, as discussed in Section 4.6. In the presentation of the potential alternative sites below, estimated capacities for the sites are provided for further discussion. The capacities were calculated in different ways, dependent upon the type of site, and a discussion of how these capacities were selected is included in the sections below.

Potential Alternatives

The following potential alternative sites for Salem Harbor were selected based on the initial screening of candidate disposal sites described in Section 4.5.2.1 through 4.5.2.3 (Tables 4-1 through 4-3). Of the 24 potential alternative sites located in the Salem ZSF, six were CDF sites (two potential tidal habitat sites), and 18 were CAD sites, including three OD, three ATC, three inshore and nine offshore CADs (Figures 4-9).

Offshore CAD Sites

Capacities of the offshore CAD sites were calculated based upon the area of the site (**Figure 3-**) and an assumed dredged material thickness of 20 feet (including 3 feet of cap). The thickness of the dredged material is ultimately dependent on the configuration of the offshore site; typically an offshore CAD site is a mounded feature, with thicker material in the center thinning out to a surrounding apron. The assumption of a 3 feet cap is included in all the CAD capacity calculations for purposes of capacity estimations only. The actual cap design (thickness and type of material) is discussed further based upon the selected preferred alternative(s).

The two offshore CAD sites located only in the Salem ZSF (S12-CAD, S13-CAD) had fairly long transit distances from Salem Harbor (7-10 miles), with water depths ranging from 80-100 feet, and capacities ranging from 2.4 to 3.2 million cy (**Table 4-1**). Although in the Salem ZSF, these site were outside of the Salem municipal boundaries.

The nine offshore CAD sites located within the Salem ZSF had overall the largest capacities and deepest water depths (greater than 150 feet). Sites SG8-CAD and SG9-CAD had the largest potential capacity (8 to 9 million cy), with water depth ranging from 100-177 feet (**Table 4-2**). The offshore CAD sites located in the Salem ZSF also had the longest transit distances from Salem Harbors, ranging from 5 to 11 miles.

Inshore CAD Sites

Several potential inner harbor CAD sites were identified in both Salem Harbor. These included the overdredge (OD) and the adjacent-to-channel (ATC) sites in the harbor (Figures 4-10 and 4-11). Construction of these CAD type sites require dredging into the basement sediments to create a confining disposal site, thus the capacities of these sites are dependent upon the ability to dredge below the existing depth. However, deep excavation in New England is typically restricted by the presence of shallow bedrock (outcrops along the coast). Dredging beyond the bedrock would require blasting to penetrate the material which is both prohibitively expensive and environmentally problematic. Therefore, an acoustic subbottom survey was conducted in each harbor to further refine the potential capacities of these inner harbor CAD sites (Maguire Group 1999). From the subbottom survey, sub-sites for the OD and ATC sites were selected based upon the apparent presence of bedrock. The location and capacities of these subsites are discussed below.

OD Sites - Dredged material disposal within the harbors could be accomplished by overdredging bottom sediments in the existing channel. Three possible OD sites were included in the potential alternative sites, one in the main Salem channel (S6-CAD/OD), one in the southern Salem channel (S7-CAD/OD; Figure 4-10). The main Salem channel OD site had a relatively large capacity (approximately 4 million cy; Table 4-2) capable of handling all of the Salem harbor or regional dredged material.

ATC Sites - The three ATC sites (S14-ATC, S15-ATC, and G3-ATC) had estimated capacities ranging from 2 to 10 million cy in Salem Harbor.

Other Inshore CAD Sites

Several CAD sites were selected in Salem Harbor which were beyond the navigational channel. Sites S-18, S-19, and S-16 CAD's were selected based on the same design premise of the OD and ATC sites to confine uncontaminated dredged material. That is to excavate a pit in the sea floor or dispose of dredged material in a natural topographic depression and then cap with suitable material. These sites were intended to support the Salem Harbor Plan by increasing existing recreational boating mooring space. Of the three sites, S-18, located in Collins Cove, has the largest capacity and S-19 the smallest (S18 = 3,489,000 cy; S-16 = 517,760 cy; S-19 = 267,000 cy).

Inshore CDF Sites

The six CDF sites were located within Salem Harbor (Figure 4-10) at Collins Cove (S1-CDF), Cat Cove (S2-CDF), City Wharf (S3-CDF), Misery Island (tidal habitat; SG4-TH/CDF), and Eagle Island (tidal habitat; SG5-TH/CDF). Of the CDFs, the two tidal habitat sites had the largest capacity (approximately 4.5 to 5.0 million cy; Table 4-2). The capacities of the other four CDFs ranged from 47,000 to 469,000 cy (Tables 4-2 and 4-3). Confined disposal facilities therefore may be used to address part of the disposal needs for Salem Harbor, but multiple CDFs, or CDFs in conjunction with another disposal alternative, would be necessary to provide a complete disposal solution for the Harbor.

Cells

Smaller sub-areas were selected for capacity calculations within Salem Harbor due to the large variability in depth to bedrock at the potential disposal sites. These cells were selected based on visual evaluation of areas that had consistently deep values of depth to basement as determined from the subbottom seismic profiling. The area of each cell was configured to maximize capacity while minimizing disturbance to surrounding environmental resources. The calculation of capacity was conducted using GIS software to measure the depth to basement (or cell bottom) in each of the cells.

First, the maximum capacity was calculated over the entire CAD site using a simple volumetric calculation, multiplying the gridded area of the basement (average depth) over the area of site. Average depth was corrected to include 3 feet of cap material, 2 feet of potential over-dredge, and the channel contingency depth for channel sites. This contingency depth of the channel 32 feet for Salem Harbor. Because this initial calculation assumes an unreasonable 1:1 side-slope (straight walls excavated over the area of the pit), volumes are recalculated using the same area but with a side-slope of 3H:1V.

Based on information gathered during the subbottom survey, three subcells were delineated in Salem Harbor. Separate design configurations were constructed for each subcell to optimize capacities for local and regional dredged material disposal scenarios. These engineering designs maximized the capacity of each subcell to address differences in disposal volumes for local vs. regional material. Two of these cells, S6-Extension and S15-ATC-1, were adjacent to channel CAD and one, S6-CAD/OD-1, was a channel overdredge CAD (Figure 4-12). SA-15-ATC-1 has sufficient capacity for all regional material, as does the combination of S6-Ext. and S6-CAD/OD-1 configured for Salem volumes (**Table 4-4**).

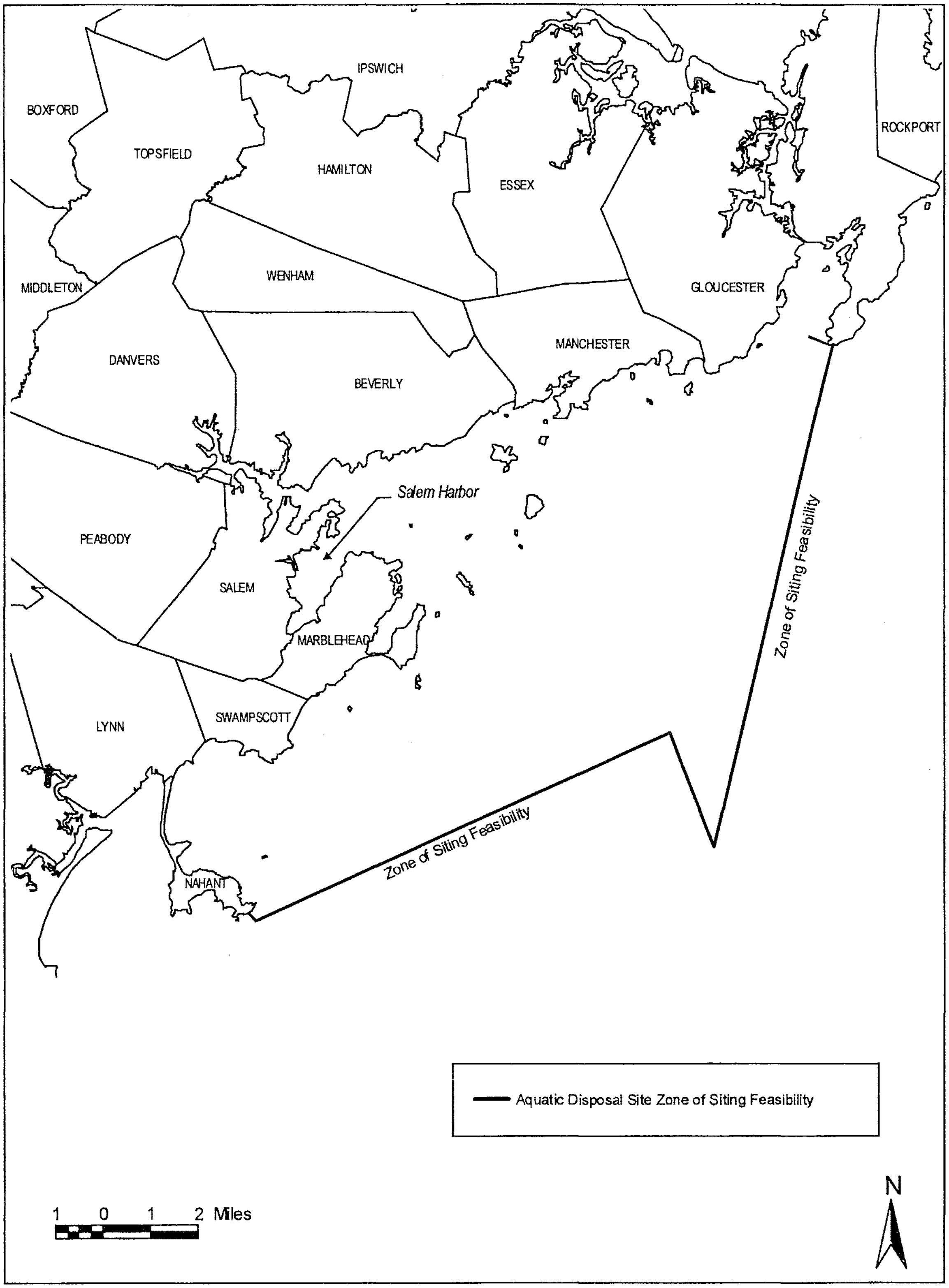


Figure 4-7: Salem Aquatic Zone of Siting Feasibility

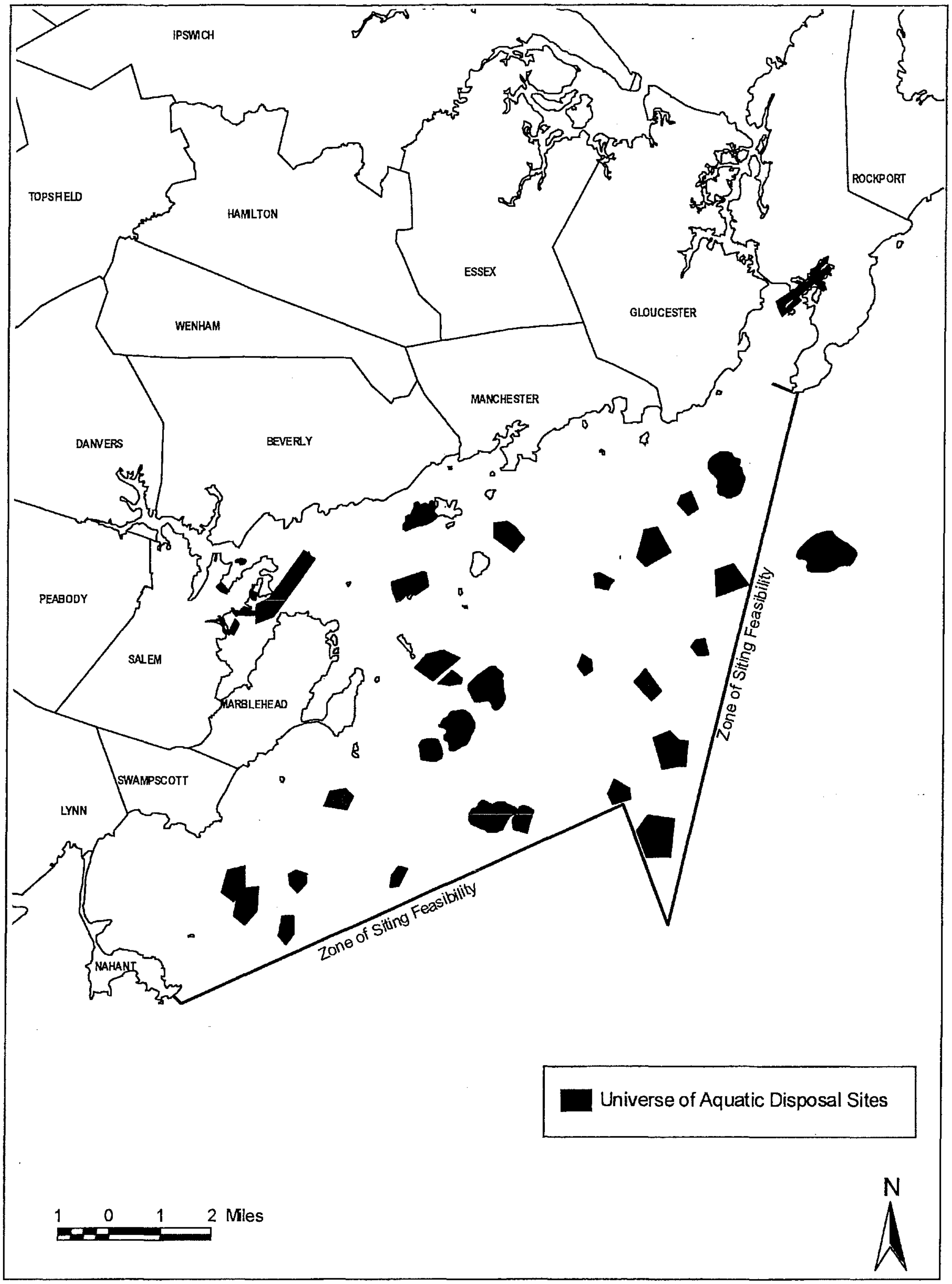


Figure 4-8: Salem Universe of Aquatic Disposal Sites

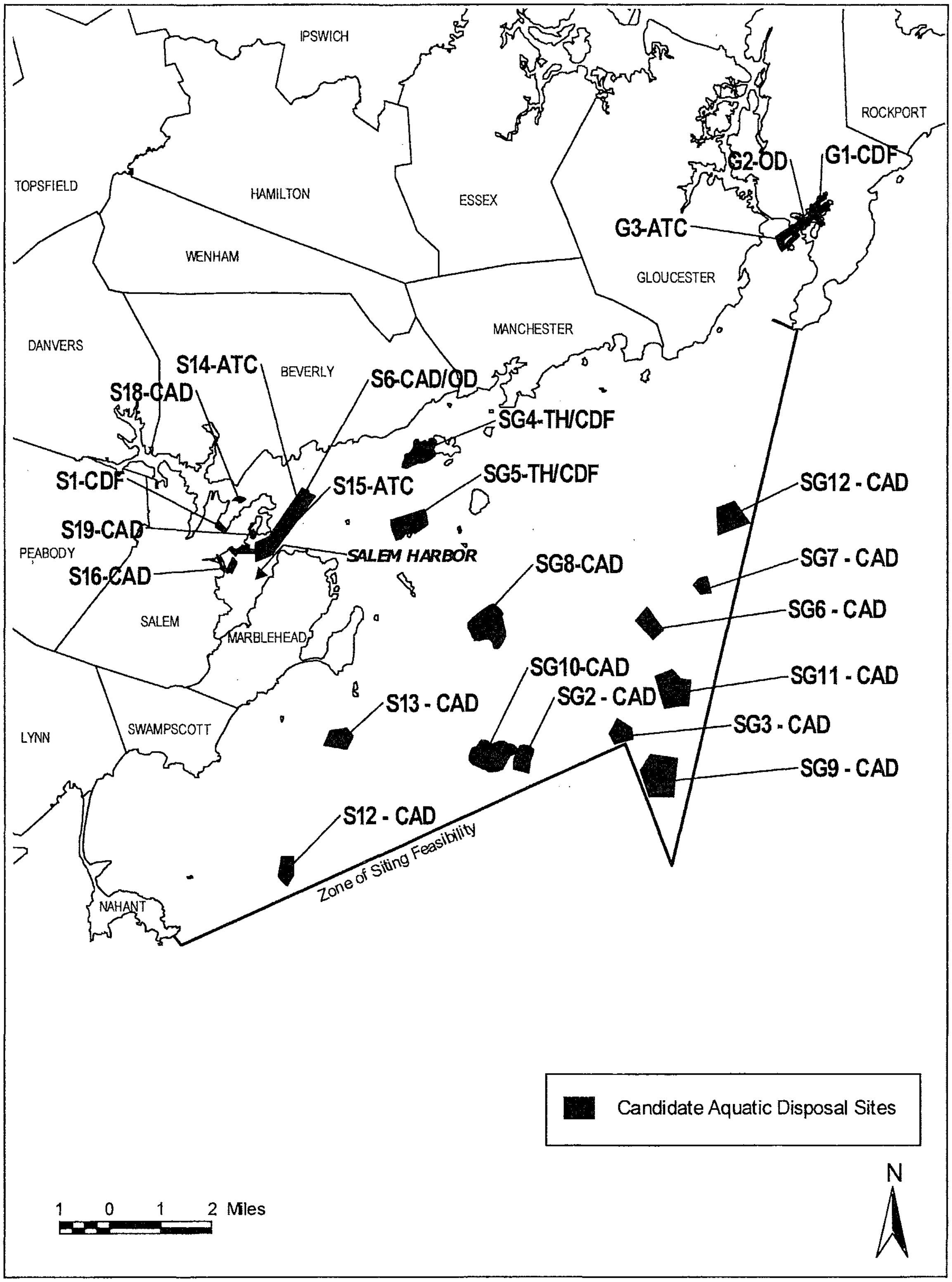


Figure 4-9: Candidate Disposal Sites within Salem Zone of Siting Feasibility

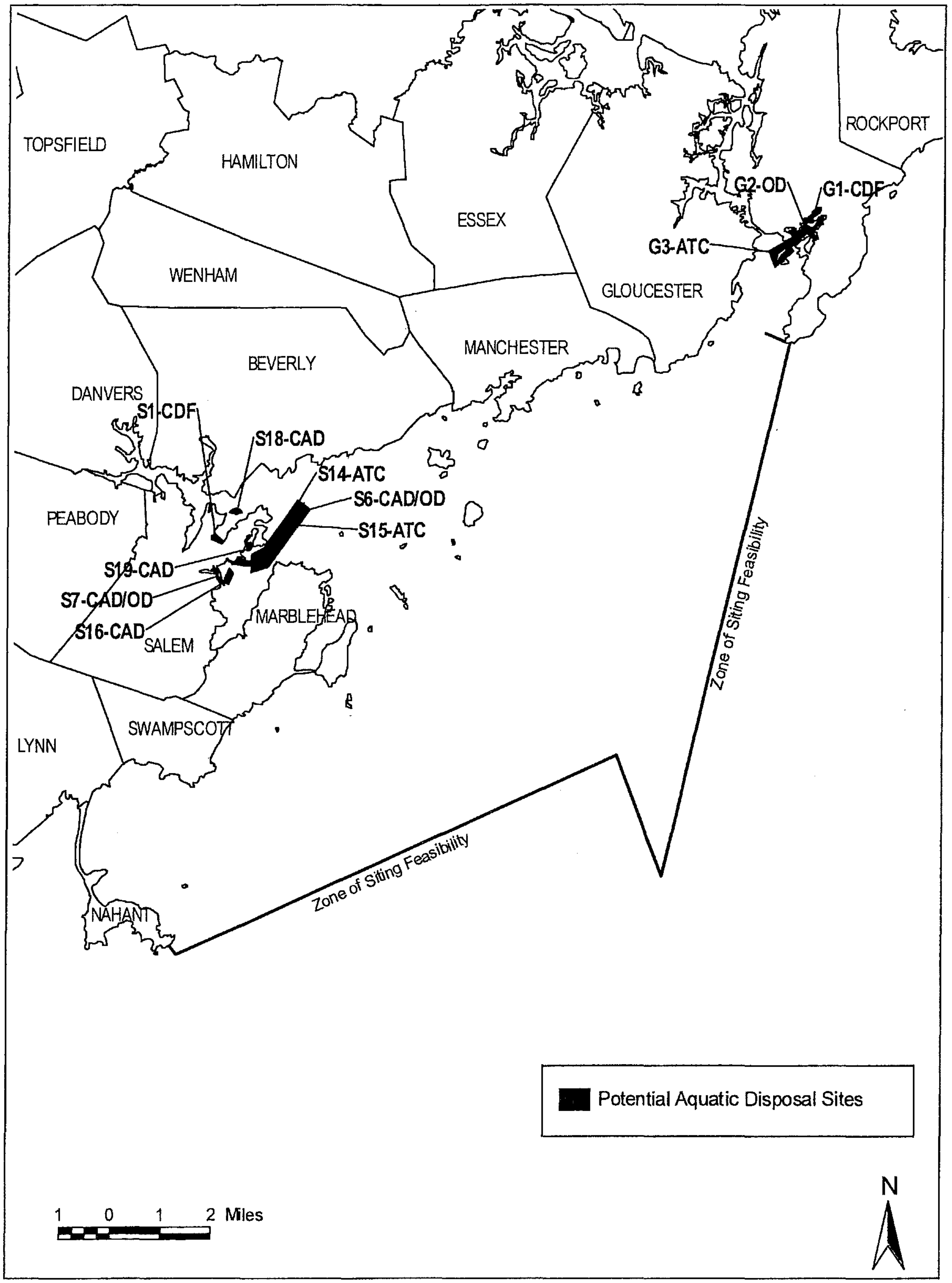


Figure 4-10: Potential Alternative Disposal Sites within Salem Harbor.

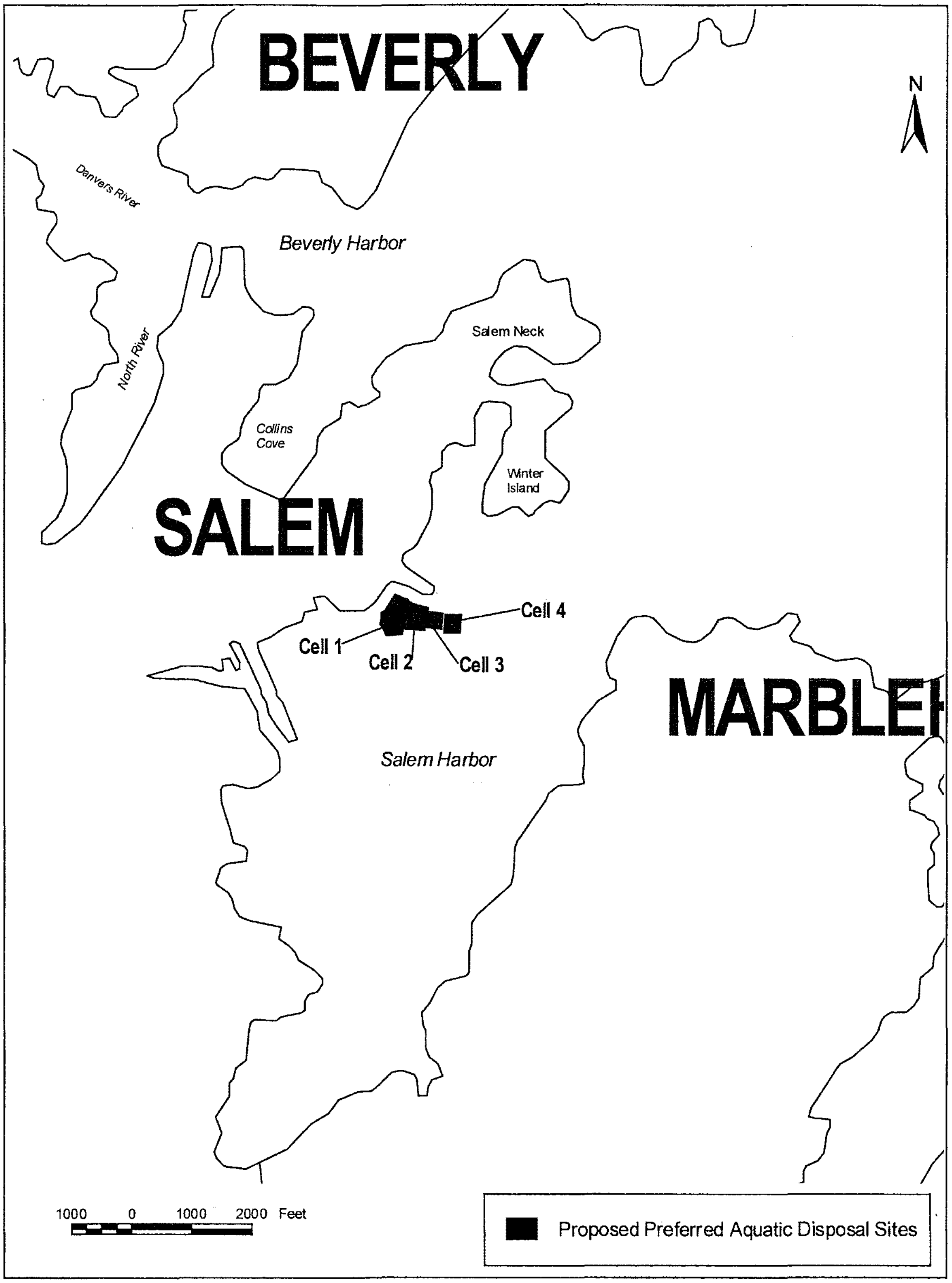


Figure 4-11: Proposed Preferred Alternative Disposal Site within Salem Harbor

Table 4-2: Physical Characteristics of Aquatic Disposal Sites Located Within Salem Harbor

Site Name	Type	Water Depth (Feet)	Size (Acres)	Potential Capacity (x 1000 c.y.)	Distance To Project (Miles)
S1-CDF	CDF	3	15	469	4
S2-CDF	CDF	3	4	142	1.7
S3-CDF	CDF	7	7	47	1
S6-CAD/OD	CAD/OD	26	92	1,090*	2.8
S7-CAD/OD	CAD/OD	3	3	97	0.4
S12-CAD	CAD	102	73	2359	9.8
S13-CAD	CAD	79	100	3229	7.1
S14-ATC	CAD/ATC	23	91	2118	2.1
S15-ATC	CAD/ATC	26	125	1,090*	2.2
S16-CAD	CAD	10	16	518	0.8
S18-CAD	CAD	3	10	3489	3.2
S19-CAD	CAD	7	8	267	1.5
G1-CDF	CDF	7	17	72	14.8
G2-OD	CAD/OD	16	81	46	17.7
G3-ATC	CAD/ATC	26	58	624	13.8

* These capacity calculations were based on the sum of maximum capacities estimated for candidate site sub-areas. All volumes are based on a 3:1 slope. Maximum capacity was calculated using the average basement depth (Maguire 1999).

Table 4-3: Physical Characteristics of Aquatic Disposal Sites Located Outside Salem Harbor

Site Name	Type	Water Depth (Feet)	Size (Acres)	Potential Capacity (x 1000 c.y.)	Distance To Project (Miles)
SG2-CAD	CAD	148	93	2993	8.5
SG3-CAD	CAD	174	85	2743	9.6
SG4-TH/CDF	TH/CDF	20	138	4459	5
SG5-TH/CDF	TH/CDF	30	155	4998	4.6
SG6-CAD	CAD	171	97	3131	9.4
SG7-CAD	CAD	174	47	1530	10.1
SG8-CAD	CAD	98	250	8080	6.8
SG9-CAD	CAD	177	293	9466	10.7
SG10-CAD	CAD	141	247	7965	7.9
SG11-CAD	CAD	187	219	7059	10.2
SG12-CAD	CAD	171	149	4797	10.6

4.5.2 Alternative Technology Assessment

This section describes the available alternative technologies for treatment of UDM, the process for evaluating these technologies, the factors used in the evaluation, and the results of this evaluation with respect to applicability to the DMMP.

Screening Process

Alternative treatment technologies and their applicability to the DMMP were evaluated in Phase 1 of the DMMP (Maguire 1997a) and updated in this DEIR.

Data on the technologies were gathered from several sources including the USEPA, US Department of Defense, USACE, Environment Canada, and others. In addition, the findings of other dredging projects involving contaminated sediments were reviewed including the Port of New York and New Jersey and Boston Harbor projects and an overview of European projects.

The inventory included technology description, treatment cost, and site demonstration information for 14 classes of treatment technologies including: chelation, chemical reduction/oxidation, dehalogenation, fungal remediation, incineration, in-situ bioremediation, pyrolysis, slurry bioreactor, solid-phase bioremediation, solidification/stabilization, solvent extraction, thermal desorption, and vitrification. An overview of pretreatment, sidestream treatment, and residuals management options was also presented.

As part of this technology assessment, a survey of vendors was conducted to gather current information in several major comparative categories including: ability to treat various contaminant types, effects of sediment characteristics on the treatment process, potential role of the vendor in a sediment decontamination project, capabilities and logistical requirements of the process equipment, and information on current and projected costs. The results of the vendor survey allowed for a comparative evaluation of the technologies using standard criteria.

Regulations governing the recycling or reuse of treated sediment have yet to be promulgated in Massachusetts. The DEP is currently developing a Comprehensive Dredging Regulation and a set of regulations/policies/procedures for the management of non-municipal-solid-waste contaminated media, both targeted for completion in 1999.

Description of Technologies

This section describes the sediment decontamination technologies. For each technology, distinct categories of the sediment decontamination process including: pretreatment technologies, treatment technologies, sidestream treatment technologies, and residuals management are also considered.

Pretreatment of the sediment typically involves removal of oversized materials and dewatering prior to treating the contaminated sediment.

Treatment of the sediment involves application of the primary decontamination process (e.g., physical, chemical, biological, and/or thermal) to reduce, destroy, or immobilize the target contaminants present in the sediments. Treatment may include use of a single technology or use of multiple technologies (i.e., treatment train) in order to address the widely-varying contamination and sediment types.

Sidestream treatment is often required for sidestream wastes (e.g., offgas, particulate emissions, and wastewater) generated during the primary sediment treatment process. These sidestream wastes typically require special handling, treatment, and/or disposal.

Residuals management involves the handling of treated solids from the primary sediment treatment process that may be acceptable for reuse or contain residual contamination which warrants special disposal.

The capabilities and costs of the treatment technology are the main consideration in the selection of a sediment decontamination method. Because sediments often contain a mixture of contaminants, the ability of a treatment technology to handle widely-varying contaminant and sediment types is very important. There are many technologies that will (relatively) inexpensively treat a specific contaminant, but require the addition of other technologies in a "treatment train" to handle a range of contaminants. Use of a treatment train increases the costs, handling requirements, potential environmental exposure, and complexity of sediment decontamination. On the other hand, some individual technologies may be more expensive, but can treat a full range of contaminants. Although the treatment process normally represents the major portion of the costs of sediment decontamination, the total costs including pretreatment, sidestream treatment, and residuals management must be considered when choosing between treatment alternatives. Public concerns about sidestream discharges, especially air emissions, can preclude the selection of certain treatment technologies.

As previously mentioned in Section 2.1, the treatment technology information contained in this section was gathered from previously-published sources. All data on costs, treatment efficiencies, and reference sites were taken from the SEDTEC (Environment Canada, 1996) and VISITT (EPA, 1996) databases. For those technologies without costs or reference sites, no datum was available in VISITT or SEDTEC.

Table 4-5 presents average values of the treatment rates and costs for the treatment technologies described in this section as well as the total number of vendors for each technology listed in the SEDTEC and VISITT databases. The average treatment costs range from $4 per cubic yard for phytoremediation to $462 per cubic yard for vitrification. The average cost for all of the technologies considered was $179 per cubic yard. These costs are strictly for comparative use and should be considered preliminary estimates only. Costs are subject to high variability based on the uncertainties associated with the widely-varying contaminant and sediment types, concentrations, and site-specific conditions.

Chelation

This process is a form of chemical stabilization that immobilizes metals. Chelation, or complexation, is the process of forming a stable bond or complex between a metal cation and a ligand (chelating agent). Chelating agents, or ligands, may form a single bond (monodentate) or multiple bonds (polydentate) with the target cation. The more bonds formed, the more stable the resulting complex and the greater degree of immobilization of the metal contaminant within the complex. Ethylenediaminetetraacetic acid (EDTA) is a commonly used polydentate chelating agent. Process efficiency is ion-specific depending upon the chelating agent, pH, and dosage.

A typical chelation treatment train consists of pretreatment, treatment, and post-treatment. Pretreatment consists of screening to remove oversized material and debris. Treatment consists of mixing the contaminated sediments with a chelating agent to form a stable complex that renders cationic metal contaminants unavailable for further chemical or biological reactions. Post-treatment consists of pH adjustment and dewatering of the treated sediments. Because metal complexation increases the potential mobility of the metal contaminants in an aqueous solution, chelation treatment may also be used in conjunction with other treatment processes such as soil washing.

The chelation process for metal immobilization may reduce the leachable metals adequately to meet the toxicity characteristic leaching procedure (TCLP) requirements. Treated sediments are the only residuals generated by the chelation process. Sidestream waste includes wastewater from dewatering of the treated sediments. Costs given by the vendor listed for chelation treatment are $83 per cubic yard.

Chemical Reduction/Oxidation

Chemical Reduction/Oxidation technology uses chemical additives to detoxify target contaminants by conversion into less toxic or immobile forms. Chemical oxidation processes work by transferring electrons from the contaminant to the oxidizing agent, which is reduced. Typical oxidizing agents include various forms of chlorine, potassium permanganate, hydrogen peroxide, persulfate, and ozone. These chemical oxidants may be catalyzed by the ultraviolet radiation or other transitional metal additives to enhance its oxidation potential by generation of free radicals.

Chemical reduction processes work by transferring electrons from the reducing agent to the target contaminant. In the process of the electron transfer, the added chemical agent is oxidized. Reducing agents used for treating heavy metals include sulfur dioxide, salts of sulfite and thiosulfite, ferrous sulfates, or metal iron, aluminum, or zinc.

Table 4-4: Cost and Production Rates of Treatment Technologies

Technology	Treatment Rate (tons/hr)	Average Cost (per cubic yard)
Chelation	16	$83
Chemical Reduction/Oxidation	172	$232
Dehalogenation	76	$263
Fungal Remediation	ND	$215
Incineration	10	$243
In-Situ Bioremediation	135	$42
Pyrolysis	9	$262
Slurry Bioreactor	17	$223
Soil Washing	32	$89
Solid-Phase Bioremediation	62	$62
Landfarming	ND	$48
Composting	40	$73
In-Vessel Bioremediation	1	$154
Solidification/Stabilization	40	$99
Thermal Desorption	27	$177
Vitrification	3	$462
Solvent Extraction	37	$182

ND = Not enough data
Source: SEDTEC 1996 and EPA 1996

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ND = Not enough data
Source: SEDTEC 1996 and EPA 1996

Dehalogenation

Dehalogenation is a process which destroys or removes some of the halogen atoms from halogenated aromatic compounds such as polychlorinated biphenyls (PCBs), dioxins, furans, and pesticides by substitution of bicarbonate or glycol for the halogen (usually chlorine) atoms. The two most common forms of dehalogenation are base-catalyzed decomposition and glycolate dehalogenation. Costs for dehalogenation range from $220 to $330 per cubic yard with an average of $263 per cubic yard.

Base-Catalyzed Decomposition

The base-catalyzed decomposition (BCD) dehalogenation technology uses a sodium bicarbonate reagent to replace the halogen atoms. BCD dehalogenation is used to destroy halogenated aromatic compounds such as PCBs, dioxins, furans, and pesticides.

A typical BCD treatment process consists of pretreatment, treatment, and post-treatment. Pretreatment includes dewatering of the sediment and screening to removed oversized material and debris and post-treatment consists of dewatering to extract excess process water and treat emissions. Treatment consists of mixing the contaminated sediment with sodium bicarbonate and a high-boiling-point oil and heating the mixture in a rotary reactor above 630° F. This process results in partial decomposition of the chlorinated organic contaminants into non-water-soluble and less toxic compounds. The resulting compounds are primarily biphenyls, olefins, and sodium chloride. Both liquid and vapor side streams are generated during treatment. Water vapors and volatile organic vapors are produced during heating and mixing in the treatment vessel.

Glycolate Dehalogenation

The glycolate dehalogenation process uses a combination of alkali metal and polyethylene glycol reagents to destroy halogenated aromatic compounds such as PCBs, dioxins, pesticides, and chlorobenzenes. This technology is commonly know as alkaline polyethylene glycol (APEG) or potassium ethylene glycol (KPEG) dehalogenation.

A typical treatment process consists of a pretreatment, treatment, and post-treatment steps. Pretreatment includes dewatering of the sediment, screening of oversized materials and debris, and pH adjustment. Treatment consists of mixing the APEG reagent with the contaminated sediments to form a slurry and heating the mixture to 200 °F - 300 °F in a treatment vessel. The polyethylene glycol replaces the halogen resulting in a less toxic or non-hazardous compounds. The resulting compounds are gylcol ethers and/or hydroylated compounds and an alkali metal salt. Post-treatment involving washing of the sediments may be required to remove residual reagents and resulting compounds.

Treatment efficiency is generally greater then 98%; reductions of PCB concentrations from as high as 45,000 parts per million (ppm) to less than 2 ppm have been reported. The cost of glycolate dehalogenation ranges from $220 to $550 per cubic yard. Refinements in the process chemistry and substitution of less expensive sodium hydroxide for potassium hydroxide may decrease the cost of the technology in the future.

Both liquid and vapor side streams are generated during treatment. Process water from the treatment vessel contains the water-soluble gylcol ethers, hydroxylated compounds, and alkali metal salts. Water vapors and volatile organic vapors are produced during heating and mixing in the treatment vessel.

Fungal Remediation

Fungal remediation is a particular subset of bioremediation that employs fungi rather than bacteria to degrade the contaminant. White rot fungus is the most commonly studied fungus because the enzymes secreted by the white rot fungus can degrade lignin, the complex organic building block of wood. White rot fungus has shown the ability to destroy complex organic compounds such as explosives, pesticides, PAHs, and PCBs. Although the potential of white rot fungus has been known for over 20 years, there have been few commercial applications of this remedial technology.

A typical fungal treatment process consists of pretreatment and treatment. Further post-treatment is not required. Pretreatment includes dewatering of the sediments and screening of the oversized materials and debris. Treatment consists of applying white rot fungus directly to the contaminated sediments. The fungus is first cultured on wood chips or cardboard and then mixed into the sediments in a manner similar to composting. The enzymes used to degrade lignin can also be used to degrade other complex organic compounds. The optimum temperature range for the lignin-degrading fungus is 86 °F to 100 °F; optimal pH is 4.5; and optimal moisture content is 40% to 45% (DOD, 1994). Secretion of lignin-degrading enzymes seems to be greatest under nutrient-deficient conditions. Rate of contaminant mineralization is two to three times faster under an 100% oxygen atmosphere.

Treatment efficiencies of approximately 50% have been reported. Costs for the two vendors offering fungal remediation are $165 to $264 per cubic yard. Residuals include the treated sediments. No sidestream wastes are generated during this treatment process.

Limitations include:

- High contaminant concentrations may be toxic to the fungus;
- Minimum degradation concentration of contaminants may not meet the cleanup standard;
- Does not treat metals;
- Unknown how salt water will effect white rot fungus;
- Short life of cultured fungi may require frequent reactor replacement; and,
- Removal efficiencies of approximately 50% are considered too low to effectively treat contaminated sediments.

Incineration

Incineration is one of the most commonly-used remediation technologies. Incineration, or thermal oxidation, destroys contaminants using high temperatures in the presence of oxygen and is effective in destroying a wide range of organic contaminants. Currently in Massachusetts, incineration of wastes is not looked on favorably by the DEP, environmental groups, and the public. It would be very difficult to site an incineration facility in Massachusetts as evidenced by recent efforts to site a portable thermal oxidizer for treatment of 30,000 cy of soil near Logan Airport. Other efforts, such as the proposed incineration of PCB-laden sediments from New Bedford Harbor in the early 1990s were also thwarted due to potential air quality impacts.

Most commercial incinerators are of the rotary-kiln design with common variations including fluidized-bed and infrared designs. Rotary-kiln incineration is a thermal process which utilizes a slightly inclined, slow rotating, refractory-lined cylinder as the primary combustion chamber for the destruction of wastes in solids, liquids, and gases. Wastes and auxiliary fuel are introduced into the high end of the kiln and pass through the combustion zone as the kiln slowly rotates.

A typical incineration treatment process employing rotary kiln technology consists of a pretreatment and treatment step. Further post-treatment may be required if heavy metals are present. Pretreatment includes dewatering of the sediment and screening of oversized materials and debris. Treatment consists of applying high temperatures from 1,400 °F to 2,200 °F in the presence of oxygen to destroy the organic compounds. The resulting compounds are completely mineralized forms including carbon dioxide, water, and ash. Afterburners are used to completely destroy volatilized organics in the offgas.

Treatment efficiency of the incineration process generally exceeds 99.99% and can be as high as 99.9999% when required for PCBs and dioxin. Costs for incineration range from $55 to $880 per cubic yard with an average cost of $243 per cubic yard. Incineration costs increase for PCBs and dioxins.

The residual is an ash material often containing heavy metals which may require post-treatment such as stabilization. Sidestream wastes generated during incineration include air emissions and wastewater. Air emissions are the main sidestream waste produced during incineration. Pollution control equipment is required to reduce particulates and other regulated air pollutants. Typical air emissions resulting from incomplete combustion may include acid fumes, carbon monoxide, nitrogen oxides, sulfur dioxides, hydrogen, methane, and other hydrocarbons. Water waste is also generated from the scrubber system containing acids, chlorides, volatile metals, and trace organics.

Limitations include:

- Requires a very low moisture content in sediments;
- Strict feedstock particle size limitations (1 - 2 inches maximum);
- Gaseous discharges are a major potential contaminant emission pathway;
- Heavy metals are not removed or destroyed and are more leachable after incineration;
- Metals can react with chlorine or sulfur to form more toxic compounds;
- Public opposition;
- Permitting difficulties; and,
- Large area required for equipment layout.

In-situ Bioremediation

In-situ bioremediation is a process in which indigenous or inoculated microorganisms (i.e., fungi, protozoa, bacteria, and other microbes) degrade organic contaminants found in the sediments. In the presence of sufficient oxygen, microorganisms may ultimately convert many organic contaminants to carbon dioxide, water, and microbial cell mass. In the absence of oxygen, the contaminants may be ultimately reduced to methane, carbon dioxide, and trace amounts of hydrogen gas. Sometimes contaminants may be degraded to intermediate products that may be equally, or more hazardous than the original contaminant. In-situ bioremediation processes have been successfully used to treat petroleum hydrocarbons, solvents, pesticides, and other organic chemicals.

A typical in-situ aerobic bioremediation process may include the injection of nutrients and dissolved oxygen into the subsurface sediments. Sometimes acclimated microorganisms and/or another oxygen source such as hydrogen peroxide or other slow release oxygen substances are also added.

Treatment efficiency of the in-situ bioremediation process generally exceeds 90% and can be as high as 99%. Costs for in-situ bioremediation range from \$6 to \$116 per cubic yard with an average cost of \$42 per cubic yard.

Limitations include:

- Extended remediation times on the order of years to decades;
- High concentrations of heavy metals and contaminants may be toxic to microorganisms;
- Bioremediation slows at low temperatures;
- Not all organic compounds are biodegradable;
- Bioremediation rates are limited by the availability of PAHs, PCBs and pesticides in the sediments; and,
- Heterogenous geological conditions and low permeability soils (less than 10^{-5} cm/sec) are not favorable for in-situ bioremediation.

Pyrolysis

Pyrolysis involves the destruction of organic material in the absence of oxygen. The absence of oxygen allows separation of the waste into an organic fraction (gas) and an inorganic fraction (salts, metals, particulates) as char material. Pyrolysis is normally used to treat high levels of organics (e.g., semivolatile organic compounds and pesticides) that are not conducive to conventional incineration.

A typical pyrolysis treatment process consists of pretreatment and treatment steps. Further post-treatment is not required. Pretreatment includes dewatering of the sediments and screening of oversized materials and debris. The treatment process involves the use of two combustion chambers. Waste material is heated at temperatures of 1,000 °F to 1,600 °F in the oxygen free primary chamber to volatilize and decompose organic material. Inert solids which remain after pyrolysis are continuously removed for disposal. The pyrolytic gases are further heated in the secondary chamber (fume incinerator) at temperatures of 1,800 °F to 2,200 °F to destroy hazardous components. Off-gases from the secondary chamber pass through air pollution control units or a resource recovery system prior to discharge to the atmosphere. Under these conditions, target organic contaminants composed of large, complex molecules (such as PAHs, PCBs, and dioxins) undergo chemical decomposition into simpler ones. One proprietary process, used at Hamilton, Ontario, incorporates a reducing agent to remove chlorine atoms.

Treatment efficiency for the pyrolysis technology generally exceeds 99%. Costs for the two vendors offering pyrolysis are $248 and $275 per cubic yard. Major factors affecting this estimate are the condition and properties of the feed sediment (i.e., moisture, total contamination, and soil characterization.

Like incineration, the treatment residual (coke) is a solid containing fixed carbon and ash, often containing heavy metals. Sidestream wastes include air and water. Air emissions are the main sidestream waste produced during pyrolysis. Typical air emissions include carbon monoxide, hydrogen, methane, and other hydrocarbons. Wastewater is also generated from the scrubber system containing chlorides, volatile metals, and trace organics.

Limitations include:

- Requires a very low moisture content (<1%) in sediments;
- Strict feedstock particle size limitations;
- Gaseous discharges are a major potential contaminant emission pathway;
- Heavy metals are not removed or destroyed, but are not more leachable after pyrolysis;
- Public opposition;
- Permitting difficulties; and,
- Site space limitations.

Slurry Bioreactor

A slurry bioreactor is a controlled biological treatment vessel where the contaminated sediments are treated in a slurry form at a low solids content. The sediment is mixed with water to a predetermined concentration dependent upon the concentration of the contaminants, the rate of biodegradation, and the physical nature of the sediments. Slurry bioreactors can treat a variety of organic contaminants including chlorinated and non-chlorinated volatile organics, PAHs, PCBs, and pesticides.

A typical bioreactor treatment process consists of pretreatment, treatment, and post-treatment. Pretreatment includes screening of oversized materials and debris and sometimes prewashing the sediment to concentrate contaminated fines. A slurry of contaminated sediment at 10% to 35% solids is typically used. Treatment consists of adding nutrients and oxygen (if an aerobic process), adjusting pH as required, and mixing the slurry to establish uniform conditions. Maintenance of the proper environmental conditions (i.e., pH, temperature, nutrient concentration, and oxygen concentration) is paramount. The slurry bioreactor offers excellent mixing and control over environmental conditions. Treatment can be combined with acid extraction to remove metals. Post-treatment consists of dewatering the slurry.

Typical treatment efficiencies of greater that 90% can be attained in a slurry bioreactor. Treatment costs range from $6 to $825 per cubic yard with an average cost of $223 per cubic yard. Treatment residuals include processed soils. Sidestream wastes include wastewater from dewatering the treated slurry and offgas from the treatment vessel.

Limitations include:

- Heavy metals at high concentrations can inhibit microbial degradation;
- Treatment and disposal of wastewater from slurry dewatering;
- Dewatering is required after treatment;
- Equipment and operation and maintenance intensive;
- Higher energy costs than solid-phase bioremediation;
- Organic destruction efficiencies are generally low at low concentrations; and,
- Low cleanup standards may be difficult to meet for recalcitrant organics.

Soil Washing

Soil washing refers to the process of using water to physically separate the sediments by particle size into a reusable bulk fraction and a smaller fraction containing concentrated contaminants. Since organic contaminants are often sorbed to the finer silt and clay particles, separation of this fine fraction from the sandy sediments allows reuse of the typically non-contaminated sands and accomplishes a volume reduction of the total contaminated sediment mass. It is also possible to add chelating agents, surfactants, acids, or bases to separate the contaminants from the sediment. Soil washing has the potential to treat a variety of contaminants including PAHs, PCBs, fuel oil, heavy metals, radionuclides, and pesticides.

A typical soil washing treatment process consists of pretreatment, treatment, and post-treatment steps.

Pretreatment consists of screening of oversized materials and debris. Treatment occurs through two means: first, separation of fines particles from the sand, then further treatment of the two fractions as necessary. In soil washing, water is used as the solvent. Surfactants, acids, or chelating agents can be added to accelerate the separation of the contaminants from the sediment particles into the water phase. Soil washing consists of a combination of physical separation/classification technologies including: screening, gravity separation, hydrocyclones, froth flotation, and magnetic separation. The sand fraction can be treated with gravity separation, froth flotation, magnetic separation, biodegradation, reduction/oxidation, and acid extraction. The fine fraction must be treated further or disposed as hazardous waste.

Post-treatment consists of dewatering of the treated sediment. The effluent from dewatering is recycled within the soil washing process. However, additional water treatment is necessary where there is a phase transfer of contaminants to the water by dissolving or suspending. In addition to wastewater from dewatering, sidestream wastes also include offgas from the treatment vessel.

Typical treatment efficiencies are greater than 90% for volatile organics, 70 to 95% for metals, and 40% to 90% for semivolatile organics. The cost of soil washing ranges from $20 to $220 per cubic yard with an average cost of $89 per cubic yard.

Limitations include:

- Soil washing is only marginally effective for sediments composed primarily of clays and silts;
- Maximum particle size typically 0.5 cm;
- Removal of fines from wastewater may require the addition of polymer flocculent;
- Treatment and disposal of wastewater from dewatering; and,
- Dewatering is required after treatment.

Solid-Phase Bioremediation

Biological degradation of contaminants is a naturally-occurring process. Bioremediation is the acceleration of the natural biodegradation processes by controlling moisture content, temperature, nutrients, oxygen, and pH to create the optimal environment. For purposes of this discussion, the varieties of solid-phase biological treatment processes have been divided into three categories based on level of engineering: landfarming, composting, and in-vessel bioremediation. Solid-phase biological treatment technologies are used primarily to treat VOCs and petroleum hydrocarbons. It is also possible to treat PAHs, PCBs, halogenated organic compounds, explosives and pesticides to some degree, especially in the more highly-engineered in-vessel systems.

Typical solid-phase bioremediation treatment processes consist of pretreatment, treatment, and post-treatment steps. Pretreatment consists of screening of oversized materials and debris and addition of amendments such as nutrients, bulking agents, and/or seed bacteria. Bulking agents, typically wood chips and leaves, are particularly important for sediments to absorb extra moisture and increase porosity. Treatment processes vary from landfarming to composting to in-vessel bioremediation as described below. Post-treatment includes those steps necessary to market the composted material. Such marketing preparation steps include final screening, addition of nutrients, and/or bagging.

Costs for all solid-phase bioremediation technologies range from $3 to $264 per cubic yard with an average cost of $62 per cubic yard. Solid-phase bioremediation is used on a production scale in Europe, especially in The Netherlands, Germany, and France.

The only residuals generated by the solid-phase bioremediation treatment process are soil. Sidestreams include leachate and offgas. Leachate can be recycled into the sediments.

Data requirements for Solid-Phase Bioremediation include:

- Bench and Pilot testing.
- Presence of inorganic and metallic contaminants.
- Specific contaminants and concentrations.
- Contaminant properties: biodegradability, solubility, soil sorption, and volatility.

Landfarming

Landfarming is the least engineered of the solid-phase bioremediation treatment processes. Landfarming consists of spreading the contaminated sediments over a large area of land and periodically tilling the sediments for aeration. Environmental conditions are controlled by watering (moisture content), fertilizing (nutrient concentration), tilling (oxygen concentration), and lime addition (pH) to accelerate natural bioremediation. Temperature cannot be regulated to a great extent, limiting the applicability of landfarming in cold climates. Since oxygen is added by tilling, the thickness of the spread contaminated sediments is limited to the tilling depth; therefore, a large area of land is required for landfarming. Landfarming may also incorporate the use of polyethylene liners to control leaching of contaminants.

Treatment efficiencies are highly variable but generally greater than 90% for contaminants amenable to aerobic bioremediation. The effectiveness in remediating petroleum hydrocarbons has been widely demonstrated. The costs for the two vendors offering landfarming are $44 and $52 per cubic yard.

Limitations of Landfarming include:

- Open landfarming may not be practical in regions of heavy annual rainfall precipitation and/or cold climate;
- Does not remediate inorganic contaminants;

- Inorganic contaminants may leach from contaminated sediments into ground;
- Ineffective for treatment of high molecular weight PAHs and highly chlorinated PCBs;
- Can generate odors;
- Of the solid-phase bioremediation treatment processes, landfarming offers the least control over environmental conditions;
- Of the solid-phase bioremediation treatment processes, landfarming offers the least control over collection of offgas;
- Of the solid-phase bioremediation treatment processes, landfarming requires the largest space; and,
- Of the solid-phase bioremediation treatment processes, landfarming requires the longest cleanup time.

Composting

Composting is the middle level of the engineering hierarchy of the solid-phase bioremediation treatment processes. The two major variations of the composting process discussed here are windrow and aerated static pile. The windrow is a pile typically 6-10 feet high, 15-20 feet wide and hundreds of feet long. Windrows are mechanically turned twice a week to once a year to aerate the pile, control the temperature, and create a more uniformly mixed material. Turning of the pile releases odors. Composting is completed in one month to a few years depending on the contaminants and the level of maintenance of the windrow.

The aerated static pile is typically 7-8 feet high, 10-20 feet wide, and of variable length. The aerated static pile is heaped over a grid of porous piping that is connected to a vacuum blower or compressor and used for aeration and temperature control of the pile. A layer of stabilized compost is normally placed over the top of the pile to reduce odor emissions. Composting is completed in approximately one month and the pile is normally allowed to cure for an additional month.

Composting processes are normally placed on a liner or slab and often incorporate leachate collection systems. Windrows or aerated static piles may also be enclosed in domes or buildings to allow for offgas collection and control. Enclosure of the process within a structure also allows for better temperature regulation in cold climates.

Treatment efficiencies are highly variable but generally greater than 90% for contaminants amenable to aerobic bioremediation. The cost of composting ranges from $25 to $198 per cubic yard with an average cost of $73 per cubic yard.

Limitations of composting include:

- A large space is required;
- Questionable effectiveness for treatment of high molecular weight PAHs and highly chlorinated PCBs;
- Requires months of cleanup time;
- Can generate odors; and,
- Collection of offgas is difficult.

In-Vessel Bioremediation

In-vessel bioremediation is the most engineered of the solid-phase bioremediation treatment processes. In-vessel biological treatment is often referred to as in-vessel composting. Here it is discussed separately since it is possible to have anaerobic conditions. Treatment consists of placing the contaminated sediment mixture in engineered treatment enclosures with leachate collection systems and aeration equipment. In-vessel composting is completed in a couple of weeks and the pile is normally allowed to cure for an additional one to three months. In-vessel systems allow stricter environmental controls, faster composting times, odor collection and treatment, smaller area requirements, and can handle a wider variety of contaminants.

Typical treatment efficiencies range from 70 to 95%. Typical costs range from $33 to $220 per cubic yard ($30 to $200 per ton) with an median cost of $154 per cubic yard.

Limitations of In-Vessel Bioremediation include:

- Ineffective for remediating inorganic contaminants;
- Difficult to treat high molecular weight PAHs and highly chlorinated PCBs;
- Most expensive of the solid-phase bioremediation treatment processes; and,
- Emission controls for offgas may be required.

Solidification/Stabilization

Solidification/stabilization is effective at immobilizing contaminants and are among the most commonly used remediation technologies. Solidification/stabilization involves mixing reactive material with contaminated sediments to immobilize the contaminants. Contaminants are physically bound or enclosed within a stabilized mass (solidification), or undergo chemical reactions with the stabilizing agent to reduce their mobility (stabilization). Binding of the contaminants to the sediment reduces contaminant mobility via the leaching pathway. A typical treatment process includes homogenization of the feed material followed by mixing of solid or liquid reagents with the feed material in a pug mill. Three specific categories examined in this screening include asphalt, cement, and lime solidification/stabilization.

Solidification is the process of eliminating the free water in a semisolid by hydration with a setting agent or binder. Typical binder materials include cements, kiln dust, and pozzolans such as lime/fly ash. Binders used in Germany and France are bentonite and Portland cement. Solidification usually provides physical stabilization but not necessarily chemical stabilization. Physical stabilization refers to improved engineering properties such as bearing capacity, trafficability, and permeability. Although solidification/stabilization technologies are not generally applied to organic contaminants, physical stabilization can also immobilize contaminants since the contaminants tend to be bound to the fines, which are physically bound in the solidified matrix. Chemical stabilization is the alteration of the chemical form of the contaminants to make them resistant to aqueous leaching. The solubility of metals is reduced by formation of metal complexes, chelation bonds, or crystaline precipitates within the solid matrix with chemical additives and by controlling pH and alkalinity. Anions, which are more difficult to bind as insoluble compounds, may be immobilized by entrapment or microencapsulation. Chemical stabilization of organic compounds is not very reliable.

Results of reactions of binders to the contaminated sediment are not always predictable due to varying contaminant types and concentrations within the test material. Therefore, laboratory leach tests must be conducted on a sediment-specific basis.

Asphalt Batching

Asphalt batching is a commonly used technology in Massachusetts and has been proven effective in immobilizing TPH, VOC, and PAH compounds. Contaminated solids are blended with asphalt emulsions in a pug mill. The asphalt-emulsion-coated material is stockpiled and allowed to cure for approximately 2 weeks. Pretreatment requirements include dewatering and size classification by screening or crushing to less than 3-inch diameter. End product can be recycled as a stabilized base material for parking lots or roadways.

Cement Solidification/Stabilization

Cement solidification/stabilization involves mixing the contaminated sediments with Portland cement and other additives to form a solid block of stabilized waste material with high structural integrity. Siliceous materials such as fly ash may be added to stabilize a wider range of contaminants than cement alone. Cement solidification/stabilization is most effective for inorganic and metallic contaminants.

Lime Stabilization

Lime/fly ash pozzolanic processes combine the properties of lime and fly ash to produce low-strength cementation. Lime stabilization involves mixing the contaminated sediments with lime in a sufficient quantity to raise the pH to 12 or higher. Raising the pH results in chemical oxidation of the organic matter, destruction of bacteria, and reduction of odor. Lime stabilization is commonly used to treat wastewater sludge and is primarily effective for organic contaminants and microbial pathogens.

Typical treatment efficiency of the solidification/stabilization process ranges from 75% to 90%. Costs range from $48 to $330 per cubic yard with an average cost of $99 per cubic yard. Residuals produced from treatment are stabilized blocks of sediment material. Air emissions are the main sidestream waste produced during the treatment operation

Limitations include:

- May not be particularly effective for organic contaminants, particularly VOCs;
- Fine particles may bind to larger particles preventing effective bonding of the binder material;
- Inorganic salts may affect curing rates and reduce strength of stabilized product;
- Organic contaminants may volatilize due to heat generated during the reaction; and,
- High moisture content requires increased amounts of reagent.

Solvent Extraction

Solvent extraction is similar to soil washing in that the technology produces a volume reduction of the total contaminated material. However, solvent extraction focuses on extracting the contaminants from the sediments using organic solvents. Contaminated material volume reductions of 20 times or more are attainable. Solvent extraction is targeted primarily at organic contaminants including PCBs, PAHs, VOCs, petroleum hydrocarbons, and chlorinated solvents. This technology is not particularly applicable to inorganics; however, organically-bound metals can be extracted.

Typical solvent extraction treatment processes consist of pretreatment, treatment, and post-treatment steps. Pretreatment consists of screening of oversized materials and debris. Treatment consists of mixing the contaminated sediments with the extraction solvent and sometimes cosolvent to dissolve the target contaminants. Sediments are divided into three fractions: particulate solids, water, and concentrated organic contaminants. The solvents containing the concentrated contaminants are then separated from the sediments and recycled. Several extraction steps are often required to reach target contaminant concentrations. Solvents are selected based on the nature of the contaminants. Typical solvents include kerosene, hexane, methanol, carbon dioxide, butane, triethylamine (BEST process), propane (CF Systems), and food-grade oil (Carver-Greenfield process). Acids may also be used to extract metals and other inorganic compounds. Since the solvents represent a significant factor in the overall cost of the solvent extraction process, separation of the contaminants from the solvent and recycling of the solvent is critical. Post-treatment consists of removal of residual solvent from the treated sediment by volatilization or biodegradation and pH adjustment of treated sediments. Post-treatment also includes purification of the contaminants and soil particulates from the solvent so that the solvent can be recycled.

Treatment efficiencies for the solvent extraction process generally exceed 90% and are typically in the 98-99% range. The costs ranges from $21 to $567 per cubic yard with an average cost of $182 per cubic yard.

Sediment residuals often contain traces of the extraction solvent. Sidestream wastes include wastewater from dewatering the treated sediments and offgas from the treatment vessel. Wastewater can be recycled into the extraction process and excess wastewater may need additional treatment for final disposal.

Limitations include:

- Less effective for sediments composed primarily of clays and silts;
- Not typically effective for removal of inorganic compounds;
- Treated soil may contain residual concentrations of solvent;
- Maximum particle size 0.5 cm;
- Treatment and disposal of wastewater from dewatering; and,
- Dewatering is required after treatment.

Thermal Desorption

The thermal desorption technology employs high temperature to volatilize organic contaminants. Thermal desorption technologies are divided into high temperature and low temperature categories. Thermal desorption is a removal process that applies to contaminants that are volatile at the process operating temperatures. Primary targets of treatment are organic contaminants including PAHs, VOCs, pesticides, and chlorinated solvents. This technology is not applicable to inorganic compounds; however, volatile metals, such as mercury, can be extracted.

A typical thermal desorption treatment process consists of pretreatment, treatment, and post-treatment. Pretreatment consists of screening of oversized materials and debris and dewatering of the sediments. Treatment consists of applying high temperatures from 400 °F to 1,000 °F to volatilize the organic compounds. The contaminant-bearing offgas is removed with vacuum or the exhaust air for treatment. The organic contaminants in the offgas can either be removed by gas scrubbing or destroyed in an afterburners. Post-treatment could consist of stabilization for metals.

High-Temperature Thermal Desorption

The high-temperature process uses temperatures between 600 °F and 1,000 °F. At these temperatures, a greater range of contaminants are volatilized including some metals (which may not be desirable).

Low-Temperature Thermal Desorption

The low-temperature process uses temperatures between 200 °F and 600 °F. The lower temperatures do not volatilize metals. Most commercial low-temperature thermal desorption units are of the rotary dryer or thermal screw design. Costs for thermal desorption range from $11 to $908 per cubic yard with an average cost of $177 per cubic yard.

Sidestream wastes generated during thermal desorption include air and water. Air emissions are the main sidestream waste produced during thermal desorption. Pollution control equipment is required to reduce particulates and other regulated air pollutants. Offgas is often treated by catalytic oxidizers or activated carbon which requires disposal when the absorption capacity is met. Water waste is also generated from the scrubber system containing chlorides, volatile metals, and trace organics.

Limitations include:

- Optimal moisture content less than 60%;
- Gaseous discharges are a major potential contaminant emission pathway;
- Feedstock particle size limited to 2 inches maximum;
- Tightly bound contaminants in clayey and silty sediments increase residence time requirements; and,
- Heavy metals are not removed or destroyed

Vitrification

Vitrification technology uses high temperatures, above 2,900 °F, to melt and convert contaminated sediments into oxide glasses, thus achieving destruction of organic contaminants and stabilization of inorganic contaminants. The resulting glass is nontoxic and suitable for landfilling as non-hazardous materials. Vitrification technology is applicable to all types of contaminants. Vitrification immobilizes inorganic contaminants in a solidified glass matrix and destroys organic contaminants with the high temperature involved in glass production.

A typical vitrification treatment process consists of a pretreatment and treatment step. Further post-treatment is not required. Pretreatment includes dewatering the sediment and screening of oversized materials and debris. The first step of treatment is blending of additives, as necessary, to give the glass product the required final properties based on the sediment and contaminant composition. The mixture is then heated above the melting point of silica.

The treatment efficiencies range approach 99% or greater for most target contaminants. Vitrification is one of the most expensive technologies; however, since vitrification can act as a stand-alone technology, the cost of vitrification can compete when a treatment train of other technologies is required. The cost of vitrification ranges from $66 to $1540 per cubic yard with an average cost of $462 per cubic yard.

Vitrification produces a glass-like slag. Air emissions of volatile organics and metals are the main sidestream waste produced during vitrification. Pollution control equipment is required to control air pollutants.

Limitations include:

- Gaseous discharges are a major potential contaminant emission pathway;
- Creates a glass material that must be reused or disposed;
- More expensive than incineration; and,
- Molten product requires long cooling period.

Screening Factors

To evaluate alternative sediment decontamination technologies, a survey was performed of potential vendors of treatment systems. Potential vendors were identified from the VISITT and SEDTEC databases. Each vendor was provided with a sediment decontamination technology vendor questionnaire to complete either on-line or through the mail. A copy of the questionnaire is provided in Appendix D. The questionnaire was developed and administered in order to obtain information for a comparative analysis of treatment technologies. Results of this questionnaire allowed development of a consistent set of results including site conditions, sediment characteristics, target cleanup levels, treatment options, and cost elements to evaluate sediment decontamination processes and vendors.

The vendor questionnaire was divided into several major comparative categories including: Business Information; Ability to Treat; Effects of Sediment Characteristics, Vendor Involvement; Process Information; and Cost. These elements, as well as several practicability criteria were applied to each technology. In addition, DEP Solid Waste Management staff were consulted regarding specific case-studies and experience in the application of alternative treatment technologies to dredged material and other media within the Commonwealth.

Ability to Treat - the ability of the technology to treat the contaminants that may potentially be present in the dredged sediments such as metals, PAHs, PCBs, and TPH. The vendor was asked to categorize their technology as providing immobilization, removal, destruction, or no effect of the target contaminants. In addition, the typical treatment efficiencies and operating ranges (i.e., low and high contaminant levels) were to be identified. Specific individual contaminant exceptions within each of the four major contaminant groups were also to be identified in this section.

Effects of Sediment Characteristics - This category requested information about the sensitivity of the treatment technology to variations in the physical and chemical properties and characteristics of the dredged sediments. Requested information included the maximum particle size accepted by the treatment system and the optimal solids content recommended for the treatment system by the vendor. More detailed information was requested on the effects of specific sediment characteristics on the treatment technology. These characteristics included sandy, silty, clayey, low and high moisture content, low and high organic content, and high metals content. Choices provided for describing the effects of the sediment characteristics on the treatment technology included favorable, no effect, impedes, or unknown.

Process Information - This category requested information specific to the design and implementation of the vendor's technology. The most critical piece of information in this category is the current scale of development of the technology. Choices included laboratory, pilot, or full/commercial scale. The total number and site-specific references were requested of those vendors with full scale operations. Process-specific information requested included pretreatment requirements, treatment batch size and treatment time, maximum system throughput, residuals generated (e.g., liquid, solid, gas, none), and residual disposal requirements. In addition, any special site- or process-specific needs such as power, water, safety, or permits were to be identified in this section. Other process-specific information included mobilization and demobilization times and layout space required.

Cost The capabilities and costs of the treatment technology are a key consideration in the selection of a sediment decontamination method. The cost of sediment decontamination technologies is relatively high ranging from $70 to $170 per cubic yard. In comparison, contaminated sediments from the Boston Harbor project will be disposed of in CAD cells (contained aquatic disposal) within the footprint of the area to be dredged at an estimated disposal cost of $36 per cubic yard.

Demonstrated Success The results of the vendor survey and pilot-scale testing for the Port of NY/NJ cast doubt on the assertion that technologies are not available and proven. The vendors surveyed reported an average of 32 reference sites for full-scale implementation, and approximately half of the vendors reported 5 or more full-scale implementations of their technology. However, the ability of a treatment system to handle widely-varying sediment and contaminant types remains a challenging issue.

Logistics The availability of space, utilities, time, and other logistics are site-specific issues not addressed in this report other than to mention the importance of considering such issues.

Permitting Issues Two issues make permitting of treatment facilities particularly difficult in Massachusetts: sidestreams and residuals management. Public concerns of sidestreams such as gaseous emissions can bring overwhelming opposition to the siting of a treatment facility. Residuals management is discussed separately below.

Residuals Management The costs incurred while managing residuals can easily result in a treatment option that is not economical. In the best case, the residuals can potentially have a commercial value to help offset treatment costs. Based on the documents contained in Appendix C, it appears that there is limited applicability of the following residuals management options: landfill disposal, recycling as landfill cover, and recycling as asphalt material. In addition, the uncertainties associated with the reuse option will greatly limit its applicability until regulations/policies have been promulgated. Although 88% of the vendors claimed that the treated sediments could be reused, it appears based on discussions of specifics with the vendors that many of the potential reuse options remain ideas and not reality.

Throughput Sediment decontamination technologies screened for the Boston Harbor Navigation Improvement Project had less throughput than required for the project. The vendor survey found that the treatment technologies generally have low throughput ranging from 30 to 2,000 cubic yards per day. Only 6 of the vendors claimed throughput rates in the range of 2,000 to 6,000 cubic yards per day.

Screening Results

The results of the alternative treatment technology inventory (presented below) were used to evaluate the potential for application of these technologies to sediments to be dredged from the Salem Harbor. The survey results are as follows:

- 77% of the technologies are at the full scale/commercial scale of development;
- Vendors offering full scale/commercial technologies have an average of 32 reference sites per vendor;
- Average throughput for all technologies is 754 cubic yards/day (838 tons/day);
- Average treatment costs for all technologies range from $70 to $167 per cubic yard; and,
- The top 4 factors affecting price are: 1) quantity of sediments, 2) moisture content, 3) target contaminant concentration, and 4) characteristics of sediments.

The following is a summary of the potential of each technology studied to solve the dredged material disposal problems in Salem Harbor.

Chelation

This process is used mainly as a means of controlling leaching of metals but it is not particularly effective on organic compounds or dredged material consisting of silts and clays (which make up a significant portion of the sediments to be dredged from Salem Harbor. Metals leaching, even in sediments containing relatively high metals levels, is typically not a problem in upland disposal. Chelation is relatively inexpensive compared to other treatment technologies ($83/cy), buit it requires extensive pretreatment and residuals management.

For the reasons above, chelation is not a viable or necessary technology for the DMMP.

Chemical Reduction/Oxidation

This process is effective in removing inorganics and organics that are present in dredged material. Throughput (172 tons per hour) is relatively high compared to other technologies, however, it's high cost ($232 per cy) makes this technology impracticable for the DMMP.

Dehalogenation

Dehalogenation processes are engineered to destroy or remove some of the halogen atoms from halogenated aromatic compounds such as PCBs, dioxins, furans and some pesticides, thereby rendering them less toxic. However, these are not the chemicals of concern in the majority of the Salem Harbor sediments and, therefore, this technology would not be applicable to the DMMP.

Fungal Remediation

This remediation process are relatively inefficient in their remediation capacity (50% removal). The process also does not treat metals and it's effectiveness in a salt-water media is unknown. In addition, the average cost is $215 per cy. For these reasons, this type of treatment technology is not viable for the DMMP.

Incineration

Incineration is one of the most commonly-used remediation technologies, however, there are several disadvantages to this technology, particularly the air emissions generated from the process. Public opposition to incineration has been strong. A small portable thermal oxidizer was proposed to treat 30,000 cy of on-site generated soils (contaminated with petroleum products only) at an isolated area over a mile from the nearest resident near Logan Airport. Public opposition was so strong that the proposal was withdrawn.

There are several technical shortcomings as well: heavy metals are not destroyed and may become more leachable after incineration; the technology is not effective on high moisture content (like sediments); and, gaseous discharges are created as a new contaminant pathway. The cost is also high at $243 per cy.

For the reasons stated above, incineration is not seen as a viable treatment alternative for Salem Harbor sediments.

In-Situ Bioremediation

In-situ bioremediation technologies have been utilized in Massachusetts for treatment of oil and hazardous materials at contaminated upland sites and could potentially be used for contaminated sediment if the intent is to only remediate the sediments <u>in-place</u>. This is not the case for the DMMP as sediments need to be removed to provide safe navigation. Therefore, this technology is not applicable to the DMMP.

Pyrolysis

Pyrolysis is very similar to incineration discussed above, except that it is used to treat very high levels of organics that are not conducive to conventional incineration. The same policy and technical problems discussed for incineration apply to this technology as well, therefore, it is not a viable option for the DMMP.

Slurry Bioreactor

This technology would require pre and post-tratment actions and extensive sidestream controls. Also, it's effectiveness in treating low levels of organic contaminants is minima. Treatment and disposal of wastewater from slurry dewatering is also required. The average cost of this treatment system is $223 [per cy?]. For these reasons, this technology would not be practicable for treating sediments from the Salem Harbor.

Soil Washing

Soil washing is one of the most common methods for treatment of dredged material. It has been used in the United States and is extensively used in Europe. This technology involves two main stages; particle separation; and, washing by water. Other substances such as chelating agents, acids or surfactants can be added to the process to aid in contaminant removal. Despite it's real world usage for large volumes of dredged material, it is not effective in treating silt and clay sediments, which comprise the majority of sediments to be dredged from Salem Harbor. Sediments that contain a high sand fraction, such as the Salem Main Federal Channel, could benefit from this technology, but at a cost of $89 per cy.

The soil washing technologies available today would not be effective in treating most of the sediments to be dredged from Salem Harbor. However, areas containing a sand/silt mixture could be remediated with this type of technology.

Solid-Phase Bioremediation

This technology includes three basic categories of processes: landfarming; composting; and, in-vessel bioremediation. Landfarming and composting require large areas of land to be effective, particularly for the anticipated dredge volume of 1.1 million cy from Salem Harbor. Also, landfarming does not remediate metals and is ineffective for high molecular weight PAHs, which is one of the primary contaminant types in Salem Harbor sediments. The same limitations are noted for composting. At an average cost of $62/cy, this is the least complicated and least expensive of the treatment technologies.

In-vessel bioremediation is more than twice as expensive as landfarming or composting because it involves engineered treatment enclosures with leachate collection systems and aeration equipment. It too is not effective in remediating metals and is only marginally effective in treating high molecular weight PAHs.

For the reasons stated above, solid-phase bioremediation processes would not likely be practicable for the DMMP.

Solidification/Stabilization

Solidification is effective at immobilizing inorganic contaminants and is one of the most commonly used remediation technologies. It has been used in New Jersey at several shoreline sites including a site in Elizabeth, where the treated dredged material is being used as structural fill for a new shopping mall.

Solidification/Stabilization technologies are potentially viable, however, the end product still needs to find an acceptable final home. That end product can be of a significantly higher volume than the original dredged material because of bulking and the amendments (fly ash, cement, bentonite, lime) that are required to immobilize the contaminants and/or control pH, odor, and sulfide reactivity. This has, to date, limited the viability of this technology.

Lime has been used as an additive to dredged material to contol nuisance odors and sulfide reactivity in Massachusetts sediments that were dredged and then used as daily or intermediate cover at landfills. This was done on dredged sediments from the Central Artery/Tunnel project.

These processes are also relatively inexpensive compared to other treatment technologies. Average cost is estimated at $99 per cy, although the unit cost at the aforementioned New Jersey mall site was $56 per cy (ECDC Laidlaw 1998).

Solidification/Stabilization technologies appear to be the most viable of all available treatment technologies. However, it's applicability to the DMMP depends on the large-scale demand for construction fill. Currently, there is no large-scale demand for fill material that cannot be supplied by upland sources. The costs for upland fill material are significantly less expensive than that of solidified dredged material. If the demand for fill material increases over the next 20 years, and the supply of upland fill material decreases, then solidified/stabilized dredged material could be marketable, cost-competitive, commodity.

Solvent Extraction

This technology is similar to and could be used in conjunction with soil washing technologies to treat contaminated sediments. However, it has a slow production rate (37 tons/hr) and is expensive (average cost $192 per cy). It's effectiveness in treating organic contaminants such as PAHs, PCBs, petroleum hydrocarbons and chlorinated solvents is good, but only for coarse grained materials such as sand. Because the majority of sediment to be dredged from the Salem Harbor is fine-grained (silts and clays), solvent extraction techniques would not be an effective solution to the DMMP. However, it could be used for small-scale project involving organic contamination of coarser grained sediments.

Thermal Desporption

Thermal desporption is very similar to incineration and pyrolysis and has the same problems and limitations as these two technologies. The average cost is $177 per cy. For these reasons, it is not a viable technology for the DMMP.

Vitrification

Vitrification is the most effective treatment system available for treating a media that contains a wide variety of contaminants, such as dredged material. Through exposure to 2,900 °F heat, the soil/sediment is melted and converted into an oxide glass-like slag that would be suitable for landfilling. Vitrification, however, is one of the most expensive treatment technologies at an average cost of $462 per cy. For the cost reason alone, this technology is not feasible for treatment of sediments from Salem Harbor.

Potential Alternatives

Alternative treatment technologies, unto themselves, do not offer any practicable solution to the management of 287,333 cubic yards of UDM from Salem Harbors. This is due to several factors, most notably cost. But the costs for some technologies such as solidification and landfarming, even though comparable to the cost of CAD disposal, do not overcome the fact that there needs to be a permanent receiving site for the treated sediment.

The practicability of finding a receiving site is discussed in Section 4.5.4 below. It is not known at this time, whether treatment of the UDM would be required for disposal at the proposed preferred upland sites; more tests need to be conducted.

Solidification/Stabilization and soil washing are the only forms of treatment that could be practicably used on Salem Harbor UDM, but a receiving site, such as an industrial or commercial development that requires large quantities of construction fill would need to identified, and the treated UDM must be competitively-priced with upland sources of fill material in order for the use of treatment technologies to be a practicable solution for the DMMP. Currently, the supply of upland fill material exceeds the demand for construction fill, and at a much lower price (approximately $20/cy) than that of even the lowest-priced treatment technology. Therefore, alternative treatment technologies are not a viable solution to the management of 287,333 cy of UDM from Salem Harbor.

4.5.3 Dewatering Site Selection

In order to consider upland disposal/reuse as a viable option for the disposal of dredged material, adequate land area is required to accommodate the process to prepare dredged material for final disposal or reuse. A site or series of sites is needed to process and dewater dredged material to reduce the moisture content before transfer to an upland disposal or reuse site. As part of the DMMP DEIR process of exploring potential disposal options, the Consultant Team examined harbor side and upland site requirements for transferring dredged material from the marine environment to the upland environment for final disposal/reuse.

Screening Process

An initial windshield survey of waterfront accessible areas throughout Salem and North Shore coastal towns from Lynn to Rockport was conducted to produce a list of potential dewatering sites. Dewatering site criteria such as size, topography and accessibility were the main factors considered during the initial windshield survey. The potential dewatering sites produced during the initial windshield survey were examined against specific screening factors so that feasible dewatering site alternatives were identified.

The DMMP dewatering screening process is a two tier process involving the initial screening of exclusionary site factors and a second tier screening of discretionary factors. The exclusionary factors only apply to the harbor side site requirements, all other criteria are discretionary. The harbor side requirements are exclusionary because they are the first link in the "dewatering process train", if a harbor side site meeting the minimum requirements can not be located, upland disposal options can not be considered.

Screening Factors

The exclusionary factors for first tier dewatering process screening are described below:

D-1. Proximity to Dredging Site - Located within 10 miles of dredging projects.

D-2. Pier Requirements - Pier or bulkhead with a minimum length of 120 feet. The harbor side site adjacent to the pier must be adequately sized to provide an off-loading area and be capable of accommodating two way truck traffic. An area that does not have a pier/bulkhead may be considered if construction of temporary structure is practicable.

D-3. Water Depth - The pier must have a minimum water depth of 12 feet during all tides. If an area is shallower than 12 feet, but has other positive attributes which could make it a suitable dewatering site, then the site may be considered, but only minimal dredging is required to obtain the necessary water depth.

D-4. Dewatering Area - A minimum area of 3.2 acres is needed to provide for a diked dewatering facility. Additionally, the dewatering facility must provide adequate area to allow the treatment of effluent and/or connection to local sewer system.

Second tier discretionary screening factors include the following:

D-5. Timing/Availability - The site (or sites) must be available for the time frame required by the particular dredging project(s) to process dredged material.

D-6 - Access to Transportation Network - The site(s) should be located in an area that has adequate land side access provided by the existing transportation network. Sites requiring minor upgrading, such as re-paving or constructing a temporary access road may be considered, provided the connecting transportation network is adequate to accommodate the trucking needs associated with the transportation of dredged material.

D-7. Haul Routes - Selected haul routes should avoid lateral or vertical obstructions or any other restrictions. Evaluation of sensitive receptors passed on the haul route should be considered. Other potential logistical problems/conflicts that might be encountered accessing a site should also be identified.

D-8. Present Habitat Types - Sites shall be evaluated for general vegetation cover, presence of wetlands, rare plant/wildlife habitat, and the surrounding landscape.

D-9. Existing Terrain (suitability to diking) - Site examination to determine potential for dike construction.

D-10. Flood Plains - National Flood Insurance Program, Flood Insurance Rate Maps will be consulted for each site to determine if a site is in or partially in a designated flood plain.

D-11. Agricultural Use - Determination of prime agricultural soils on the site.

D-12. Surrounding Land Use - Evaluation of adjacent ownership, present and projected land use. Sites located in industrial or commercial areas are preferred over sites in or adjacent to residential or recreational areas.

D-13. Odors/Dust/Noise Receptors - Evaluation of potential impacts and distance to sensitive receptors of odors, dust and noise from dewatering process methods selected. Sites at a distance from sensitive receptors area preferred over sites adjacent to sensitive receptors.

D-14. Consistency with Port Plan - Each proposed site will be reviewed for consistency with the appropriate Harbor Plan, specifically to determine whether the site(s)enhance the values articulated in the Plan and conform to projected site-specific uses. This criteria is only applicable to sites in Salem.

D-15. Local, Regional, State Plans - Evaluation of consistency with Local, Regional and State long-range plans.

D-16. Ability to Obtain Permits - Likelihood of local, state, and federal regulatory approval.

D-17. Cost - The cost of the construction, operation, and restoration of the site was calculated for comparative purposes.

Screening Results

A total of eight-one (81) candidate dewatering sites were identified (**Figure 4-14**), including twenty-nine (29) candidate sites in Salem. Dewatering sites from Lynn in the south to Beverly in the north were identified, including potential sites in the Towns of Nahant, Swampscott, Marblehead and Danvers. Potential dewatering sites in Salem only are shown on **Figure 4-15.**

All sites were subject to a windshield survey and review of existing information. Each dewatering site was evaluated against the evaluation factors listed above, and a summary of the dewatering screening evaluation is summarized in **Table 4-x** below.

Exclusionary Screening

A strict interpretation of the exclusionary screening criteria resulted in all but seventeen (17) candidate sites failing the screen. Fifteen (15) sites were eliminated because they were located more than ten (10)

Table 4-5: Dewatering Screening Summary

* * * **TABLE TO BE INSERTED** * * *

miles from the nearest dredging project in Salem; thirty-two (32) sites either had no existing piers or bulkheads located on site or were determined to have no practicable means of constructing such a structure; sixty-one (61) sites were determined to be located in shallow water with no practicable means of dredging to gain adequate navigation depths (seventy-seven (77) sites had less than 12-feet of water); and forty-one (41) sites were less than the required 3.2 acres in size.

Discretionary Screening

Carrying the 15 sites surviving the exclusionary screen into the discretionary screen eliminated <u>all</u> of the candidate dewatering sites. Salem and surrounding communities are densely developed, and available land area, particularly bordering the waterfront, is minimal. Waterfront land uses in the communities are active, and sites are generally smaller in size, and bordered by a variety of land uses.

Of the discretionary factors influencing the results, Timing and Availability of all fifteen Potential dewatering alternatives was the main reason for eliminating the sites. All fifteen sites are in active commercial, industrial or park use, and owned by private or public interests. Availability of any of the fifteen Potential Practicable alternatives cannot be assured for the twenty-year DMMP planning horizon.

Other discretionary factors that resulted in the elimination of the fifteen Potential dewatering sites included Transportation Network (3 sites); Haul Routes (4 sites); Habitat Types (6 sites); Existing Terrain (2 sites); Floodplains (13 sites); Surrounding Land Use (8 sites); Odors/Dust/Noise Receptors (5 sites); and Local, Regional and State plans (2 sites).

Although none of the 81 candidate dewatering sites survived the screening process, several of the 15 Potential dewatering alternatives might possibly be considered for use by smaller, individual dredging projects within Salem and surrounding communities. The 3.2 acre minimum site size is a minimum size intended to accommodate the larger dredging projects with larger potential volumes of unsuitable dredged material, such as the maintenance dredging of the Federal Channel or the New Salem Wharf project. Smaller dredging projects will have smaller land are requirements because of the reduced site area required to accommodate a volume of dewatering dredged material for up to one week. Likewise, smaller projects will have a shorter duration, and availability may be less of an obstacle.

If one of the upland sites is selected as the Preferred Alternative, or an alternative treatment technology proves a feasible option in the future, a dewatering site will be necessary. At that time, the dredging contractor can be required to secure a site to be used for dewatering of the unsuitable dredged material. A number of the eighty-one identified candidate sites may be used for this purpose, or the contractor can secure use of an alternate site at the time it is needed.

Potential Alternatives

No dewatering sites survived the screening process within Salem. However, an analysis of a waterfront industrial site in close proximity to the planned dredging projects in Salem Harbor as a typical dewatering site can be provided for purposes of comparing environmental impacts for different disposal and reuse alternatives.

The conceptual Salem dewatering site is located at the northwest corner of Collins Cove. The site includes land owned by both Boston Gas Company and Massachusetts Electric Company. Availability of the site is questionable as the northern portion of the site is currently being used by Boston Gas for storage of liquified natural gas in a large storage tank. The site has an existing pier adjacent to the main navigation channel to the Danvers River and Beverly Harbor. Deepening of the approach to the pier would be required to provide unimpeded access to the pier under all tidal conditions for a 3,000 cy barge. The site has good access to the regional highway network, with state Route 1A located one block to the west. Public access to the site is currently restricted.

The site borders Collins Cove Park to the south. Several residences border the southern half of the site to the west, with commercial uses along Route 1A and the approach to the Beverly-Salem bridge border the northern half of the site to the west. Bordering the site to the east is Collins Cove and to the north is Salem Sound/Beverly Harbor.

Conceptual use of the site as a dewatering site would require either purchase or a negotiated temporary easement from the current owners of the site. As dredging project proponents would have no authority under existing state law to take property by eminent domain, use of the site would require the cooperation of the site owners. Relocation of the existing industrial use of the site may be required.

4.5.4 Upland Reuse Disposal Alternatives

Screening Process

The purpose of the upland screening process is to identify sites where disposal of dredged material would be feasible and least environmentally damaging to the natural and man made environment. This was accomplished by employing a tiered screening process as portrayed in Figure 4-6 The screening was done following the guidelines of 40 CFR Part 230, established under Section 404(b)(1) of the Federal Clean Water Act and complying with 310 CMR 16.00 (Site Suitability Regulations) for dredged materials classified as solid waste by DEP (MDPW, 1990).

The first tier involved the establishment of a zone of siting feasibility (ZSF), i.e. the area that was to be studied for site selection. The ZSF was established based upon a reasonable truck travel distance from Salem Harbor. A 50-mile ZSF Figure 4-17 was scribed because it is the maximum distance a truck could travel to and from the dewatering site in a normal 8-hour working day. This included the time for loading and offloading at the dewatering site and disposal site, respectively. The upland ZSF includes: most of eastern and central Massachusetts, extending as far west as Worcester; most of the New Hampshire coastline; most of Rhode Island; and a portion of eastern Connecticut. Commercial landfills within these states were also investigated.

The universe of upland sites was compiled from the several sources including the following previous siting studies that have been conducted for dredged material disposal and disposal of other materials:

- Boston Harbor Navigation Improvement Project
- Central Artery/Tunnel Project
- MWRA Residuals Management Facility Plan
- DEP Active Muncipal Solid Waste Landfills and Active Demolition Landfills in Massachusetts
- DEP Inactive or Closed Solid Waste Landfills in Massachusetts
- Massachusetts Division of Capital Asset Management Inventory of State-Owned Properties
- Lists of active landfills in Connecticut, Maine, New Hampshire and Rhode Island
- Meetings and conversations with local, state and federal agencies
- Requests for Expressions of Interest in major newspapers and municipal chief elected officials

This compilation resulted in a universe of 1,123 sites within the ZSF. These sites were then subjected to a feasibility screen, where sites that were smaller than the minimum size required to accommodate a certain volume of dredged material were eliminated.

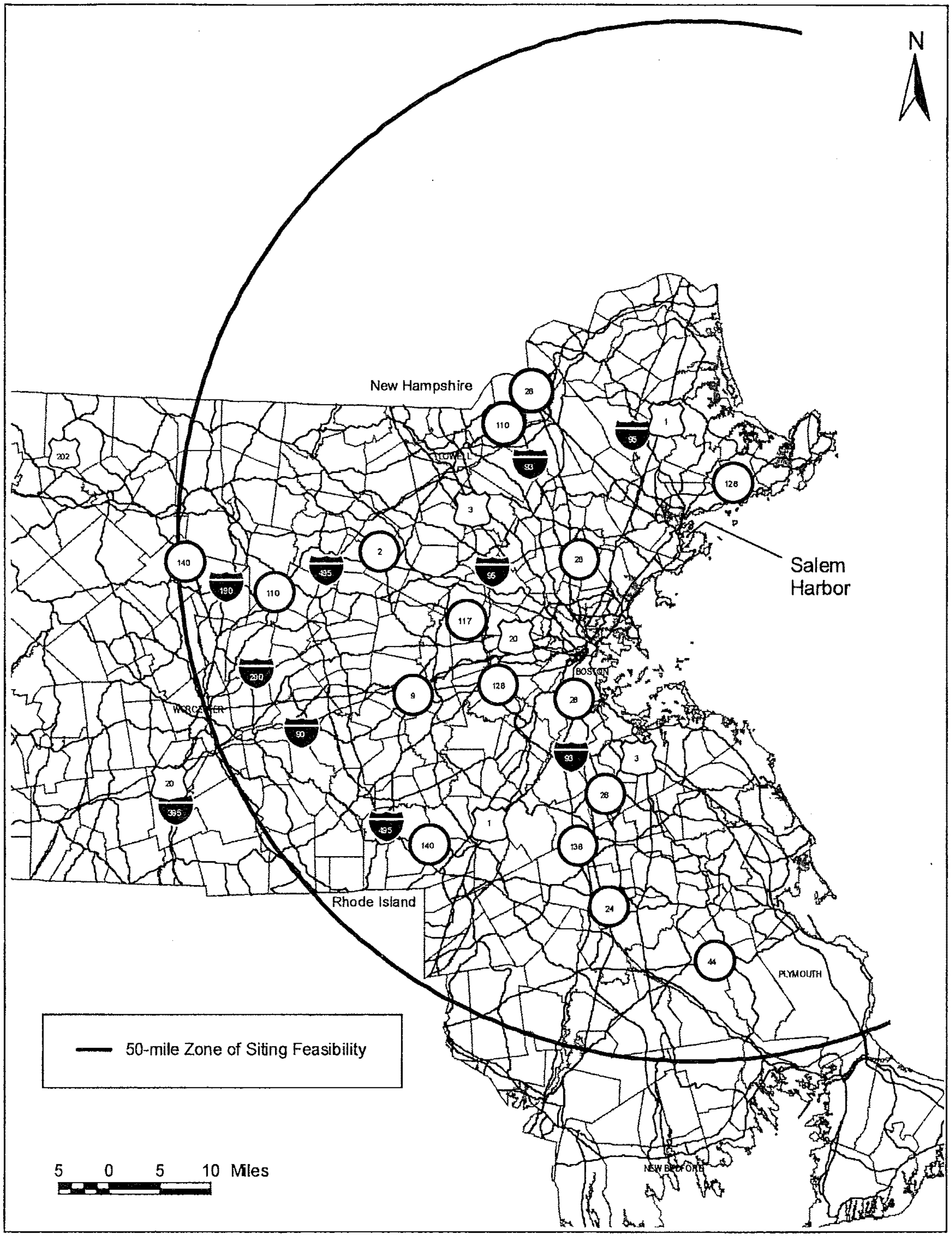


Figure 4-14: Salem Upland Zone of Siting Feasibility

The criteria for determining the minimum disposal site size was based upon two primary factors: 1) the minimum area required to accommodate 10,000 cy of dredged material with; 2) setback distances for solid waste management facilities as specified in the Massachusetts Solid Waste Management Regulations at 310 CMR 19.000. The 10,000 cy minimum volume was selected because it is the threshold for triggering environmental review under MEPA and it is a volume that is typical of smaller, marina dredging projects along the North Shore. A 500-foot buffer distance from the potential disposal area to adjacent properties was assumed as per DEP regulations. This resulted in a minimum disposal area of 25 acres. Any of the 1,123 sites less than 25 acres in size were eliminated. There were 270 sites eliminated based upon this criteria, leaving 853 remaining candidate sites.

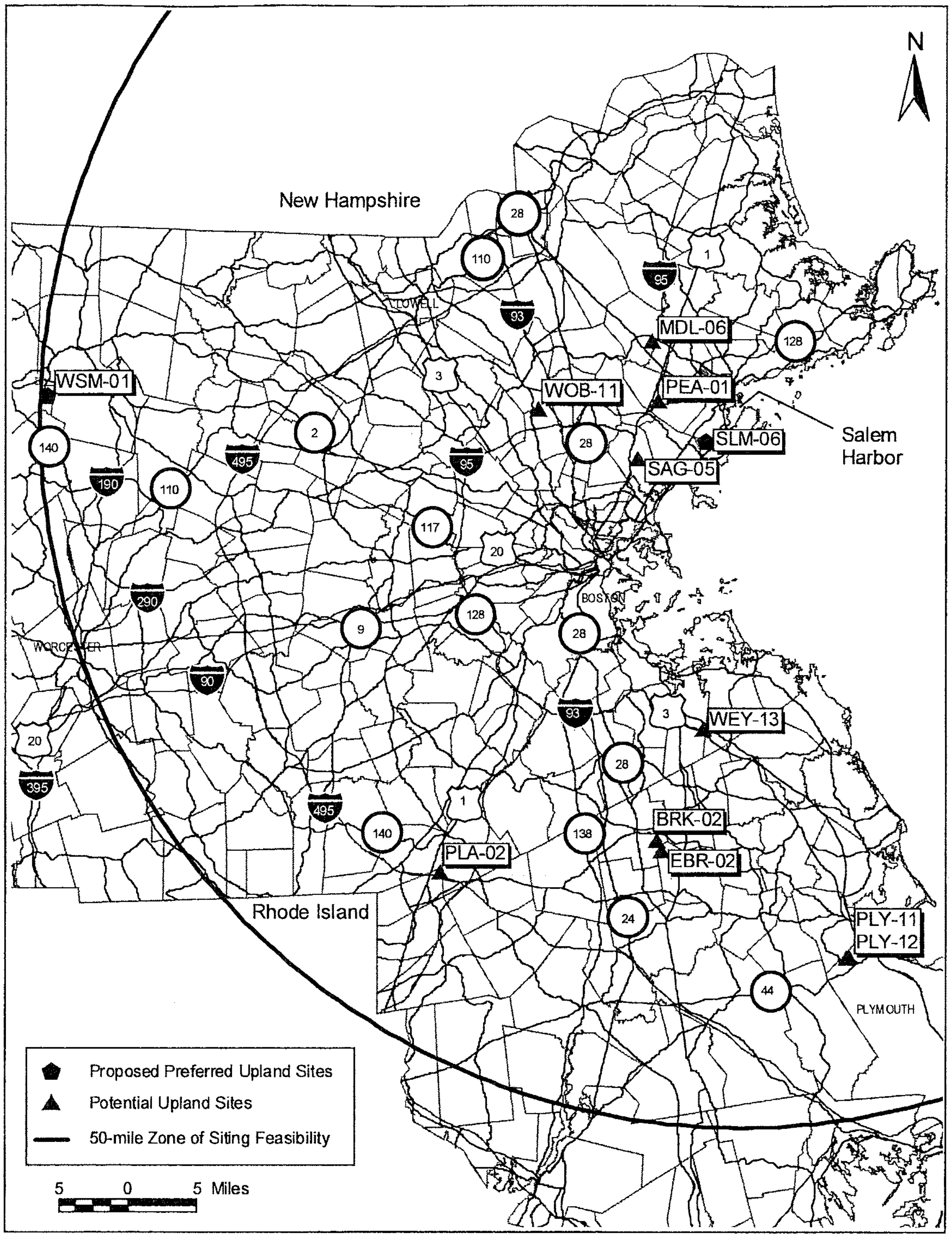


Figure 4-15: Salem Harbor Candidate Upland Disposal Sites

The candidate sites were screened through a series of exclusionary criteria. These criteria are described in detail below. The exclusionary criteria include those factors that would essentially prohibit disposal based upon state or federal law or regulation. For example, if an endangered species is known to be present at a particular site, then that site was eliminated because the federal Endangered Species Act would essentially prohibit any development at this site. After applying the five exclusionary criteria, an additional 837 sites were eliminated, leaving 11 potential alternatives.

The 11 potential alternatives were then evaluated based upon a set of secondary or discretionary criteria, consisting of 15 factors that could affect the feasibility and potential impacts of a disposal site. These factors are described in detail below.

Each of the potential alternative sites Figure 4-18 were then compared, relative to one another, using the discretionary criteria. Finally, DEP policies and regulations related to waste disposal were applied to the set of potential alternatives to determine the relative feasibility of each site for accepting dredged material.

Screening Factors

The upland disposal site screening involved a tiered process. Sites were eliminated based upon a feasibility screen (size, capacity) and the application of exclusionary criteria. The remaining sites were then evaluated using a set of discretionary criteria. Then, the feasibility of obtaining approvals for these sites accepting dredged material was evaluated based upon existing DEP policies and regulations regarding waste management.

The following exclusionary factors were applied to those sites 25 acres in size or greater, i.e. the candidate disposal sites:

U-1. Rare and Endangered Species - (Critical habitat or resource-use area for federal or state listed rare or endangered species or species of concern) - The locations of the sites identified in the initial screening will be provided to the Massachusetts Natural Heritage and Endangered Species program and the US Fish and Wildlife Service for threatened and endangered species review

U-2. Historic/Archeological Sites or Districts - The sites will be evaluated for potential cultural resource constraints through consultation with the Massachusetts Historic Commission and review of any local, State or National designations for the site.

U-3. Drinking Water Supply - Groundwater - Sites were evaluated for proximity to an area with Zone II designation and sole source aquifer designation.

U-4. Drinking Water Supply - Surface Water - Sites were evaluated for proximity to public drinking water supplies, location within one-half mile upgradient of a surface water supply, potential pollutant pathways to a water supply, and potential for water quality degradation.

U-5. Land Designation

U.5.a - National Seashore - Sites were evaluated for federal designation as a National Seashore. Massachusetts Solid Waste Regulations, 310 CMR 19.000, prohibit placement of unsuitable material in a designated National Seashore area.

U.5.b - Wilderness Area - Sites were evaluated for federal designation as a Wilderness Area. Massachusetts Solid Waste Regulations, 310 CMR 19.000, prohibit placement of unsuitable material in a designated Wilderness Area.

U.5.c - Area of Critical Environmental Concern (ACEC) - Sites were evaluated for state designation as an ACEC. Massachusetts Solid Waste Regulations, 310 CMR 19.000, prohibit placement of unsuitable material in an ACEC.

The following discretionary factors were used to evaluate the potential upland disposal sites.

U-6. Groundwater - General - Evaluation of types of aquifers in the vicinity and depth to groundwater at the site.

U-7. Surface Water Quality

U.7.a - Water Bodies and Rivers - Evaluation of set back of site from water bodies and rivers.

U.7.b - Wetlands - Evaluation of set back of sites from wetland resource areas.

U-8. Site Accessibility - Description of most practical route to transport dredged material to the disposal site, including any potential logistical problems that might be encountered during use or construction of the proposed site. Sites should be directly accessible from a regional highway, have a rail or navigable waterway nearby, have a local access route that does not include lateral or vertical obstructions or restrictions, and a local access route that does not pass by sensitive receptors.

U-9. Physical Area of Impact - Evaluation of the amount of land area in acres that would be directly affected by disposal activities.

U-10. Duration of Potential, Adverse Impacts - Estimation of recovery time based on the type of disposal and present site conditions.

U-11. Present Habitat Types

U-11.a - Successional Stage - Evaluation of vegetation stage (e.g., forest grass) and whether wetlands were present.

U-11.b - Degree of Disturbance - Evaluation of the visual evidence of site disturbance.

U-11.c - Diversity of Plant and Animal Species - Evaluation of the type and amount of vegetative cover to estimate species diversity, highlighting the presence of wetlands on or adjacent to the site.

U-11.d - Integrity of Plant and Animal Species - Evaluation of integrity of plant and animal species by considering the degree of disturbance for the site and the surrounding landscape conditions.

U-11.f - Wildlife Function - Assessment of wildlife value by considering degree of disturbance and landscape position.

U-12. Existing Terrain (suitability for diking) - Determination of ability to construct dike.

U-13. Flood Plains - Determination whether site is in or partially in a designated floodplain, consulting National Flood Insurance program Flood Insurance Rate Maps.

U-14. Agricultural Use - Determination of prime agricultural soils on or near the site.

U-15. Adjacent Land Use - Evaluation of adjacent ownership, present and projected land use.

U-16. Risk of Containment Facility Failure - Review of characteristics and engineering requirements for each site to assess the potential stability of material disposed of at the site.

U-17. Odors / Dust / Noise - Evaluation based on proximity to sensitive receptors of odors, dust and noise.

U-18. Local, Regional, State Plans - Evaluation of consistency with local, regional and state long range plans.

U-19. Ability to Obtain Permits - Evaluation of likelihood of local, state, and federal regulatory approval.

U-20. Cost - Estimation of comparative costs for construction, maintenance, and monitoring of proposed sites.

Screening Results

Using the methodology and criteria described in Section 4.5.5, the initial screening narrowed the universe of sites. This initial screening of the Massachusetts sites was conducted using the following:

- Massachusetts Geological Information Systems (MassGIS).
- United States Geologic Survey Topographic Maps.
- Massachusetts National Heritage Atlas.
- Massachusetts Historic Commission maps.
- Bureau of Waste Site Cleanup Sites Transition and Reportable Releases Lists.
- Information gathered in previous reports and databases.
- Information obtained about sites within the city limits of the harbors at meetings with town officials.

Over one thousand sites within Massachusetts had exclusionary constraints, causing them to be eliminated. Table 4-6, summarizes the results of the initial screening.

Table 4-6: DMMP Upland Disposal Exclusionary Site Screening Summary

Site Sources:	Active Landfills	BHNIP	CA/T	DCAM	Planning Depts.	Inactive Landfills	RMFP	UR Parcels	Total Sites
Candidate Sites	37	12	6	380	3	368	312	5	1,123
Sites Failing Exclusionary Criteria:									
Capacity/Status	25	4	0	11	0	162 (2)	67	1	270 (2)
Rare and Endangered Species	0	0	0	37	0 (1)	23	21	0	81 (1)
Zone II Aquifer	1	2	1	19	0	30	71	0	124
Sole Source Aquifer	2	0	1	4	0	17	15	0	39
Surface Water Source	0	0	0	2	0	9	5	0	16
National/Historical Monument	2 (1)	0	0	11	1	62 (1)	68	0	144 (2)
National Seashore	0	0	0	0	0	0	0	0	0
Wilderness Area	1	1 (1)	1	280	1 (1)	37 (1)	59	2	382 (3)
ACEC	0	2	0	31	0	15	14	2	64
21E Site	3 (1)	2	3	4	0 (1)	16 (1)	13	0	41 (3)
Screened by Agency Action	2	1	1	0	0	56	16	0	76
Sites Eliminated	35 (1)	10 (1)	6	378	2 (1)	362 (4)	309	5	1107 (7)
***Potential Alternatives*:**									
in Massachusetts[4]	2	2	0	2	1	6	3	0	16
outside Salem ZSF									5
within Salem ZSF									11

Notes:

1. Sites in parentheses failed the exclusionary screening, but were not eliminated because of their potential as disposal sites.
2. Some sites failed more than one criteria.
3. A site would fail due to capacity/status if: site is smaller than 25 acres, site has capacity less than 10,000 cu yd, site is too narrow to accommodate landfill construction, site has been developed (e.g. residences, industrial park, highway), landfill is closed and capped, landfill only accepts MSW, or site is no longer part of database that included it in this list.
4. Within the overlapping ZSFs of MA North Shore and South Shore Harbors.

Site Sources:

Active Landfills - Active MSW Landfills and Active Demolition Landfills in Massachusetts (DEP, April 1998), Connecticut Active Landfill Sites (CT DEP, February 1998), Rhode Island Licensed Solid Waste Landfills (RI DEM March 1996). Landfills Operating - 1997 (NH DES, November, 1997), and Maine: Operating Landfills (Maine DEP).
BHNIP - Boston Harbor, Massachusetts: Navigation Improvement Project and Berth Dredging Project (April 1994).
CA/T - Central Artery/Tunnel Project: Results of Upland Disposal Site Screening Study (November 1990).
DCAM - Massachusetts Division of Capital Assets Management (formerly Division of Capital Planning Operations) Sites.
Planning Depts. - Suggested during meetings with members of Salem Planning Office (December 8, 1998) and Gloucester Planning Office (December 15, 1998).
Inactive Landfills - Inactive or Closed Solid Waste Landfills in Massachusetts (DEP, April 1998).
RMFP - MWRA Residual Management Facilities Plan (MWRA, 1986 and Black and Veach, 1987).
UR Parcels - Massachusetts Highway Department Uneconomic Remainder Parcels.

The remaining 11 sites either did not have exclusionary constraints or were active commercial landfills or contaminated sediment treatment facilities and therefore could potentially be used as a disposal site for dredged material.

Because the 50-mile ZSF extended beyond Massachusetts, out-of-state sites were also considered. Only active commercial landfills were considered in Connecticut, Maine, New Hampshire, and Rhode Island. Within 50 miles of the harbors, there were two such landfills in Rhode Island and two in Connecticut. All four landfills were screened out, for reasons detailed in Table 4-7. It was therefore determined that there are no out of state facilities that could be used by the DMMP.

Table 4-7: Out of State Potential Upland Disposal Sites

Site #	Town	Site	Reason for Screening
CT-SPR-01	Sprague, CT	International Paper Landfill	Will not accept contaminated soil/sediments as determined by the Connecticut Department of Environmental Protection (Maguire, 1995).
CT-STO-01	Stonington, CT	Connecticut American Water Co. Landfill	Does not accept material for disposal or cover from out of state, but if sediments are guaranteed to meet S1 criteria they may be accepted for construction purposes.
RI-JOH-01	Johnston, RI	Rhode Island Central Landfill	Closed in 1994.
RI-NKI-01	North Kingstown, RI	Hometown Properties Landfill	Closed in 1998.

Potential Alternatives

The 11 potential upland sites in Table 4-8 have been identified based on the initial screening. Detailed information about each of these sites can be found on data sheets in Appendix D. The further screening of these sites is in Section 4.7, where the sites are discussed and the discretionary criteria are applied.

Table 4-8: Potential Upland Disposal Sites

Site #	Town	Address
BRK-02	Brockton	Brockton Landfill, 413 Thatcher St
DAR-06	Dartmouth	Cecil Smith Landfill, 460 Old Fall River Rd
EBR-02	East Bridgewater	Northern Disposal BFI Landfill, 234 Thatcher St
FRV-02	Fall River	BFI-Fall River Landfill, 1080 Airport Rd
MAT-01	Mattapoisett	Mattapoisett Landfill, North St/Tinkham Hill Rd
MDL-06	Middleton	DFA Middleton Colony Parcel, High Rd
OX-Q	Oxford	Oxford Quarry, Old Charlton Rd/Ennis Rd
PEA-01	Peabody	NESWC Ash Landfill, Farm Ave/Dearborn Rd
PLA-02	Plainville	Plainville Landfill, 14 Belcher St/Route 145
PLY-11/12	Plymouth	MHD R.O.W. Parcel Rte 80/Plympton Rd (Map 104, Lots 14/16)
SLM-06	Salem/Swampscott	Bardon Trimount Quarry, Swampscott/Danvers Rds
SAG-05	Saugus	Saugus Landfill, Longwood Ave
WSM-01	Westminster	Fitchburg-Westminster Landfill, Route 31/Princeton Rd
WEY-13	Weymouth	Bates Quarry
WOB-11	Woburn	West of Route 38 at Wilmington line
WOR-03	Worcester	Greenwood Street Landfill, Greenwood St

4.6 Detailed Screening of Potential Aquatic Disposal Sites

4.6.1 General

This section of the Salem Harbor DMMP DEIR presents a more detailed description of the screening process for potential preferred aquatic disposal sites within the Salem aquatic ZSF.

4.6.2 Sediments and Water Quality

Short-term Water Quality Impacts

The disposal of dredged material unsuitable for open-water confinement can directly impact short-term (hours to days) water quality conditions within and adjacent to the disposal site, and can consequently have an adverse effect on biological resources. During a single disposal event, up to several thousand cubic yards of material may be released from a scow located directly over the disposal site. As the sediment descends from the scow to the seafloor, a plume will be produced as fine-grained particulate matter becomes entrained in the water column, generating elevated suspended sediment concentrations. The plume may also contain elevated concentrations of chemical contaminants, associated with very fine-grained sediment particles when the dredged material is exposed to the water column.

Previous studies of short-term differences (one week) in water quality have shown an increase in turbidity, total suspended solids (TSS), total organic carbon (TOC), ammonia (NH_3), nitrate (NO_3), nitrite (NO_2), total phosphorous (TP), chlorophyll, and a decrease in dissolved oxygen (DO) at disposal sites. Other properties such as temperature, salinity, and pH were not altered (Rees and Wilbur 1994).

Elevated suspended sediments during disposal can affect aesthetics, light penetration, feeding by benthic organisms and fish, and at very high levels can kill aquatic organisms. However, water quality conditions typically return to baseline values in a short period of time (hours)and benthic resources impacted by open-water disposal generally recover over time (months). Typically, an assessment of short-term water quality impacts can be estimated prior to disposal using computer models and then validated using comprehensive water quality monitoring conducted during disposal events.

The predominate effects of the disposal of dredged material on biological resources are elevated suspended solids, exposure to increased contaminant concentrations, and burial of non-mobile benthic resources. Although organisms can typically tolerate adverse conditions for a short duration, exposure to high concentration of contaminants over sufficient time can be detrimental to marine organisms. Complete mortality of sessile benthic or low-mobility demersal organisms is expected within the disposal site footprint causing a short-term loss of benthic productivity. Motile organisms such as marine mammals or fin fish have reduced risk since they are capable of quickly evacuating the site. Fauna located downstream from the disposal should be able to tolerate short-term fluctuations in DO and TSS associated with disposal events, although disposal is likely to temporarily reduce feeding. Reduced water quality conditions and elevated suspended solid concentrations may cause gill abrasions, lower pumping rates, and reduced predation capabilities through lower visibility and lower chemo-reception capability (Stern and Stickle 1978). Disposal times should also be scheduled to avoid coinciding with anadromous/catadromous fish runs and seasons of demersal fin fish and shellfish spawning/nursery activity. High suspended solids and associated chemicals from dredged material would mask the ambient chemical signals necessary for anadromous fishery migrations. Furthermore, lower life stages of aquatic species are at greater risk to reduced water quality conditions.

The following sections describe three potential short-term water quality impacts that may occur as a result of dredged material disposal:

Sediment Loss

The disposal of silty dredged material in aquatic environments typically results in dispersion and loss of 1 to 5 percent of the sediments away from the disposal location (Truitt 1986). This loss of contaminated material outside the confinement zone poses an increased toxicity risk to marine organisms. A number of factors may influence the rate of sediment loss including the frequency of disposal, the volume of material being disposed, the type of disposal site, and local hydrodynamic conditions. Typically a small percentage of disposed sediments accumulates like an apron outside the disposal site boundary. The water quality impact from these losses would be minimal since exposure concentrations would be low, particularly when this thin layer mixed with ambient sediments.

During the disposal of dredged material from a scow, the sediment behaves in three separate phases: convective descent; dynamic collapse; and passive transport and dispersion. During the convective descent, dredged material released from the barge falls very rapidly through the water column due to combination of gravity and momentum from the release. Most of the material falls as a mass during the descent to the ocean bottom, but some of the sediment (3 to5 percent) becomes entrained in the water column and forms a low density plume. During the dynamic collapse stage, the descending stream of material impacts the sea floor and spreads horizontally. Sediments suspended in the water column may be advected away from the disposal site by ambient currents and turbulence during the passive transport and dispersion phase (ACOE 1998).

Short-term water quality conditions may also be influenced by the frequency of disposal. Typically, the disposal of dredged material is scheduled to provide a sufficient time-lag between events to ensure water quality conditions have ample time to return to near-baseline conditions. However, an accelerated dredging production rate may require the repetitive discharge of material, thus dumping a second load before water quality conditions have return to ambient levels. In this situation consecutive disposal events would exacerbate already deteriorated water quality conditions generated by previous disposal events. Because of the additive effects of repeated discharges, suspended solid concentrations are more likely to exceed chronic and acute water quality criteria during these repeated disposal events (See Draft Disposal Management Plan Section 9.0).

The type of containment site and the capacity of the site will also influence the amount of sediment lost. For instance, a pit (CAD/OD or ATC) that has been excavated from the ocean sea floor is more likely to prevent the lateral spread of disposed material than a open-water site where mounds of material are created on the sea floor. This is because the wall of the pit site acts to confine the horizontal spread of the material. By the same principle, an empty CAD cell tends to retain suspended material better than a full or nearly-full cell because an empty cell has deeper walls and thus a greater vertical barrier to prevent spreading. If more than one disposal is necessary to fill a cell, than the physical forces produced by each subsequent disposal may act to resuspend and displace material already present in the disposal cell.

Material should not be lost when disposing into a Confined Disposal Facility (CDF) because these sites require some type of seaward confinement structure, such as a berm or bulkhead, which would prevent the diffusion of sediment beyond the confines of the disposal site. Differences among the open water disposal alternatives (i.e., CAD, ATC, open-water CAD) would also vary as a function of water column depth. The volume of water through which the material must travel and the current regimes would influence the concentration of the of the suspended particles and distance of dispersal. The greater water depth and more variable current regimes at the offshore Salem Harbor sites would likely contribute to greater sediment loss and dispersion than inshore sites.

Other factors such the amount of marine vessel traffic over the site and propeller wash by the dredge scow may also contribute to higher sediment loss. Sediment loss is also influenced by the water content and grain size of the disposed material. For instance, a higher concentration of fine-grained sediments and a greater percentage of water in the dredged material will contribute to greater suspended solids, larger plume area, and protracted TSS concentrations. Current velocities, tidal frequency, and meteorological conditions may also contribute to sediment loss.

Pollutants

The introduction of contaminated sediments into aquatic systems by dredged material disposal represents a potential short-term source of pollutants to the environment. Short-term water quality impacts may result from unsuitable dredged material disposal by initiating the release or dissolution of water-soluble contaminants present in sediments as the material falls to the sea floor. Also, the physical disturbance of sediments from the disposal process may mobilize and release insoluble components that had previously been strongly sorbed to sediment particles (Thibodeaux et al. 1994). The suspension of contaminants in the water column dramatically increases the risk of exposure to aquatic organisms, as these particle are more likely to be become bioavailable through ingestion, filtration, or entrainment on respiratory surfaces.

The prediction of water quality impacts during the disposal phase can be assessed using water column testing. The primary objective of testing is to determine whether the sediment plume created during the disposal substantially will affect marine resources, although previous studies suggest that no unacceptable water column impacts are expected (USACE/MPA 1995, USACE 1998). Testing is conducted by measuring the amount of contaminants released to the water column from the sediment using elutriate tests, and assessing the toxicity of the materials by exposing sensitive species to samples of the plume material. These test are commonly conducted during the dredged material evaluation stage.

Modeling of the disposal plume can also be conducted to test whether sufficient dilution of the material will occur within a short time period, minimizing the possibility that chemical concentrations will exceed water quality criteria. Elutriate testing will determine which contaminants meet water quality criteria without any mixing. The pollutants identified by elutriate testing that exceed water quality standards can be examined using the STFATE (Short-Term Fate) model to determine if mixing and dilution during the disposal process would meet water quality standards. For instance, elutriate testing in Boston Harbor indicated that contaminants such as mercury, copper, and PCBs could be released from the sediment particles as the dredged material descends through the water column to the disposal sites, thus proper disposal precautionary measures as well as intensive water quality modeling were implemented (USACE/MPA 1995).

The STFATE model simulates the single release of material in an unbound region with steady current velocities. The model tracks the evolution and dispersion of the plume as it sinks through the water column, contacts the bottom, and is dispersed. The model predicts the bottom accumulation of material and the size and extent of the tracer cloud in open water at various times, depths, and distances from the disposal point (Johnson 1990). In addition, the Applied Science Associates (ASA) WQMAP model system is able to predict the distribution of pollutants at potential disposal sites based on variation in currents in time and space. The system incorporates a hydrodynamic model which predicts current velocities and direction as a result of river flow and tides to determine the pollution concentration over time. The model also incorporates estimates of settling velocity and loss rate depending on the specific constituent being modeled (USACE/MPA 1995).

Dissolved Oxygen

The reduction in DO during disposal can be attributable to a chemical reaction of the most frequently encountered, readily oxidized chemical compounds found in marine and estuarine sediments (i.e., ferrous iron and free sulfides). However, the DO decline related to the dispersion of the plume in both time in space is trivial due to the transient nature of the dispersing plume. The more significant effects of disposal of dredged material is related to accelerated BOD (Biological Oxygen Demand) and COD (Chemical Oxygen Demand) that takes place at the sediment water interface of the dredged material over the first few months after deposition. These influences include: (1) direct utilization of dissolved oxygen from the water column by aerobic activity in the surficial sediments leading to hypoxic or anoxic conditions in near-bottom water, and (2) release of essential nutrients from the water which can stimulate phytoplankton growth, followed by deposition and decay of phytoplankton biomass at the sediment interface and further depletion of DO in deep waters.

Until there is adequate recolonization of the sediment surface, and bioturbating macrofauna and meiofauna oxidize the surface to a depth of several centimeters, there will be a measurable sulfide flux out of the sediment water interface and into the benthic boundary layer. Sulfide fluxes are known to attract pioneering polychaete species (e.g., Capitella) onto disposal surfaces. These dense populations of tube-dwelling and bioturbating species play and important role in enhancing BOD and COD. Depending on ambient water temperatures, BOD and COD rates will decline after a few months as the inventory of reduced compounds at, or near, the sediment surface are oxidized away (Don Rhoads, pers. com.).

<u>Long-Term Water Quality Impacts</u>

Successful disposal of contaminated sediments in aquatic environments is based upon the premise that contaminants can be permanently isolated from biological and physical processes through confinement in disposal a cell. Assuming physical confinement can be achieved and maintained, then there is no reason to suspect that there will be any significant long-term water quality impacts. Field data collected from several confined disposal operations confirms that this hypothesis holds true in the majority of instances. But occasionally, either due to extenuating physical or biological disturbances, or unexpected design or implementation flaws, adequate containment of contaminated material is not achieved. It is during these unlikely circumstances that water quality and marine resources may be compromised by exposure to contaminants which are no longer adequately isolated.

Given the dynamic nature of aquatic environments some degree of disturbance and cap failure is plausible. The biggest threats to containment failure include 1) storm-induced scouring of the sea floor, 2) small, but continuous erosion of cap material from currents, 3) biologically-induced bioturbation of the cap, and 4) human disturbances from propeller wakes, ship anchoring, or trawling activity. Given sufficient consideration and contingency planning, the impact of other factors can be minimized through over-compensation in disposal design, and thus long-term water quality can be ensured.

Existing water quality conditions within Salem Harbor, although by no means pristine, are sufficient to support diverse and abundant assemblages of marine species. Trawl surveys , sediment profile imaging, and lobster trawling have unequivocally documented the presence of economically and ecologically important marine resources. Protected bodies of water provide important habitat conditions to support the development of lower life stages of fish and invertebrates. Multiple conditions make the bays and inlets suitable for spawning and nursery activities including optimum temperature and salinity, high food availability, and structures providing protection from predators (i.e. SAV's, oyster reefs, cobble/rock). It is essential that disposal activities ensure the long-term integrity of these habitat conditions and meet Water Quality Standards imposed by the Commonwealth of Massachusetts.

It is commonly recognized that the impact of dredged material disposal is short-term, (<6 months) if contaminated material is successfully isolated. In fact, the siting and selection of the proposed preferred alternatives has given considerable consideration to minimizing water-quality impacts. It was recognized that selecting disposal sites within or adjacent to dredging activities would have the effect of reducing the net disturbance to water quality since these locations would likely be disturbed by dredging in any case.

Although there a multiple potential long-term impacts of dredged material disposal on water quality, more conclusive and accurate predictions will not be possible until modeling is conducted. For instance, the Coastal and Hydraulics Laboratory of the U.S. Army Corps of Engineers, Waterways Experiment Station for the New England District used a numerical model to predict the long term fate of sediments (LTFATE) and the potential stability of sediment caps at the Portland Disposal Site, Maine. Results from the model showed amount of capping material needed to provide protection for the capped sediments even under extreme wave conditions based on predicted erosion from such waves.

A potential unintended consequence of deepening the navigational channel and dredged material disposal on the channel sea floor would be to alter current bottom circulation patterns within Salem Harbor. Although the channel deepening is unlikely to be significant enough to alter the tidal prism, changing the water column depth may have the effect of reducing existing flushing rates. Circulation within both harbors is dominated by tidally-generated and wind-induced forcing mechanisms. The magnitude of these physical forces is inversely proportional to water column depth. Thus alterations in hydrologic conditions by deepening may further reduce vertical water column mixing, particularly during stratified summer conditions, and thereby exacerbate reduced DO concentrations in near-bottom waters.

In addition to reducing bottom DO concentrations via altered hydrologic conditions, the introduction of organically-rich capping and dredged material may further deteriorate water quality conditions by increasing biological and sediment oxygen demand. Biological oxygen demand will increase at the sediment-water interface within days after the disturbance as pioneering benthic species begin to recolonize sediment. Colonization and BOD will increase until a maximum carrying capacity is reached after several months (500- 600 days; Rhoads et al. 1978) or until nutrients are depleted. Post-disposal abundances typically will exceed pre-disturbance organism numbers, exerting additional demand on limited oxygen availability. Furthermore, the introduction of sediments rich in organic material will stimulate increased microbial activity within sediment pore waters, contributing to reduced and potentially anaerobic conditions in sediments below the water interface.

The failure of the cap material and the subsequent exposure of contaminants to the aquatic environment poses the greatest risk to long-term water quality. In the event cap failure, the contaminants will no longer be isolated from the environment and thus may be subjected resuspension, dissolution, or ingestion by biological organisms. Once chemicals are no longer isolated, the risk of dispersion and potential exposure to human activities increases dramatically. Biomagnification of contaminants up the trophic food chain or advection of contaminants to other location frequented by humans are two possible scenarios. Other possible effects from exposure include increased marine organism mortalities, reduced finfish and shellfish reproductive capability, reduced larval and egg survival, reduced feeding rates, or decreased growth rates. The risk of exposure can be minimized through periodic biological monitoring of benthic organism recolonization rates, early-detection of cap failure, and enacting a contingency response plan.

Sediment Composition

The composition of the existing sediments at three general areas are discussed: Salem Harbor and offshore in Massachusetts Bay. The existing character of the sediment was sampled during both the DMMP dredged material evaluation study (Maguire Group 1997) and during the habitat characterization study (SAIC 1999a). In addition, potential sources of contaminants to the sediments of Salem Harbor was evaluated during the Due Diligence study during the DMMP Phase 1 (Maguire Group 1997).

Fine-grained sediments (>4 phi) dominate the potential alternative aquatic disposal sites in Salem Harbor (Figure 4-19). This type of sediment suggests a low-energy, depositional environment. This characterization is in close agreement with sediment testing results conducted in 1997 in support of the Salem Port Development Plan and New England Power Basin (Maguire Group 1997). The Salem Port Development Plan testing area overlies portions of the S3-CDF, S6-CAD/OD, and S16-CAD potential alternative aquatic disposal sites. Also, the New England Power Basin testing area coincides with the southern portion of site S6-CAD/OD. Sediment tests on composite grain samples, consisting only of the upper 2 feet of sediment, revealed that areas within site S6 contained sediments that were greater than 75 percent silt and clay and areas within site S-16 were less than 50 percent silt and clay (Figure 4-19).

Other physical parameters were also evaluated using sediment profile image data to provide further insight into the sediment character. Typical indicators of a depositional environment, for example, are a high apparent redox potential discontinuity [definition?] (RPD) value (less than 3 cm) and the presence of Stage III taxa. The Salem Harbor sites showed high RPD values, indicating good sediment aeration, good tidal flushing, and bioturbation by Stage III organisms (subsurface deposit-feeders) for all sampled sites except S3-CDF, S16-CAD, and S19-CAD. Images from sites S3 and S19 primarily displayed 2 to 3 cm RPD values while images from site S16 primarily displayed 1 to 2 cm RPD values. All three of these sites exhibited successional stage designations of Stage I. Lower RPD values and a Stage I designation are normally indicative of high-disturbance regimes. The Salem channel (S6) and the adjacent to channel (ATC) (S14 and S15) sites exhibited fine-grained sediments with successional designations of Stage III or Stage I on III and RPD depths exceeding 5 cm. These successional designations and RPD values are indicative of low-energy regimes and thus depositional environments.

<u>Offshore Salem</u>

The sediments in the area offshore of Salem in Massachusetts Bay demonstrated a wide variety of sediments, ranging from those dominated by silt and clay, to sand, gravel, and rocks. Data specific to the offshore disposal sites demonstrated this variability. Of the eleven offshore sites, five of the distant deep water sites (SG-3, SG-7, SG-9, SG-11 and SG-12) were dominated by a fine-grained sediment type, providing evidence that these sites may be depositional (Figure 4-21). Subsurface deposit feeders (Stage III) tend to favor organic-rich, soft mud bottoms, but most of the Salem sites were characterized by more compact, silty or sandy sediments and hence resulting in the scarcity of Stage III organisms.

REMOTS® images for several Salem sites (SG-2, SG-4, SG-5, SG-6, SG-8, and SG-10 - a mixture of near-shore and deep water locations) repeatedly showed sediments consisting of rocks (less than -1 phi) and medium to very fine sand. This mix of rocks and sand is typically indicative of an erosional environment given the high-energy regimes that normally coincide with these types of sediments. Of those sites containing sediments of less than -1 phi, SG-2, SG-8, and SG-10 coincide with "sediment re-working" areas delineated by Knebel and Circe (1995).

Hard sand/rocky sediment environments typically are indicative of higher near-bottom energy regimes, and thus erosional sedimentary environments. Salem Harbor's open water sites (S12-CAD & S13-CAD), located south of the harbor, displayed sandier sediments ranging from hard fine to medium sand and unconsolidated fine sand habitats. These sites also occurred in "sediment re-working" areas (Knebel and Circe 1995).

Circulation Impacts

The containment of disposed dredged material in aquatic environments is dependent upon a number of physical and biological factors known to influence and disturb benthic sediments. Local and regional sediment transport in coastal waters is a natural process that is a consequence of the transfer of energy from tidal and wave currents to the movement of sediment. However, the type of sediment moved, the quantity, and the location it is moved to is dependent upon the energy and direction of the currents. And while dredging and dredge material disposal may alter the distribution and quantity of sediments within a coastal body, sediment is constantly being supplied to Salem Harbor through riverine input and redistributed within the coastal body by water movement. Aquatic dredge material disposal planning must properly consider baseline and episodic events which will influence oceanographic conditions at the disposal sites, and thereby insure that the integrity of the disposed material is maintained despite the dynamic nature of estuarine environments.

Immediately following the disposal of material, the disposal mound or site undergoes the "remolding phase" in which compaction, local erosion, and redistribution of mud clasts occurs. Over a period of several months, the cap becomes dominated by coarser grained material as finer material is eroded away. Eventually, equilibrium is reached when grain size of the surface material exceeds the critical erosion velocity. At this stage the surface of the material becomes armored with a layer of sand, shell, and gravel (SAIC 1994).

Hurricanes are the single most important cause of sediment dispersal in aquatic environments. Hurricanes pass through New England about once every 7 years and can potentially be an important source of turbulence, causing the dispersion of surface sediments from disposal sites. For instance, loss estimates from Long Island Sound disposal sites indicate that 27 percent of the total mass of dispersal sediments is accounted for by hurricanes (SAIC 1994).

Other physical factors may influence the containment stability of the disposal site including duration and frequency of tides, water depth at the site, fetch, regional weather patterns, and inertial currents. For instance, sites in deeper water may have greater protection from storm and wave action since the magnitude of surface currents is reduced with increasing water depth. Higher wind-generated currents, including those at the bottom, generally occur in winter months in New England when strong winds blow at the greatest frequency. Episodes where significant wave heights rose above the peak are generally correlated with local wind events associated with atmospheric low-pressure systems during winter (SAIC 1999b).

Numerical schemes are also available to evaluate the potential for given bottom sediment populations to be resuspended and transported due to the combined influence of waves and currents. Actual measurements taken at the proposed disposal sites can help validate predicted current and wave conditions generated by the numerical model. For example Applied Science Associates, Inc. (ASA) developed a report on velocity estimates for five disposal sites located in Narragansett Bay to determine mean and soring, tide-driven, peak, and vertically-averaged velocities. Based on peak vertically-averaged velocities, ASA was able to estimate the erosional depth at each site using the LTFATE computer-based erosion model. The output from the model, can be used to evaluate the sediment size classes that might be expected to be resuspended and transported from the disposal site (SAIC 1999b).

Bioaccumulation in Plants and Animals from Disposal Sites

Bioaccumulation is a general toxicological term used to describe the net uptake of chemicals by one or more possible routes (i.e., respiration, diet, dermal) from any source in an aquatic environment where chemicals are present (i.e., water; dissolved, colloidal, or particulate organic carbon; sediment; or other organisms). Bioaccumulation of contaminants is of concern both for its possible negative effect on ecologically and economically important estuarine species, and the potential for contamination of higher trophic levels, including humans.

The accumulation of chemicals by organisms in aquatic environments is based on the interaction of a variety of physical, chemical, and biological characteristics and processes. These characteristics may influence a number of other factors which determine whether contaminants bioaccumulate in plants or animals including the characteristics of the contaminant (i.e., grain size or total organic carbon content), the location of the sediment, and the type of plant or animal. Aquatic animals are particularly susceptible to bioaccumulation of toxins since their systems are physiologically designed to facilitate the exchange of oxygen and other essential molecules through gills and other body surfaces. Plants can absorb contaminants directly from the sediments, whereas animals either accumulate contaminants directly from the sediments, through pore water partitioning across cell membranes, or by feeding on vegetation or other animals exposed to the sediments.

Many of the pollutants entering marine/estuarine environments from industrial discharge, atmospheric deposition, and non-point source runoff are accumulated in the bottom sediments. Marine animals bioaccumulate chemicals in their tissues when exposed to sediments or seawater containing bioavailable forms of metals or organic chemicals, often to concentrations higher than those found in the sediments or water column (Brown and Neff 1993). For instance, bivalve mollusks are excellent accumulators of metals and organic contaminants since they are typically found at the sediment surface interface and filter large quantities of water. However, biomagnification of sediments at higher trophic levels has only been substantiated for certain pesticides (DDT and DDE), polychlorinated biphenyls (PCBs), toxaphene, total and methyl mercury, and arsenic in aquatic environments (Dillon et al. 1995).

In water, a chemical can exist in three different basic forms that affect its availability to organisms: dissolved; sorbed to abiotic or biotic components and suspended in the water column or deposited on the bottom; and incorporated into organisms.

Dissolve (i.e., water soluble or hydrophilic) chemicals are readily available to organisms in the water column. Hydrophobic (i.e., low water solubility but fat soluble or lipohilic) chemicals may be sorbed on chemicals, large suspended organic colloids, or other particulates and may be generally unavailable. Some of these bound chemicals may be most available to benthic organisms through ingestion or direct uptake from the interstitial water. Sediment bound chemicals are typically most available when the sediment is disturbed by dredging or when bioturbating organisms burrow into surficial sediments. "Free" and/or dissolved chemicals are often more available for organism uptake and may be potentially toxic. Conversely, reduced bioavailibility is associated with chemicals bound to sediment particles in the aquatic environment.

The basic form of a chemical can be determined by its chemical properties in aquatic environments. Organic pollutants can be divided into two general classes: compounds such as acetone with high water solubility and low Kow (octanol -water partition coefficient) values that do not tend to adsorb to particulates; and compounds such as DDT, dieldrin, PCBs (polychlorinated biphenyls), and heavy metals with low water solubility, high Kow and readily partition to particulates. The second suite of pollutants most readily adsorb to sediments where they can be bioaccumulated by benthic organisms and then transferred to higher trophic levels. (Lee 1996). Heavy metals can move into aquatic food webs when metal constituents become unbound from sediment particles. These contaminants can become available to plants and animals when sediments become acidic due to the oxidation of sulfides, decomposition of organic material, or drying (USACE 1998).

As a result of large surface-area-to volume ratio and other factors (e.g surface electrical charge), fine grained sediments typically have large adsorptive capacities for chemicals compared to coarse-grained sediments. For this reason, fine-grained sediments are responsible for much of the chemical transport in lakes, estuaries, near shore coastal areas. The largest volume of surface sediments is associated with the interstitial water that is found in the open spaces between the particles of sediment. Conditions within the pore water may vary considerably with that of the overlying water due to the interaction of particulate matter and the water. Consequently, the concentration of chemical contaminants within sediment pore waters may be many times higher than that in overlying water.

Bioavailability is a critical concept in determining the effects of contaminated sediment introduced through dredged material disposal since contaminants that are present, but not bioavailable are unlikely to produce any adverse effects if organisms are exposed. There are several factors which can influence the bioaccumualtion potential of contaminant exposure. Environmental availability is a factor which estimates the portion of the chemical present in the environment that is exposed to physical, chemical, or biological modifying processes. For instance, if 60 percent of the contaminated material is well isolated in deep marine sediment, than only 40 percent of contaminants are environmentally available for possible bioaccumulation. The second bioaccumulation factor assesses the amount of material that an organism actually accumulates when it processes or is exposed to environmentally available material. For instance, the environmental bioavailability may be a measure of the ratio of the amount of material a suspension feeding organism clears from the water to the rate of encountering the contaminant in water or food. Lastly, the toxicological bioavailability of the material will influence bioaccumulation effects. This factor measures the amount of biologically available contaminant that actually reaches the site(s) of toxic action through the process of absorption, circulation in the organisms, biotransformation, and excretion.

A number of ecological and human health impacts can occur as a result of bioaccumulation of sediment-associated pollutants by benthic organisms. Benthic organisms have a higher risk of contaminant accumulation since many pollutants readily adsorb to sediments. Bioaccumulation of pollutants by benthic organisms can cause both chronic and acute effects which alter benthic community structure and function. Because benthic organisms are an important food source for many fish and invertebrates, predation on contaminated benthic organisms is an important pollutant uptake route. Transfer of the pollutants can continue to higher trophic levels such as seabirds, marine mammals, and humans, once introduced to the pelagic foodweb (Lee et al. 1989).

Capping

The risks associated with the disposal of unsuitable dredged material into the marine environment can be greatly reduced by confining and capping the contaminated sediments. The primary purpose of capping the disposed dredged material is to isolate the sediments from the surrounding environment, thereby reduce exposure to biological activity and the water column. Determining the thickness of the cap necessary to isolate contaminated material from the aquatic environment is dependent on: the degree of erosive currents, human disturbance of the cap (i.e., trawling, propeller wash, lobster pots), the nature of the dredged material and contaminants, and burrowing capability of the benthic community (SAIC

1997). Thus the measurement of storm-induced bottom currents, the potential for sediment resuspension by marine traffic, and benthic species composition to determine the maximum depth of burrowing are necessary prior to disposal in order to accurately predict the depth of the cap material needed to effectively isolate the dredged material.

The US Corps of Engineers Waterways Experiment Station (WES) has conducted several capping demonstration projects to assess the ability of various sediments to isolate contaminated dredged material (USACE 1986, SAIC 1988). WES found that caps containing higher quantities of silt and clay were more effective in preventing the loss of contaminants to the water column or benthic biota than those made of sand. Normally metals will bind with clay mineral particles and sulfides whereas organic contaminants normally bind to natural organic particles within the sediments. Thus a cap of mostly silt and clay with high concentrations of organics would retard contaminant migration better than sand (USACE 1998), however sand is more effective at resisting erosion and reducing the depth of bioturbation.

Despite the effectiveness of the cap, some degree of contaminant advection is expected. Typically, pollutants in areas of higher concentration will naturally migrate to areas of lower concentration through a slow process of molecular diffusion. However, this process can be accelerated if the cap has been breached by bioturbation or sediment loss. Thus the calculation of cap material coverage must incorporate sufficient buffer to minimize the impacts of some degree of biologically-induced vertical mixing to ensure contaminant containment (Murray et al. 1994).

Testing

Given the importance of determining the bioaccumulation of contaminants by benthic organisms, scientists have developed scientifically credible and cost-effective methods to measure benthic tissue residues resulting from exposure to sediment contamination. Bioaccumulation tests are conducted when sufficient evidence exists (i.e., sediment bulk chemistry) that suggests contaminant availability in the sediments. The tests are performed to determine the potential for contaminants to be taken up in the bodies of organisms, with the possibility of entering the food chain. Contaminants examined in the bioaccumulation tests are selected based on contaminant concentration in the sediments, its potential to accumulate, and its toxicological importance. The contaminants to be selected for analysis are typically chosen through consultation with state and Federal regulators (i.e., DEP, EPA, NMFS, and FWS), and by considering the bulk sediment concentrations of chemicals in the dredged material and their potential for bioaccumulation and toxicity (USACE/MPA 1995).

A variety of chemicals commonly found in sediments dredged from industrialized urban area may be bioaccumulated by aquatic organisms. For example, organic contaminants such as PCBs, which are highly resistant to metabolic degradation, can accumulate to high levels in animal tissues (USEPA/USACE 1991). PAHs (polycyclic aromatic hydrocarbons), on the other hand, although readily taken up by organisms, may not be present in high concentrations in the tissue due to rapid metabolization. Thus, tissues with relatively low concentrations of organic chemicals may "...suggest either low bioavailability and therefore low bioaccumulation, or that bioaccumulation was followed by metabolization" (USEPA/USACE 1991). Thus, bioaccumulation testing must properly evaluate the concentration of contaminants and also the potential biotransformation of xenobiotics.

The bioaccumulation potential of some organic compounds can be estimated through calculation of the Theoretical Bioaccumulation Potential (TBP). The distribution of nonpolar organic chemicals in the environment is largely controlled by their solubility in various media. Therefore, nonpolar organic compounds are typically associated with organic matter within sediments, and with body fats or lipids within organisms. TBP assesses the bioaccumulation potential from dredged material by estimating the organic carbon content of the sediments, the lipid content of the organism, and the relative affinity of the chemical contaminants for organic carbon and lipid content into the following function: TBP = 4(CS/%TOC) %L (USEPA/USACE 1991).

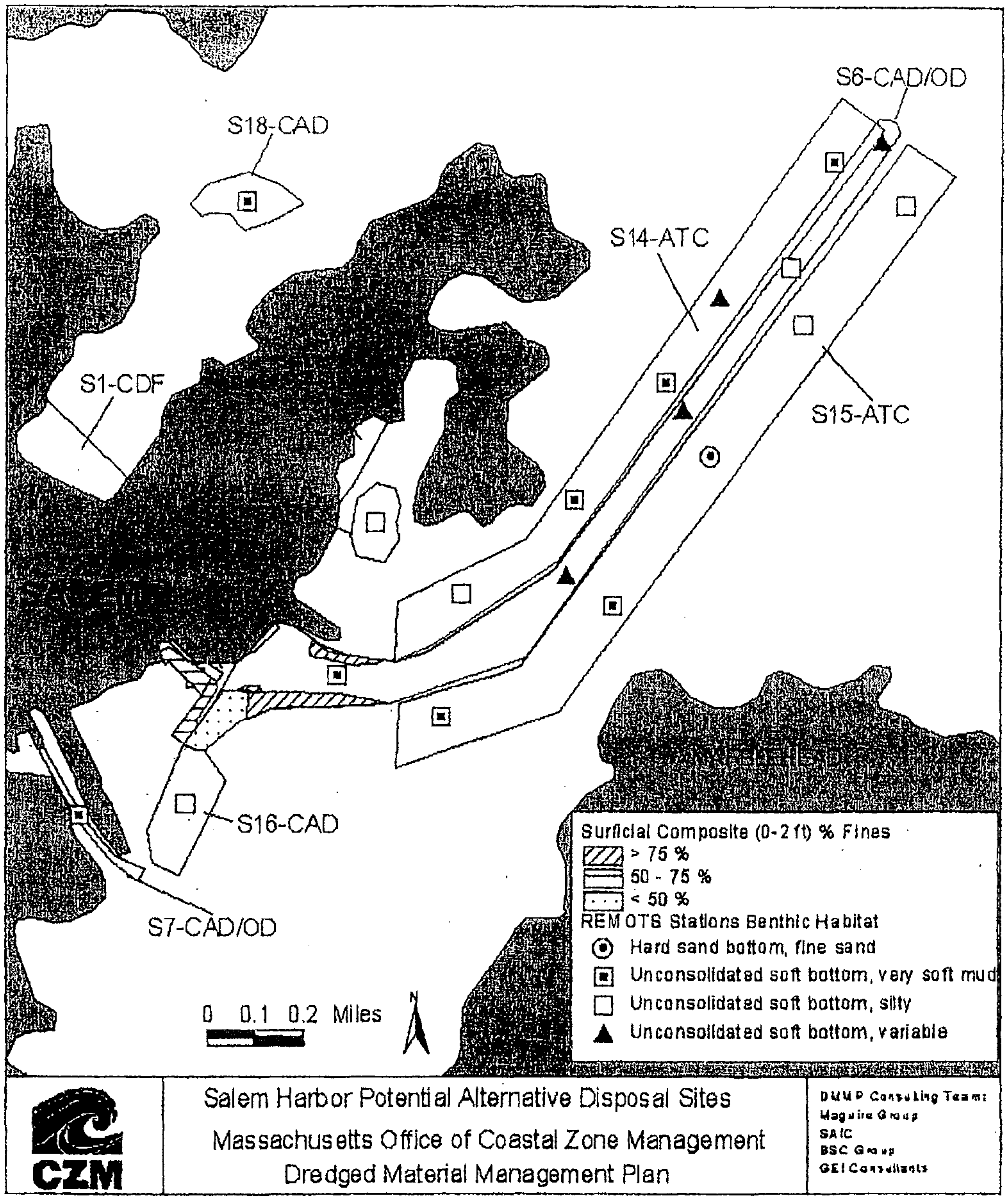
The TBP calculation carries several assumptions: chemicals are freely exchanged between the tissues and the sediments; compounds behave conservatively; lipids and organic carbons in different organisms and different sediments, respectively, have similar distributional properties; the chemical undergoes no metabolic degradation or biotransformation; and the sediment chemical of concern is completely bioavailable to the organism. Given these assumptions, the TBP calculation yields an environmentally conservative bioaccumulation value for the dredged material (USEPA/USACE 1991).

At the Tier II level, TBP calculations can be applied as a screening tool to identify sediments "...that contain unacceptable concentrations of bioavailable contaminants of concern" (USEPA/USACE 1991). At present, the TBP calculation can only be performed for nonpolar organic chemicals, and other contaminants of concern (e.g., polar organic compounds, organometals, and metals) will have to be evaluated using Tier III or IV testing procedures. Nonpolar organic chemicals, at the Tier II level, include halogenated hydrocarbons, chlorinated hydrocarbon pesticides, and many priority pollutant PAHs, furans, and dioxins (USEPA/USACE 1991).

Bioaccumulation testing is also a critical component of Tier III of the proposed monitoring plan (See Section 9.0 - Draft Disposal Site Monitoring Plan) to estimate the ability of the cap to isolate contaminated material. Bioavailability testing is triggered by rejection of the null hypothesis at Tiers I and II, indicating insufficient recolonization of the disposal site by benthic organisms. This hierarchical testing approach minimizes the need for more costly and complex Tier III testing until absolutely necessary, but also provides enhanced data resolution to help estimate potential failure of the capping material.

Before a chemical can produce a response in an organism, it must accumulate to some extent in tissues. Bioaccumulation tests are designed to evaluate the potential of benthic organisms to accumulate contaminants of concern by exposing organisms to the dredged material for either 10 days or 28 days (USEPA/USACE 1991). Regulations generally require that filter-feeding, deposit-feeding, and burrowing species be used in conducting bioassay tests. A 10-day test is conducted for heavy metal contaminants and a 28-day test is applied if the contaminants are organic or organometallic. Testing should be conducted by deploying caged benthic organisms at mid water column depth 300 yards from the disposal cell and at the reference station for the appropriate period of time. Analyze mussel tissues for the metals arsenic, cadmium, lead, mercury, and organics (PCBs and PAHs). Contaminant concentrations in the tissues should be analyzed and are then statistically compared to Federal standards, FDA Action Levels for Poisonous and Deleterious Substances in Fish or Shellfish for Human Food, to determine if critical bioaccumulation levels have been reached (USEPA/USACE 1991).

Figure 4-16: Sediment Characteristics of Salem Harbor Disposal Sites



4.6.3 Benthos

Impacts on Benthic Invertebrates

Any impacts to benthic organisms at a disposal site will be temporary and reversible. Immediately after disposal, the site will be devoid of benthic populations, because the benthos will have been removed by overdredging or buried under disposed sediments.. However, most benthic species are capable of rapid dispersal and colonization by means of planktonic larvae, and will quickly recolonize disturbed areas. The post-disposal benthic populations at in-harbor sites may be healthier and more diverse than those existing at present, since contaminated sediments will have been removed or buried and the new populations will be growing in the cleaner surface sediments.

The potential for improvement in the quality of benthic habitat will be greatest in those areas where habitat is presently degraded and habitat quality is low. Habitat quality was measured by a REMOTS sediment-penetrating camera which can indicate successional stages of organisms and depth of oxygenated sediments (Valente *et al.*, 1999; see Section 5.1.3.2). Habitat quality is lowest in the most inshore sites in Salem Harbor (Sites S3, S7, S16, S18, and S19), and higher in the channel and adjacent sites (Sites S6, S14, and S15).

At the Salem sites, penetration of the REMOTS camera was limited due to rocks and hard sand, but surface photographs indicated a well-developed and diverse surface benthic community. The highest habitat quality at areas where the cameras could penetrate was at Sites SG9, SG11, and SG12.

Dredge disposal will therefore have the least adverse impact on benthic invertebrates, and possibly some positive impact, in the sites closest to shore in Salem. Where there are now healthy benthic populations, in and adjacent to the Salem channel, and at the Salem sites, the benthic invertebrate populations will be temporarily removed by dredge disposal, but should recover completely.

Impacts on Commercially and Recreationally Harvestable Shellfish

As with other benthic invertebrates, shellfish will be temporarily impacted at areas of dredge disposal by dredging or burial, but given their rapid dispersal by planktonic larvae, the populations should completely recover in the cleaner final surface sediments, unless the site becomes a confined disposal facility. In Salem, the one site which has been shown to have high soft shell clam densities is a CDF, Site S1 in Collins Cove. There are two other CDF sites in Salem, at Cat Cove (S2) and City Wharf (S3), two Salem-Gloucester CDF sites, at Misery Island (SG4) and Eagle Island (SG5), and one in Gloucester, the Fish Pier Extension (G1). The Misery Island and Eagle Island sites are tidal habitat, and could therefore support shellfish and other benthic populations. The other CDF sites have not been shown to contain significant shellfish populations, which may be due to surveys not being directed specifically at them. The known areas of high soft shell clam concentration within Salem Harbor are along the shore near the south end of the harbor, and are unlikely to be affected by dredge disposal.

In October 1998, SCUBA surveys were conducted at the channel and adjacent-to-channel sites in Salem (S6, S14, and S15) as well as at the more near shore sites S16-CAD at Long Point/Derby Wharf and S19-CAD in Cat Cove. The only one of these sites where shellfish beds were seen was at S16, which contained many clusters of European oyster in the shallow portion of the site.

The only other location where a disposal site would impinge directly on a shellfish bed is at the confined disposal facilities at Misery and Eagle Islands (SG4 and SG5), where the facilities are located in areas of sea scallop concentration, with European oysters also present at Misery Island. Converting the sea bottom in this area to intertidal habitat would eliminate some sea scallop habitat, since this species is usually found at depths of at least several meters.

None of the other shellfish mapped by the Division of Marine Fisheries for this project, blue mussels, quahogs, and ocean quahogs, are located within or in close proximity to a disposal site (see Section

5.1.3.3) and should therefore not be a factor in site selection.

Impacts on Lobsters

Lobsters are abundant and the basis of productive fisheries in Salem. Since lobsters are mobile and are found throughout the region, it is difficult to differentiate between dredge sites on the basis of their impact on adult lobsters. Surveys of the marine resources of the Salem area, while reporting on the overall importance of the lobster fishery to the area, do not specify which sites or areas are more productive than others. Probably, given the abundance of lobsters throughout the Salem area, dredge disposal in any one limited site would not have a significant effect on the adult lobster population of the area.

A survey of early benthic phase (EBP) lobsters was conducted by suction sampling combined with SCUBA observations in Salem Harbor in October 1998 (NAI 1999, see Section 5.1.3.4). Sites surveyed included the channel and adjacent-to-channel sites (S6, S14, S15), and two more nearshore, shallow water sites in Salem Harbor, S16 and S19. Few lobsters were collected, although numerous burrows were observed, apparently excavated and used by a variety of organisms.

The presence of only a few larger lobsters in the channel and ATC areas indicates that this is not a settlement area for lobsters. Burrows found there are likely transient-use shelters. At Site S16, near Long Point and Derby Wharf, numerous juvenile lobsters as well as large numbers of juvenile winter flounder were observed associated with European oysters. Site S19, in Cat Cove, contained a dense stand of eelgrass in the nearshore part of the site. Few burrows and no juvenile lobster were observed.

Disposal in Sites S6, S14, and S15 would probably not impact settlement habitat for EBP lobster, and although habitat for larger lobster would be temporarily impacted, this habitat may not be more significant than in many other areas of the harbor.

Disposal at Site S16 would have an adverse effect on an area with excellent conditions for construction of long-term shelters and demonstrated presence of EBP lobsters and well as juvenile winter flounder.

At Site S19, the presence of eelgrass may have hampered the detection of lobster burrows and juvenile lobsters. The inner part of this site should be avoided for disposal because of possible impacts on juvenile lobster habitat as well as on the eelgrass itself.

Impacts to Submerged Aquatic Vegetation

Two eelgrass beds were identified from aerial photographs of the Salem area by the Mass. DEP in 1997 (See section 5.1.5.2). One of these, at the southern tip of Winter Island in Salem Harbor, is adjacent to Disposal Site S19 in Cat Cove. Although the bed identified by aerial photography is adjacent to the east side of Site S19, Division of Marine Fisheries divers in October 1998 observed a dense stand of eelgrass in the western 20 to 40 percent of the Site S19. No eelgrass was observed in dives at Sites S6, S14, S15, and S16.

The other eelgrass bed identified by the DEP extends along the Beverly shore from just east of Tuck Point to Curtis Point. Although much more extensive than the beds in Salem Harbor, it is not in the vicinity of any proposed disposal sites, being approximately 400 meters from Site S14 at its closest point.

Submerged aquatic vegetation is characteristic of shallow, nearshore areas, and would not be expected to be found in the more offshore sites between Salem.

In summary, submerged aquatic vegetation would be a constraint for disposal at Site S19, at least in the western part of the site, but should not preclude disposal at any of the other proposed sites.

4.6.4 Finfish

Impacts on General Fishery Resources

Impacts on general fishery resources of the Salem area will be negligible. The footprint of any one disposal site is very small compared to the area as a whole, adult fish are mobile and can avoid any temporary disturbance, and they will return to a disposal site once operations have ceased and food organisms have moved back in to the area. Juvenile fish may not be able to avoid short-term dredge disposal impacts as well at adults, and areas of known concentration of young fish should be avoided. Given the relatively small area and temporary nature of dredge disposal impacts, however, even disposal in a nursery area, although not recommended, would probably not have a long-term impact on the population of any species.

Impacts on Fishery Resources of Disposal Sites

Seine and trawl sampling in Salem by DMF in 1965 and 1997 (Jerome *et al.* 1967), and by consultants for this project in 1998 was not designed to sample the resources of specific disposal sites, and results can be used to assess the most common fish species of the harbor as a whole (see Section 5.1.4.3), but not to differentiate among proposed disposal sites.

SCUBA observations by DMF divers in October 1998 were directed at specific potential disposal sites in Salem Harbor, and it was observed that at Site S16-CAD clusters of European oysters with the attached algae *Codium* and *Ulva* provided ideal cover and habitat for juvenile winter flounder, evidenced by the sighting of numerous young of the year and age 1+ fish. No concentrations of fish were noted in the channel or adjacent-to-channel sites (S6, S14, and S15), or at S19-CAD in Cat Cove, although the eelgrass observed at S16 undoubtedly provides habitat for juvenile fishes.

Although sampling for fish was not directed specifically at disposal sites, the deeper sites in both Salem were dominated by winter flounder and skate, probably because these species lie on the bottom, and the trawl samples those fish close to the bottom. Winter founder and skate, as well as other species such as red hake and cod would therefore be temporarily displaced from the area of deeper-water disposal operations, but would recolonize the presumably cleaner bottom found at the end of dredging operations. At nearshore CAD sites, smaller forage fish such as silversides and herring would be displaced by disposal operations, but the displacement would be temporary and not significant in terms of the total habitat of the harbors.

In the open ocean sites off Salem, temporary impacts would occur on the bottom where the dredged material is deposited, and also in the water column due to turbidity. When the size of the disposal areas is considered in relation to the total area of the ZSF, and in relation to the mobility of the fishes found there, and also given the fact that the sites will be capped with clean sediments, it is apparent that no long-term impact on the fishery will occur from disposal at any of these sites, and that short-term impacts will be minimal.

In summary, the two shallow-water CAD sites examined in detail, S16 and S19, contained evidence of value as finfish nursery habitat, either through direct observation of juvenile fish or the presence of eelgrass, whereas in the deeper sites, the channel and adjacent to it, no such evidence of nursery habitat characteristics was observed. Since young winter flounder are also one of the more common species in beach seine hauls in Salem, it is probable that most shallow water, nearshore sites have some value as nursery habitat which is not shared by the deeper sites.

4.6.5 Wetlands

Impacts on Freshwater Wetlands

No aquatic disposal sites will have an impact on freshwater wetlands.

Impacts on Coastal Wetlands

Although disposal at any aquatic site will be regulated under the Massachusetts Wetlands Protection Act (See Section 7.1.3), coastal wetlands as defined in this report are limited to salt marshes, which are also protected under federal law (Section 7.2.5.3). National Wetlands Inventory mapping indicates that salt marsh exists only in small patches in Salem Harbor, remote from the proposed disposal sites. The existing marshes are too isolated from any site to be affected by disposal operations, and therefore will not be a factor in site selection.

4.6.6 Wildlife

General

Activities adjacent to shore could temporarily impact some shorebirds or alter their habitat, but other than this, there should be no impacts on wildlife or wildlife habitat from disposal operations.

Impacts on Shorebird Habitats

Shorebird habitat consists mainly of intertidal beaches and tidal flats. The confined disposal facility sites S1, S2, and S3 in Salem are located in intertidal areas and disposal there could cause a loss of shorebird habitat. Disposal at SG4 or SG5 would create intertidal habitat and therefore increase habitat for shorebirds.

Impacts on Marine Mammals

As discussed in Section 5.1.6.3, numerous species of whales, dolphins, and porpoises are found in the waters in and around Stellwagen Bank, 12 to 30 nautical miles from any potential disposal sites. These mammals would only rarely be found in the ocean waters off Salem, and probably never in the harbors. One mammal which commonly seen in harbors in this region from late September to late May is the harbor seal, which emerges from the water on sheltered and undisturbed rock ledges.

No disposal is proposed in the habitat of any marine mammal, and all local species are mobile enough to avoid any areas of temporary turbidity caused by disposal operations.

Impacts on Reptiles/Amphibians

Sea turtles, the only marine reptiles found in the area, do not breed in or near Massachusetts, and are oceanic animals, feeding on jellyfish and present mainly in summer (See Section 5.1.6.4). They are not dependent on the bottom and would not be affected by any localized change in bottom conditions. Turtles are sparse in distribution and could readily avoid any local, temporary changes in water conditions brought about by disposal operations. Although sea turtles are more likely to be found near one of the open ocean sites off Salem than within the harbor, their presence should not be a determining factor in site selection.

4.6.7 Endangered Species

General

The Massachusetts Natural Heritage Atlas does not indicate any estimated habitat of state-listed rare wildlife in or adjacent to the Salem Harbor Zone of Siting Feasibility with the exception of Tinkers

Island to the southeast of Marblehead. It does not indicate any priority sites of rare species habitats or exemplary natural communities in this area. Tinkers Island is approximately 0.6 mile from the nearest candidate disposal site, S13-CAD. It is very unlikely that disposal in urbanized areas or others historically under heavy human influence will impact endangered species.

Of the marine mammals and reptiles reported on in Sections 5.1.6.3 and 5.1.6.4, five whales and two turtles are federally listed as endangered (See Section 5.1.7). These species, if they attain enough numbers to have centers of concentration at all, are found mainly at Stellwagen Bank off the northern tip of Cape Cod or at Jeffreys Ledge north of Cape Ann.

Impacts to Endangered Species

The marine endangered species occurring in the ocean off Salem Harbor may occur very rarely near the open ocean sites off Salem, but probably never within the harbors. The listed species are mobile and can avoid any temporary impacts from dredge disposal. Impacts to endangered species is therefore not a factor in screening aquatic disposal sites.

4.6.8 Navigation and Shipping

Salem Harbor is the second deepest harbor in Massachusetts, after Boston Harbor. The primary economic role of the port of Salem is as a petroleum and coal receiving port. On an annual basis, an average of 3.5 million barrels of No.2 and No, 6 distillate fuel oil and 850,000 tons of coal are received at the PG&E Generating Salem Station pier, for use at the power plant or for distribution as home heating oil through the Cargill Petroleum bulk oil terminal adjacent to the power plant.

Two federal navigation channels are located in Salem Harbor. The main Federal channel is located in the northern portion of the harbor and extends towards Salem Sound between Winter Island in Salem and

Naugus Head in Marblehead. Originally constructed in 1905, the channel has a draft of 9.6 meters (32-feet) at Mean Low Water. The second federal channel is located at the South River. The South River channel has a navigation depth of 2.4 meters (8 feet). A 3 meter (10 foot) draft entrance channel connects the harbor to the South River channel.

Approximately 1,200 single point moorings are distributed within five mooring basins in the harbor. Salem Harbor is a significant recreational boating destination, with a large number of tourist-related and historic landside attractions.

4.6.9 Land Use

General

Land use in Salem Harbor is typical of dense urban areas, consisting of a range of land uses including residential, industrial and commercial, and recreational.

Several candidate disposal sites, including both CDF sites and CAD sites, are in close proximity to the shoreline in Salem Harbor and vicinity, and use of these sites for dredged material disposal may result in land use impacts.

Land Use in the Vicinity of Disposal Sites

Generalized land use patterns in the vicinity of Salem Harbor are illustrated on **Figure 4-x**. There are three CDF alternatives located in or in close vicinity to Salem Harbor:S1-CDF (Collins Cove); S2-CDF (Cat Cove); and S3-CDF (New Salem Wharf). Because a CDF is constructed as an extension of or an addition to the shoreline, adjacent land use is an important consideration.

S1-CDF This site is adjacent to Collins Cove Playground, a public park located on the west side of

Collins Cove. The Collins Cove Walkway, a public passive recreation area, runs along the southern end of the cove. Residential land use abuts the site to the south and east.

S2-CDF This site abuts the South Essex Sewage District Secondary Wastewater Treatment Plant, a heavy industrial use on the west side of Cat Cove. Across the Cove to the east is Winter Island, an important recreational resource in the City of Salem.

S3-CDF This site is adjacent to Hewitt's Cove Marina, a commercial use on the south, and the Cargill Petroleum bulk oil terminal facility and PG&E Generating Salem Station electrical generating plant on the north, both heavy industrial uses.

Potential CAD alternative sites in Salem Harbor are located in open water and generally removed from shore. However, portions of the channel overdredge sites, S6-CAD/OD (main federal channel) and S7-CAD/OD (South River entrance channel) are close to shore.

S6-CAD/OD The turning basin at the end of the main channel is adjacent to the Cargill Petroleum bulk oil terminal facility and PG&E Generating Salem Station electrical generating plant on the north, both heavy industrial uses.

Figure 4-17: Generalized Land Uses around Salem Harbor

S7-CAD/OD The entrance channel threads its way between Central Wharf on the east, part of the Salem National Historic Park, and the imposing Shetland Office building on the west, a commercial use.

Other CAD alternatives in Salem Harbor removed from shore and adjacent land uses. The southern end of S14-ATC lies just offshore to the east of Winter Island, an important recreational use. S16-CAD is immediately offshore and to the north of the end of Central Wharf. S19-CAD lies at the mouth of Cat Cove, with the SESD plant to the west and Winter Island to the east.

The S15-ATC and S18-CAD sites are removed from landside uses. S15-ATC, bordering the main federal channel to the east, is several hundred feet off the northwestern end of the Marblehead peninsula at its closest point, where residential use predominates. S18-CAD lies at the mouth of Collins Cove, with the commercial uses at the northwestern edge of the cove lying closest to the site.

Consistency With Port Plan

One of the Potential Alternative Aquatic sites in Salem Harbor is included as a specific project identified in the Salem Harbor Plan: the S16-CAD site located off Central Wharf. The Salem Harbor Plan calls for a mooring field, accommodating up to 80 boats, including mooring anchors, a dinghy dock with land access, and a suitable channel from the dock to the mooring area.

All other Potential aquatic sites in Salem Harbor are not in conflict with the recommendations of the Salem Harbor Plan. In particular, site S3-CDF (New Salem Wharf), S7-CAD/OD (South River entrance channel) and S6-CAD/OD (main federal channel) are consistent with the recommendations of the plan to support maintenance dredging activities in the harbor. All of the other potential aquatic sites are consistent with the harbor plan in that establishment of a disposal site for unsuitable dredge material in Salem Harbor will support the public and private dredging projects included in the Area-Wide

Recommendations section of the plan.

4.6.10 Air Quality / Noise

Disposal operations at aquatic disposal sites result in temporary air quality and noise impacts, primarily resulting from diesel exhausts and noise of the tugs transporting the dredged material dump scows to CAD sites or heavy equipment used to construct CDF cells.

As with land use, proximity to shore is the main factor in distinguishing the air quality and noise impacts among the Potential Alternative aquatic sites in Salem Harbor.

The CDF alternatives (S1, S2 and S3) pose additional noise and air quality impacts due to the assumed longer duration of construction activities at the sites. A CDF is constructed along the shoreline and is filled over a period of time. The proximity to landside sensitive noise and air quality receptors and the length of the construction time period pose greater impacts to the nearby residential receptors.

Use of near shore portions of the S6 and S7 CAD/OD sites and the S16, S18, and S19 CAD sites and the S14 and S15 ATC sites would result in lesser air quality and noise impacts compared to the CDF alternatives. These sites are removed from shore, farther from sensitive air and noise receptors, and the use of heavy equipment with attendant air quality and noise impacts is generally less and for a shorter duration, compared to the CDF sites.

4.6.11 Historic and Archaeological Resources

Because of the long maritime history of the port of Salem and the known archaeologic sensitivity of coastal locations, all of the Potential aquatic sites within Salem Harbor are located in the vicinity of archaeological resources. At this time, the exact locations of these resources is not known. Approximate locations have been determined based on existing historical information. Any of the aquatic disposal sites in Salem Harbor would need to be surveyed for archaeological resources before its use as a disposal site.

Sites S7-CAD/OD and S16-CAD are closest to the Salem Maritime National Historic Park and the Derby Street National Historic District and therefore pose the greatest potential for impacts to landside historic resources.

4.6.12 Recreation

Recreational resources in Salem Harbor include both active and passive recreational areas. Because of the densely developed urban nature of the City of Salem, the existing recreational sites are important to the quality of life in the city. Recreational areas in the vicinity of Salem Harbor are illustrated on Figure 4-18.

Site S1-CDF in Collins Cove directly abuts two important recreational sites in the city, the Collins Cove Playground and the Collins Cove Walkway. Site S18-CAD at the mouth of Collin Cove lies to the west of and just offshore of Salem Willows Park, an important regional recreational resource.

Site S19-CAD lies just to the west of Winter Island and the public boat ramp located at the southern tip of the park, at the mouth of Cat Cove. Likewise, a portion of S14-ATC lies just offshore of Waikiki Beach at Winter Island, a popular bathing spot in the summer season. Site S2-CDF, while not directly abutting a recreational area, would pose indirect impacts to the Winter Island area, particularly with longer duration noise impacts. The southern portion of S15-ATC is located offshore of Danger Beach in Marblehead, a popular local swimming spot.

Figure 4-18: Recreational Areas in the Vicinity of Salem Harbor

Because of the permanent impacts to the sites that would result from the construction of the S1-CDF site in Collins Cove, it has comparatively greater impacts than the other potential aquatic sites in Salem Harbor. Use of any of the CAD alternative sites will pose relatively lesser impacts. It is likely that the CAD disposal sites would be used during the late Fall to early Spring time periods, when active use of the public recreation areas is less than during peak summer months and swimming activity is virtually non-existent. However, passive use (sightseers, walkers, children, fishing) of the recreation areas in the city is still significant. Therefore, aquatic sites farther removed from existing recreational areas are preferred sites closer to the areas.

4.6.13 Economic Environment

Costs of Aquatic Disposal Options

To estimate the potential cost of aquatic disposal options, cost estimates (per cubic yard) from a variety of recent dredging studies were compared. Estimates are available from the Boston Harbor Navigation Improvement Project (BHNIP), New Bedford Harbor Cleanup Plan, Salem Port Development Project, EPA Assessment and Remediation of Contaminated Sediments (ARCs) program, projects in New York and New Jersey, and the US Navy EIS on Homeporting for the Seawolf Submarine. Recognizing that a site specific cost estimates for Preferred Alternatives will not discussed until Section 5, the mean of estimates from the BHNIP was determined most applicable for comparing aquatic disposal alternatives in the DMMP. Table 4-9, contains a comparison of costs associated with aquatic disposal options considered in the Salem Harbor DMMP DEIR.

Table 4-9: Aquatic Disposal Cost Comparison

Disposal Type	Cost per Cubic Yard	
	Range	**Mean**
CAD	$30 - 30	$30
CDF (filled above mean high water)	$38 - 61	$50
CDF/TH (± mean low water)	$45 - 241	$142
CAP	$16 - 33	$24

4.6.14 Local/Federal Screening - Proposed Preferred Alternative

4.6.15 Results of Detailed Screening

4.7 Detailed Screening of Potential Upland Disposal Sites

4.7.1 General

Map analyses, file reviews, and site visits were used to acquire more detailed information for each potential upland disposal site identified during the initial screening. Detailed information about each of these sites was recorded on fact sheets that are located in Appendix D. DMMP team members and representatives of local, state, and federal government met and reviewed this information to review potential alternatives. Discretionary factors were discussed to determine the benefits and constraints of using each site.

The sites that survived the detailed screening are "Proposed Preferred Alternatives". The discretionary evaluation criteria used during the second tier upland disposal site screening are outlined below, with more detailed discussion in the sections of 4.7.2.

U-6. Groundwater - General - Evaluation of types of aquifers in the vicinity and depth to groundwater at the site.

U-7. Surface Water Quality

U.7.a - Water Bodies and Rivers - Evaluation of set back of site from water bodies and rivers.

U.7.b - Wetlands - Evaluation of set back of sites from wetland resource areas.

U-8. Site Accessibility - Description of most practical route to transport dredged material to the disposal site, including any potential logistical problems that might be encountered during use or construction of the proposed site. Sites should be directly accessible from a regional highway, have a rail or navigable waterway nearby, have a local access route that does not include lateral or vertical obstructions or restrictions, and a local access route that does not pass by sensitive receptors.

U-9. Physical Area of Impact - Evaluation of the amount of land area in acres that would be directly affected by disposal activities.

U-10. Duration of Potential, Adverse Impacts - Estimation of recovery time based on the type of disposal and present site conditions.

U-11. Present Habitat Types

U-11.a - Successional Stage - Evaluation of vegetation stage (e.g., forest grass) and whether wetlands were present.

U-11.b - Degree of Disturbance - Evaluation of the visual evidence of site disturbance.

U-11.c - Diversity of Plant and Animal Species - Evaluation of the type and amount of vegetative cover to estimate species diversity, highlighting the presence of wetlands on or adjacent to the site.

U-11.d - Integrity of Plant and Animal Species - Evaluation of integrity of plant and animal species by considering the degree of disturbance for the site and the surrounding landscape conditions.

U-11.f - Wildlife Function - Assessment of wildlife value by considering degree of disturbance and landscape position.

U-12. Existing Terrain (suitability for diking) - Determination of ability to construct dike.

U-13. Flood Plains - Determination whether site is in or partially in a designated floodplain, consulting National Flood Insurance program Flood Insurance Rate Maps.

U-14. Agricultural Use - Determination of prime agricultural soils on or near the site.

U-15. Adjacent Land Use - Evaluation of adjacent ownership, present and projected land use.

U-16. Risk of Containment Facility Failure - Review of characteristics and engineering requirements for each site to assess the potential stability of material disposed of at the site.

U-17. Odors / Dust / Noise - Evaluation based on proximity to sensitive receptors of odors, dust and noise.

U-18. Local, Regional, State Plans - Evaluation of consistency with local, regional and state long range plans.

U-19. Ability to Obtain Permits - Evaluation of likelihood of local, state, and federal regulatory approval.

U-20. Cost - Estimation of comparative costs for construction, maintenance, and monitoring of proposed sites.

4.7.2 Soils and Groundwater for the Upland Sites

Soil

Dredged sediments pose risks to the environmental and human health if contaminants are released from the disposal area. The runoff of water remaining in the dredged material after dewatering or rainwater that runs off of the material could potentially transport contaminants and salts from the dredged material to soil near the disposal area. The salts and contaminants could adversely effect the soil, thereby affecting plant and animal habitats. There is also the potential for bioaccumulation of contaminants in organisms living in or on the soil.

To protect the soil near the disposal site, as well as other environmental receptors, a confined facility would be engineered to contain the dredged material at the disposal site. Liners with drainage systems would surround the dredged material to form a physical barrier between the UDM and the environment. Results from sampling monitoring wells and soil around the disposal site could be used to monitor for contaminants that escape from barrier. If there is a break-through, the operator monitoring the conditions would know about it and be able to respond quickly.

Sites located within or near areas that have already been disturbed would likely experience less potential impact from dredged material runoff and fugitive dust. Sites within or near soils that have not been disturbed have a greater potential for being affected by the dredged material. All the potential disposal sites are in areas whose soils have been disturbed in some fashion, either the topsoil has been stripped or covered, therefore, on-site soils is not a discriminating factor in evaluating the potential disposal sites.

Groundwater

If contaminants from the dredged material come in contact with soil, there is the potential for them to be transported to groundwater. Protecting drinking water supplies, particularly groundwater supplies, is an important goal in the disposal site screening process. These resources are critical to human populations and are in fixed locations.

To avoid potential impacts to groundwater, sites located above important groundwater resources were eliminated. Sites located within the Zone II (Zone of Contribution) of a public water supply well, within an Interim Wellhead Protection Area (IWPA), or within a Sole Source Aquifer failed the initial screening, in accordance with the Massachusetts Site Assignment Regulations for Solid Waste Facilities (310 CMR 16.00). None of the potential disposal sites are located above a Zone II, IWPA, or Sole Source Aquifer. The locations of potentially productive and other aquifers at or near the site were considered in the discretionary screening.

To further minimize the potential for the disposal of dredged materials to impact groundwater, the Site Assignment Regulations require that the disposal area be at least four feet above groundwater. At a site that has a shallower groundwater table, the disposal facility can be engineered so that there is at least 4 feet between the lower-most liner and the high level of groundwater.

As indicated above, any disposal facility used or built would be lined to keep any runoff from the dredged material from coming into contact with groundwater. Monitoring wells would be used to confirm that leaks into groundwater do not occur.

Sites SLM-06, EBR-02, and WEY-13 have shallow depth to groundwater (< 4ft.) and, therefore, risk of groundwater contamination at these sites would be greatest. The two quarry sites, SLM-06 and WEY-13 are excavated pits and, therefore, are actually *below* the groundwater table.

Bioaccumulation in Plants and Animals from Disposal Sites

If contaminants from the dredged material are released into the environment, they could be ingested by organisms. Contaminants can accumulate within the bodies of the organisms, and potentially be tranferred up the food chain as the organisms are consumed. Ultimately, fish, birds, and mammals near the top of the food chain may accumulate contaminants at unacceptable levels. Dangerous levels of toxins in these organisms endanger ecosystems as the toxins weaken or kill some species. Human health can also be impacted, particularly if food sources are contaminated.

The confinement of the dredged materials in a contained facility will minimize the potential of contaminants being released into the environment and therefore reduce the likelihood of plants and animals accumulating contaminants in their bodies. Also, as per DEP policy, lime could be added to sediments that have high sulfide reactivity. Elevated sulfide concentrations in the sediment can cause leaching of contaminants, especially metals, when the sediment is brought into an aerobic environment (i.e. on land) (ACE 1996). Controlling the pH of the sediments through lime amendments can signficantly reduce the leachibility and bioavailability of metals.

4.7.3 Wetlands

General

Wetlands and watercourses, by definition, "waters of the United States" and, therefore, are protected under the Federal Water Pollution Control Act (a.k.a. Clean Water Act) and the Massachusetts Wetlands Protection Act. Permits for placement of fill in or near wetlands is regulated at both the state and federal level.

Impacts on Freshwater Wetlands

While disposal of dredged material into freshwater wetlands is not absolutely prohibited, it would be difficult to obtain a permit for such an activity. For this reason, candidate upland disposal sites that are wholly or in large part covered with wetlands were eliminated from further consideration, however, sites that contain a minimal amount of wetlands were not because disposal site design could avoid impacts to the wetlands. However, sites that do not contain any nearby wetlands would obviously be preferred over sites that are adjacent to wetlands.

Wetlands were identified through the use of U.S.G.S. Topographic Maps and the National Wetlands Inventory (NWI) mapping developed by the U.S. Fish and Wildlife Service. The NWI maps only identify and described relatively large wetlands (>5 acres), so other, smaller, wetlands may be present at these sites. A site-specific field delineation would be required to define the regulatory limits of these wetlands.

All the potential disposal sites either contain or abut wetlands. The entire western perimeter of the BFI Landfill in East Bridgewater (EBR-02) is a shrub/scrub and forested wetland. The Ipswich River runs through the Middleton Colony Parcel (MDL-06). The southwest quadrant of the Brockton Landfill (BRK-02) contains a forested shrub/scrub wetland. The remaining eight sites either have small, isolated wetlands on site or are have wetlands near the property borders.

4.7.4 Wildlife

Potential wildlife impacts were considered in the evaluation of the potential disposal sites. Using available data from the U.S. Fish and Wildlife Service National Wetlands Inventory Mapping and aerial photographs from M.I.T. along with field visits, the ability of the potential upland sites as habitats for various wildlife was estimated. Sites in or near large blocks of forest, marsh or other undisturbed habitat generally are considered to have higher habitat value than those sites in or near developed areas.

All potential disposal sites contain some level of wildlife value, although those that are least disturbed, containing large tracts of land, and in proximity to wetlands, forests, and other potential wildlife resources were considered as having higher wildife habitat potential.

Although each potential disposal site has undergone some degree of disturbance, the wildlife value of the site can be largely dependent on the integrity of adjacent natural resources. Sites WSM-01, PLA-02, PLY-11/12 and EBR-02 are relatively good wildlife habitat because of their proximity to large undeveloped tracts of wetland and/or forest.

Amphibian/Reptile Habitat Impacts

The relative amphibian and reptile habitat value of each potential upland disposal site was considered by evaluating the potential for each site as habitat for these organisms. Sites that contain or are within close proximity to shallow-water lentic systems (ponds, lakes, vernal pools) were considered potential valuable habitat for amphibians and some reptiles. Sites containing surface rock and large forested areas are considered relatively good reptile habitat.

Those sites that have good general wildlife habitat, as described above, would be expected to have relatively good amphibian/reptile habitat as well. However, site-specific investigations are needed to assess the habitat potential for these types of organism.

4.7.5 Endangered Species

Impacts to Endangered Species

Species designated by the U.S. Fish and Wildlife Service as rare, endangered or threatened are afforded protection under the Endangered Species Act. To keep rare and endangered species from being affected by the disposal of dredged material, sites containing their habitats failed the initial screening. The Bardon Trimount Quarry (SLM-06) is the only site containing rare or endangered species habitat that was not eliminated, because the species of concern is located in the northern perimeter of the site, removed (400 feet) from the disposal area itself. The habitat covers approximately 5% of the entire property.

Of the remaining 10 sites, only one, PLY-11/12 has a rare, threatened or endangered species habitat, nearby. Such a habitat is located 0.25 miles away. To help protect the organism, the species and it's exact location are not given here.

4.7.6 Land Use

General

Public health and safety, as well as environmental concerns, must be considered when evaluating on-site and adjacent land use of a potential disposal site. The siting of a disposal facility in the vicinity of residential areas or sensitive receptors such as nursing homes, hospitals, or elementary schools is not desirable. These receptors would not only be at greater risk in the event of a release, but would also be affected by the increased truck traffic that would be transporting the dredged material to the facility.

A location that has recently been or is presently a disposal site would be a preferred place to put the dredged material rather than a new disposal site. Such a site would have already been impacted by previous disposal activities, thereby reducing the incremental impact of sediment disposal on the local environment. If a new disposal site is used, an industrial site would be more appealing than a residential or open space property. It is likely that there was previous contamination in an industrial area, and increased truck traffic would probably not be a significant issue.

There are other specific land uses that would affect choosing a site for a disposal facility. For example, if runoff from the dredged sediments were to leak into the environment, salts in the material left from seawater are likely to wash out and would have a negative impact on cropland nearby. A public utility easement at the site, such as a natural gas pipeline or electric power line, may also impede truck movement and disposal activities at a site.

Impacts on Land Use in the Vicinity of Disposal Sites

Of the 11 potential sites, two sites, only one, WSM-01, is an active landfill. This site is currently being impacted by ongoing disposal activities, so the disposal of dredged material at the site would not greatly change the current land use. WSM-01 is surrounded by a state forest on three sides, with residences and undeveloped land abutting the other.

Five of the sites, EBR-02, PLA-02, BRK-02, WOB-11, SAG-05 and PEA-01 are either inactive or closed landfills. These sites are not pristine, having already been impacted by previous disposal activities. The streets leading to them have been used by heavy trucks during past disposal use, so truck access is relatively good. SAG-05 is an exception, because at this site trucks would need to negotiate residential roads. Most of the sites are in commercial and industrial areas, with some residences nearby. Three sites, EBR-02, PEA-01, and SAG-05, have abutting residences. PLA-02 also has cranberry bogs northwest of the site.

There are four sites that would be new disposal areas, SLM-06, WEY-13, PLY-11/12, and MDL-06. Both SLM-06 and WEY-13 are active quarries in industrial areas, with some residences nearby. MDL-06 is mostly covered with cropland, and there are residences that abut to the north. PLY-11/12 is an undeveloped wooded site, with residences abutting the south side of the site.

Consistency with Port Plan

All of the upland disposal sites are outside Salem Harbor, and therefore outside the geographic study area for the port plan.

4.7.7 Air Quality/Noise

Air Quality Impacts

Air quality impacts from upland disposal of dredged material are primarily associated with tailpipe emissions from trucks that are transporting the dredged material to the site, and the on-site equipment used to handle the material. At each of the potential disposal sites, there would be temporary increases in carbon monoxide, nitrous oxides, volatile organic compounds, and particulate matter during the disposal operations.

Some contaminants present in the dredged material have the potential to volatilize to the air when placed in the upland environment (ACE, 1990, 1998). Some organic compounds such as PAHs and PCBs can volatilize when brought into contact with air. PAHs, are present at elevated levels in some Slame Harbor sediments, and isolated areas have elevated PCB levels.

All potential disposal sites are in areas of non-attainment for ozone, i.e. ozone levels are consistently above the National Ambient Air Quality Standards (NAAQS). There is no appreciable difference in air quality among the potential sites, however, locally, air quality impacts from truck traffic and fugitive dust can be different. The relative air quality impacts would be greatest at and near those diposal sites within or near residential areas. Also, fugitive dust, if unabated, can negatively affect vegetation, so densely vegetated areas in the predominant downwind direction of the disposal area can be affected if dust is not controlled by wetting.

Noise

As with air quality, noise impacts from upland disposal are associated with truck transport and material handling equipment. Temporary increases in noise are expected at and near the disposal sites, and the significance of these impacts is a function of the sensitivity of nearby receptors. For example, if trucks would be passing through residential neighborhoods, the increased noise would be a concern, whereas if the truck traffic traverses industrial areas, then impacts would be less severe.

Receptors located near existing landfills would likely be less affected by truck noise because there is already heavy truck usage associated with the current landfill operation. Inactive landfills, or new site monofills would cause more substantial noise impacts.

4.7.8 Historic and Archaeological Resources

General

Cultural resources in Massachusetts include historical and archaeological features such as prehistoric dwellings and historic structures. Both archaeological and historic sites, including those on the National Register of Historic Places, can be found in Massachusetts Historical Commission records. If in the vicinity of a disposal area, these sites would likely be subjected to increased degradation due to truck traffic and disposal activities. There is the potential for cultural resources contained on the property of a proposed disposal site to be destroyed if it is near the disposal area. Efforts will be made to avoid known resources, and actions would be taken to protect resources that are found in excavations during the building or operation of the disposal facility.

Consequences for Historic and Archaeological Resources

There are no disposal sites that contain archaeological sites, but there is one site that is listed as historical. The active quarry itself at SLM-06 is listed as an historic site. If the site is used as a disposal site, the quarry would be at least partially filled.

PLA-02 and WSM-01 both have archaeological sites abutting their properties. WEY-13 abuts a historic site. All of these abutting historic and archaeological resources have likely already been impacted by the active or recent disposal and quarry activities at these potential disposal sites.

4.7.9 Recreation

General

Recreational use at an upland site could include hiking, biking, fishing, hunting, boating, camping and birdwatching. If a site disposed of dredged material in or near a recreational area, some of these activities may have to be discontinued. Use of sites for recreational purposes was considered as part of the exclusionary wilderness area criterion. Sites were eliminated if they included protected open spaces and recreational areas as determined using MassGIS database.

Impact on Recreational Resources of Sites

Portions of BRK-02, EBR-02, and SLM-06 are listed as Protected and Recreational Open Space, according to MassGIS. The first two sites were recently active landfills, so it is likely that the wilderness areas have already been impacted. At SLM-06, it is the area of the quarry that is listed as wilderness area, although the site is zoned as industrial, and large scale quarry activities have been going on for some time. Several other sites have undeveloped regions of the property where there may be potential for recreational activities such as hunting or fishing. These sites include PLY-11/12 and SAG-05.

Several sites abut protected and recreational lands. FRV-02 and WSM-01 are both active landfills situated next to state forests. MDL-06 abuts protected open space. These areas could potentially be negatively affected by disposal activities.

4.7.10 Economic Environment

Costs of Disposal Options

Placing dredged sediments in the upland environment is a relatively expensive disposal option, with unit costs for the potential alternatives ranging from $117 to $683 per cubic yard. The construction of a new facility is generally more expensive than using an active landfill, due to the extra costs required to site, permit, build, monitor, and close the landfill. Economies of scale also make building a facility at a small site with minimal capacity cost more on a unit cost level than a larger facility. This is in part because the same siting and permitting process is required for all sites.

Upland Disposal Impacts

There could be a positive economic benefit to those involved in the disposal operation, from the truckers to the landfill operators, as a result of upland disposal. While municipal landfills do not generally generate large revenues, some well-managed facilities could receive a profit from receipt of dredged material.

There would be a significant amount of heavy truck traffic utilizing federal, state and local streets. It is estimated that for 1.1 million cy of sediment to be dredged and transported over the next 20 years, approximately 70,000 20-ton truck trips (one-way) would be required to haul the dredged material. This could cause significant wear on the transportation infrastructure, therefore costs for repair and maintenance would be borne by the governmental body responsible for the road (Massachusetts Highway Department or municipality) maintenance.

In the long-term, the capped landfill is likely to result in a permanent mound of material. While the dredged materials would be sealed within this mound, the topography of the mound may result in the loss of that land beneath the footprint of the landfill for other uses. There may be potential for reuse of the disposal site after it is closed, but at this time it is not known if this would be viable.

4.7.11 Local/Federal Screening - Proposed Preferred Alternatives

After reviewing the potential alternatives in detail, it became apparent that capacity is a major criterion in determining which sites to carry forward as proposed preferred alternatives, for reasons of both logistics and cost. While sites with smaller capacities may have potential for small, individual projects, they are not practical for the state-wide DMMP. These small sites will hold only a small fraction of the dredged materials from each of the harbors, and their high unit costs make them much less desirable choices.

No one site has sufficient capacity to accommodate the 1.1 cy of UDM, therefore, a combination of sites would need to be used to solve the dredged material disposal problems in Salem Harbor. The USACE, after reviewing the upland disposal site analysis, has stated that upland disposal is not practicable for the DMMP due to cost (USACE - 6/8/99 letter).

Nevertheless, two upland disposal sites are carried forth in this DEIR, the Bardon-Trimont Quarry in Salem/Swampscott (SLM-06) and the Westminster Landfill (WSM-01). These sites have a combined capacity of approximately 1.2 million cy. These sites are described in greater detail in Section 5.2.

Table 4-10: Capacities and Unit Costs of Potential Upland Disposal Alternatives.

Site #	Town	Capacity (cu yd)	Unit Cost ($/cu yd)
SLM-06	**Salem/Swampscott**	**849,400**	**$117**
WSM-01	**Westminster**	**282,700**	**$154**
EBR-02	East Bridgewater	711,100	$137
WEY-13	Weymouth	189,600	$169
PLA-02	Plainville	172,800	$197
PLY-11/12	Plymouth	124,400	$172
MDL-06	Middleton	51,400	$238
BRK-02	Brockton	42,500	$333
WOB-11	Woburn	41,500	$289
SAG-05	Saugus	29,600	$403
PEA-01	Peabody	10,900	$683

Bold denotes proposed preferred alternatives

4.7.12 Results of Detailed Screening

Although ACE screened out all of the upland sites, it was determined that two of the sites had sufficient potential as disposal sites to warrant further investigation: WSM-01 and SLM-06. These two upland sites, listed in Table 4-11, survived the discretionary screening. Further discussion of these sites is in Section 5.2.

Table 4-11: Upland Proposed Preferred Alternatives

Site #	**Town**	**Address**
SLM-06	Salem/Swampscott	Bardon Trimount Quarry, Swampscott/Danvers Rds
WSM-01	Westminster	Fitchburg-Westminster Landfill, Route 31/Princeton Rd

Figure 4-19: Preferred Upland Alternative #1 - WSM- 01- Westminster-Fitchburg Landfill

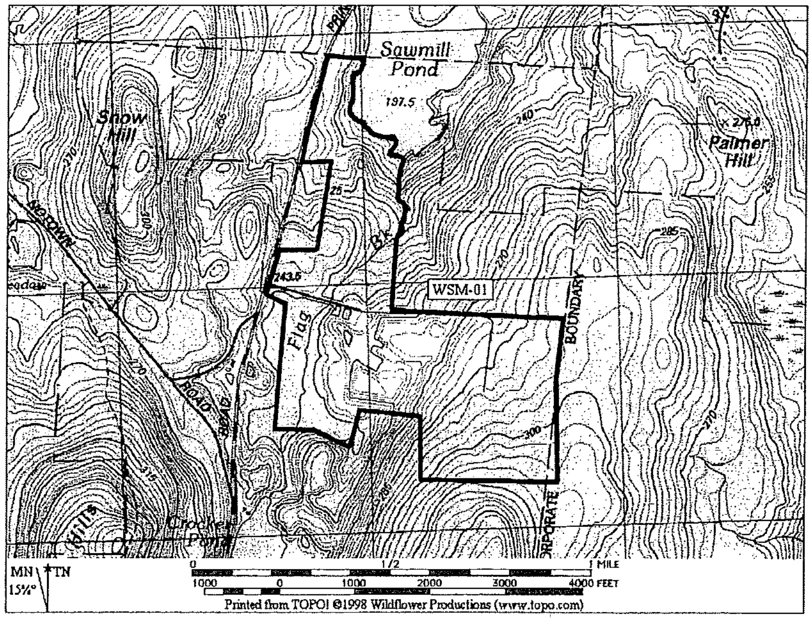


Figure 4-20: Preferred Upland Alternative #1 - SLM- 06- Bardon Trimount Quarry

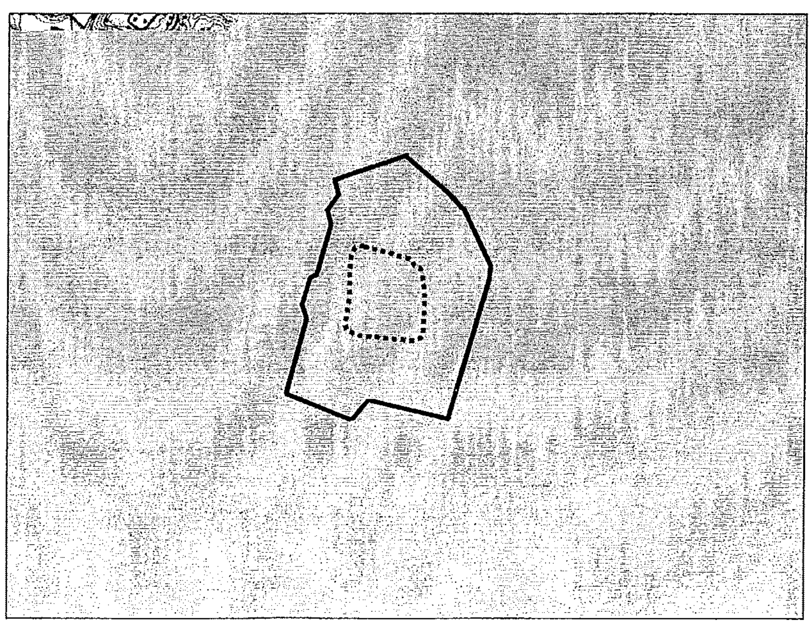


Table 4-12: Proposed Preferred Sites - Initial Screening Summary

Screening Factors	**S6 - CAD/OD**	**S15-ATC**
Disposal Capacity	4 MM CY	10.8 MM CY
Benthic Habitat	Good, Healthy Mean OSI - 9	Good, Healthy Mean OSI - 8
Permitting Feasibility	Probable	Probable Portion w/in Marblehead
Consistency with Port Plan	No Conflict	No Conflict
Proximity to Dredging	Close to Most Projects	Close to Most Projects
Water Dependent Recreation	No Conflict	No Conflict
Comments	Active Navigation Channel Previously Disturbed Area	Immediately Adjacent to Disturbed Area

Notes:
CAD - Confined Aquatic Disposal
OD - Over Dredge
ATC - Adjacent to Channel
MM CY - million cubic yards
OSI - Organism Species Index, a measure of species diversity

Table 4-13: Initial Screening Results - Reserved Sites Summary

Site Name	Rationale for "Reserved" Status
S14-ATC	Shallow bedrock prevents construction of compact disposal area
S16-CAD	SAV, shellfish, nursery habitat
S1-CDF	Low capacity, proximity to residential area, presence of productive habitat, recreational fishing area
S2-CDF	Low capacity, productive intertidal and subtidal habitat, recreational fishing and shellfish
S3-CDF	Very low capacity, productive intertidal and subtidal habitat
S7-CAD/OD	Very low capacity, confined space for operations, overlap with shellfish resources
S12-CAD	High fishery productivity, gillnet fishing, high commercial fishing activity
S13-CAD	High fishery productivity, gillnet fishing, high commercial fishing activity
S18-CAD	Presence of eelgrass and shellfish, proximity to mudflats, high nursery habitat potential
S19-CAD	Low capacity, eelgrass
G1-CDF	Low capacity, long access distance, loss of intertidal/subtidal habitat
G2-OD	Low capacity, long access distance
G3-ATC	Medium capacity, long access distance, shellfish resources
SG2-CAD	High fisheries productivity, high commercial fishing activity
SG3-CAD	High fisheries productivity, high commercial fishing activity
SG4-TH/CDF	High fisheries productivity, high commercial fishing activity
SG5-TH/CDF	High fisheries productivity, high commercial fishing activity
SG6-CAD	High fisheries productivity, high commercial fishing activity
SG7-CAD	High fisheries productivity, high commercial fishing activity
SG8-CAD	High fisheries productivity, high commercial fishing activity
SG9-CAD	High fisheries productivity, high commercial fishing activity
SG10-CAD	High fisheries productivity, high commercial fishing activity
SG-11-CAD	High fisheries productivity, high commercial fishing activity
SG12-CAD	High fisheries productivity, high commercial fishing activity

4.8 Identification of Preferred Alternatives

The results of the alternatives analyses for potential upland and aquatic disposal sites, as described in the preceding sections, have shown that there is one proposed preferred aquatic and two proposed preferred upland disposal sites.

These are:

- S6-CAD/OD; this site is located entirely within the PG&E Basin and is capable of accommodating the entire UDM volume from Salem Harbor.

- SLM-06, Bardon-Trimont Quarry; site is an active quarry, 28 acres in size, that could potentially accommodate up to 849,000 cy of UDM.

- WSM-01, Westminster Landfill; an active 17-acre landfill that could potentially hold nearly 100% of the UDM from Salem Harbor.

Each of these sites is described in greater detail in Sections 5.1 and 5.2. The environmental consequences of disposing of the UDM at these sites are analyzed in Section 6.0.

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SECTION 5.0 - AFFECTED ENVIRONMENT

5.0 AFFECTED ENVIRONMENT

This section of the DEIR describes the environmental and cultural resources which will be affected by the alternatives for dredged material disposal. This section provides a baseline against which the impacts of the various preferred aquatic and upland disposal alternatives described in Section 4 can be analyzed in further detail in Section 6. The sites under consideration for the disposal of dredged material from Salem Harbor are located in Salem Harbor and upland areas of Massachusetts.

5.1 Affected Aquatic Environment

5.1.1 General

Location and Hydrography

Salem Harbor is located on the North Shore of the Massachusetts coast and borders the communities of Marblehead, Salem, and Beverly. The mean tide range in Salem Harbor is nine feet. Average water depth in Salem Harbor is 31 feet.

Regulatory Jurisdictions

Disposal of dredged material in Salem Harbor and Salem Sound falls under the jurisdiction of several federal and state environmental programs. The principal federal jurisdiction is Sections 401 and 404 of the Clean Water Act of 1977, which regulate the disposal of dredged material in open water landward of the baseline of the territorial sea. All potential aquatic disposal sites for disposal of unsuitable dredged material from Salem Harbor are located in the area landward of the territorial sea baseline are thus not subject to regulation under Section 103 of the Marine Protection, Research and Sanctuaries Act of 1972.

The Section 401 Water Quality Certification program is administered by the Massachusetts Department of Environmental Protection. A Water Quality Certification must be issued for the disposal of dredged material within the limits of state waters, which extends from the shoreline seaward for three miles, or to the territorial sea baseline.

Other state regulatory programs including the Public Waterfront Act (Chapter 91 of the Massachusetts General Laws (MGL)) and the Wetlands Protection Act govern dredged material disposal activities in the aquatic environment.

Approach to Resource Characterization

In preparing the characterization of natural and cultural resources which is included in this section, existing information sources were collected and reviewed for pertinent information. Several specific sources of existing information were of particular use, including a map of sediment types in Salem Sound prepared by the US Geological Survey (Knebel et. al.), used to characterize general sedimentary environments in the Sound. Recent fisheries information collected by Salem Sound 2000 and the Massachusetts Department of Marine Fisheries was useful in the characterization of existing fisheries and habitat resources. Natural resources mapping prepared by the Massachusetts Department of Environmental Protection (eelgrass) and data provided by the Massachusetts Geographic Information System (Mass GIS) office (wetland resources) was also useful.

Site-specific field studies were performed at each of the candidate site to collect sediment profile samples, using the Sediment Profile Imaging (SPI) capabilities of the Remote Ecological Monitoring of the Seafloor (REMOTS) camera system. These SPI images provide valuable site-specific information on the sediment types and biological activity at the site.

5.1.2 Sediments and Water Quality

Physical Characterization of Existing Sediments

Fine-grained unconsolidated sediments (>4 phi) dominate the proposed preferred aquatic disposal sites, S6-CAD/OD and S15-ATC, in Salem Harbor. This type of sediment suggests a low-energy, depositional environment which is typical of protected coastal embayments with limited freshwater inflow and a moderate tidal prism. This characterization is in close agreement with sediment testing results conducted in 1997 in support of the Salem Port Development Plan and New England Power Basin. Testing areas from these two surveys partially overlayed portions of S6-CAD/OD. Sediment tests on composite grain samples taken from the upper 2 ft of sediment, revealed that areas within site S6-CAD/OD contained sediments that were greater than 75% silt and clay (Maguire Group 1997).

Other physical parameters were also evaluated using sediment profile image data to provide further insight into the sediment character. The majority of Salem Harbor sites showed high RPD values, indicating good sediment aeration, good tidal flushing, and bioturbation by Stage III organisms (subsurface deposit-feeders) for the majority of stations within S6 and S15. These sites exhibited fine-grained unconsolidated sediments with successional designations of Stage III or Stage I on III and RPD depths exceeding 5 cm. These successional designations and RPD values are indicative of low-energy regimes and thus depositional environments. Images from two sites within the central portion of S15 displayed 1 –2 cm RPD and exhibited successional stage designations of Stage I. Lower RPD values and a Stage I designation are normally indicative of high-disturbance regimes. Planview images were not obtained because of camera malfunction, although distinguishing biological features such as early benthic phase lobster burrows were observed on the seafloor surface in both sites during diver transects (NAI 1999).

Greater than 50% of the replicate images at S15 and 100% of the images at S6 had Organism Sediment Index (OSI) values greater than +6, suggesting good or healthy overall benthic habitat quality. OSI is a metric which defines overall benthic habitat quality by reflecting the depth of the apparent redox layer, successional stage of infauna, the presence/absence of methane gas in the sediment, and the presence/absence or reduced (i.e. anaerobic) sediment at the sediment-water interface. These high values reflect the widespread presence of bioturbating Stage III organisms coupled with relatively deep apparent RPD depths at these sites (Maguire Group 1999).

Sediment Transport/Circulation in the Vicinity of Disposal Sites

The circulation of water in coastal embayments such as Salem Harbors is influenced by a complex combination of forces produced by tidal fluctuations, wind, and density gradients. Although general information about present circulation conditions within these harbors has been collected (see below), no data exists describing the actual sediment transport and circulation patterns at the proposed preferred sites. In addition, other factors affecting potential sediment transport at these sites are dependent on disposal site design.

Detailed site-specific information is required in order to project the fate of dredged material disposed of at these locations with a strong degree of confidence. At present, understanding of the magnitude and seasonal and spatial components of these physical forces is insufficient to make an informed decision about the long-term stability of dredged material at these disposal sites. It is recommended that additional efforts include detailed, *in situ* measurements of tides, circulation, and patterns of sediment resuspension at the proposed preferred disposal sites. This includes deployment of a tidal gauge; current meters to provide a vertical profile of flows, bottom shear stress, and wave height; and an OBS (optical backscatter) meter to determine the relationship between wave heights, water currents, and sediment resuspension.

General sediment transport and circulation conditions within the vicinity of the disposal sites is provided below:

Circulation patterns and sediment transport within of Salem Harbor has not been well characterized due to limited number of oceanographic studies. Physical oceanographic studies conducted by the South Essex Sewerage District (SESD) and the Salem Harbor US Power Generating Plan indicate that currents in Salem Sound at the existing SESD Discharge exhibit a pattern of prevailing net flow from the east to the southwest on the order of 350 to 1000 million ft^3 (CDM 1987). Circulation patterns within Salem Harbor and Salem Sound are primarily driven by meteorological events and mixed semi-diurnal tidal currents. Mean tidal amplitude within the harbor is approximately 9.0 ft. During a tidal cycle, the surface area of the Beverly-Salem Harbor decreases approximately 11% from mean high to mean low water. Compared to other coastal embayments in Massachusetts, Salem Harbor exhibits a relatively small volume change and consequently there is a comparatively lower rate of tidally-induced dispersive currents (Jerome et al. 1967).

Meteorological forcing and storm-driven events may have a strong influence on sediment resuspension in Salem Sound and Harbor. In Massachusetts Bay, sediment resuspension is most prominent during the late fall through early spring when large waves from the northeast, north, and northwest are generated by storms. During spring and summer, winds are typically from the southwest and west, waves are smaller and weaker, and resuspension is less likely (Knebel et al. 1996). Salem Harbor is oriented to the northeast which makes it most susceptible to storms and waves originating from this direction. Data collected from NOAA's National Weather Service, Beverly Station, indicate that wind from the N and NE primarily occurs in winter and fall (Figure 5-1a and 5-2a). Average winds are highest during these seasons (Figure 5-1b) as is the frequency and duration of gusting winds from the NE (Figure 5-2b; NOAA 1998). Relatively long expanses of open water with nearby depths in Salem Sound of at least 45 ft are conducive for the development of large waves from winds out of the north and northeast. The Salem Harbor Master office confirmed that wave heights reach their maximum (approximately 1 ft) within Salem Harbor with winds from the northeast (20-25 kts) (Matt Plauche, pers. com.).

Water Quality Classifications

The Massachusetts Department of Environmental Protection has established Water Quality Classifications for the Commonwealth's surface waters, as listed below. Each class is defined and governed by the most sensitive water, and therefore governing, water uses to be achieved and protected. Figures 5-1, and Table 5-1, show the water quality classifications and restrictions for the Federal channel and disposal sites under consideration for Salem Harbor maintenance dredging projects.

Coastal and Marine Classes

Class SA - These waters are designated as an excellent habitat for fish, other aquatic life and wildlife and for primary and secondary contact recreation. In approved areas they shall be suitable for shellfish harvesting without depuration (Open Shellfish Areas). Eastern portions of Salem Harbor within the Marblehead town boundary and extending out to the 3 mile state boundary are designated as Class SA (Figure 5-4). Southern portions of the Salem Harbor proposed preferred site S15-ATC are designated as Class SA. A small southeast section of S6-CAD/OD is also considered Class SA.

Class SB - These waters are designated as a habitat for fish, other aquatic life and wildlife and for primary and secondary contact recreation. In approved areas they shall be suitable for shellfish harvesting with depuration (Restricted Shellfish Areas). These waters shall have consistently good aesthetic value. The major portion of Salem sites S6-CAD/OD and S15-ATC occur within Salem town waters and therefore are subject to Class SB Commonwealth criteria (Figure 5-4).

Class SC - These water are designated as a habitat for fish, other aquatic life and wildlife, and for secondary contact recreation. They shall also be suitable for certain industrial cooling and process uses. These waters shall have good aesthetic value. No proposed preferred sites occur within waters designated as Class SC.

Other Restrictions

In addition to the basin classification system of surface waters, the Commonwealth has also denoted specific subcategories of use assigned to water segments that may effect the application of criteria or specific antidegradation provisions of 314 CMR 4.05. Those restrictions pertinent to the siting of disposal material from Salem Harbor include:

Shellfishing – open shellfishing areas are designated as "(O)" and restricted shellfishing areas are designated as "(R)." These waters are subject to more stringent regulation in accordance with the rules and regulations of the Massachusetts Division of Marine Fisheries pursuant to M.G.L. c. 130 § 75. These include applicable criteria of the National Shellfishing Sanitation Program. Shellfish Growing Area Designations by the DMF indicate that all of Salem Harbor, Beverly Harbor, the Danvers River and tributaries, and an area extending 3 miles into the ocean off Salem are currently classed as prohibited areas for fishing. (MADMF 1999).

CSO – These waters are identified as impacted by the discharge of combined sewer overflows in the classification tables in 314 CMR 4.06(3). Overflow events may be allowed by the permitting authority without variance or partial use designation.

Water Quality

Historically, waters of Salem-Beverly Harbor were utilized for the disposal of millions of gallons of raw industrial and domestic sewage, as is typical of many tidal bays and estuaries in Massachusetts. Pollution and the subsequent reduction in water quality have been a contributing factor to the disappearance of

Figure 5-1: Salem Harbor Area Water Quality Classifications important commercial and recreational finfish species, as well as the closure or restriction of harvesting from shellfish beds (Jerome et al. 1967). Significant improvements in the marine environment have been evident since the addition of primary sewage treatment (1978) and cessation of sludge discharge (1984) (CDM 1992). Permitting requirements associated with the operation and expansion of the South Essex Sewage Treatment Center and the Salem Harbor Electric Generating Station have provided the primary characterization of past water quality conditions. More recently, the Massachusetts Department of Marine Fisheries (MA DMF) conducted the Salem Sound Resource Assessment study to monitor present water quality and fishery abundance conditions (Chase, In prep). MA DMF measured dissolved oxygen, temperature, salinity, turbidity, and secchi depth once a month at six shallow water and sampled eight deep water sites at monthly intervals from January-April, November-December, and biweekly for May-October (Figures 5-9 and 5-10).

The five deep water sites (6-13 m) exhibited a strong hyperbolic pattern in water temperature in close agreement with seasonal changes in air temperatures. Minimum surface water temperatures (~2 °C) occurred in winter (December-February) and maximum temperatures (~18 °C) during summer (July-September). A vertical temperature gradient (bottom vs. surface temperatures) of approximately 4°C was most developed during summer months at sample stations of greatest water depth (SH, BH, HC, HS, and MH; Figure 5-__). A seasonal thermocline was not evident at shallower stations most likely due to greater water column mixing to depth (BC, UDR, and LDR; Figure 5-__). Depth at the shallower sites were less than 6 meters.

Strong seasonal variation in DO concentration was present at all sites with concentrations being maximum during winter (11-14 mg/l) and lowest during late-summer (6-8 mg/l). In general, the amount of DO in the water changes as a function of temperature, salinity, atmospheric pressure, and biological and chemical processes. The equilibrium (or saturated) concentration of DO in natural waters ranges from about 6 to 14 parts per million (or mg/l). The higher the temperature or salinity, the lower the equilibrium DO concentration. Biological processes such as respiration and photosynthesis can affect the concentration of

DO faster than a new equilibrium can be reached with the atmosphere. Thus under reduced mixing conditions or short periods of time, DO can decrease to hypoxic (less than 5 mg/l) or anoxic (0 mg/l) conditions in deep or stratified bodies of water or can increase to supersaturation in dense algal blooms (Dallaire and Halterman 1991).

Maximum DO readings were consistently observed in winter due to low water temperatures and high oxygen solubility. Dissolved oxygen was lowest in summer when oxygen solubility is reduced by high water temperature. Bottom DO was consistently lower than surface DO at all sites (Figure 5-9). This was a function of stratified conditions typical of New England waters in the summer in which cool, salty water is at the bottom, and warm freshwater is present near the surface. Bottom waters have reduced DO because oxygen is consumed through respiration and chemical oxidation from the decay of large amounts of organic material. Typically, these depths are below the euphotic zone, thus light penetration is insufficient to support photosynthetic production of oxygen. These field data, supplemented with collected sediment profile images, suggest that anoxic or hypoxic conditions are not present in Salem Harbor.

The Salem Sound 2000 study observed uniformly high salinity (>30 ppt) across all sites throughout the year (Figure 5-10). There was some variability at the Upper Danvers River station, perhaps due to its close proximity to the major source of freshwater into Salem Sound. High salinity, marine conditions are typical for coastal bays such as Salem Harbor which have reduced freshwater inflow. However, Anderson et al. (1975) measured some seasonal variability in salinity with the concentration lowest during high spring precipitation and high freshwater inflow. They observed a gradual increase in salinity from a spring minimum to a maximum in winter.

Turbidities were highest at the Upper and Lower Danvers River sites, 35 and 23 NTU's respectively, during May through June. Typically, freshwater inflow and suspended sediments are highest during spring, due to seasonal increases in precipitation. Turbidities were also exceptionally high during March (58 NTU) at Haste Station, a location relatively exposed to tidal or meteorological induced sediment resuspension from

Massachusetts Bay conditions (Figure 5-10).

Anderson et al. (1975) reported seasonal variation in phytoplankton production, as estimated by chlorophyll *a* concentration, was evident within Salem Harbor. Seasonal patterns and bloom conditions were similar to those reported for other estuaries in temperate climates. High temporal and spatial variability in chlorophyll concentration is characteristic, caused by fluctuations in riverine inflow, wind-driven turbulence, or patchy nutrient distribution. The first and largest bloom typically occurs in late winter to early spring with warming of surface waters and the introduction of nutrients from freshwater inflow. Primary productivity may be reduced during summer due to nitrogen limitation, and increases again during fall with increased mixing and resuspension of organics in bottom waters (Riley 1967, Anderson et al. 1975). Chlorophyll *a* concentration ranged from 0.69 to 29.08 mg/m^3 over the course of the study (July 1973-December 1974), and present algal concentrations were estimated to be medium (>5 - ≤ 20 mg/m^3; NOAA 1997). NOAA's (1997)Estuarine Eutrophication Survey estimated that nuisance algal blooms do not have an impact on biological resources, but toxic algal blooms do occur within Salem Sound/Massachusetts Bay .

Sediment Quality

The shoreline of Salem Harbor is a dense mix of residential, commercial and industrial land uses (Maguire Group Inc., 1997). The PG&E Plant and South Essex Sewage Plant, among the 16 registered NPDES discharges within the Salem area, are classified as major sources of discharge and are located along the harbor's eastern shoreline. Sources of potential contamination within Salem Harbor were evaluated during the Due Diligence review (Maguire Group 1997). Since 1990, there have been two significant aquatic oil spills. In 1996 a gasoline spill occurred near the jetty at the PG&E Power Plant. A petroleum spill occurred within Salem Harbor in 1990.

Prior to testing in Salem inner harbor, the presence of metals, pesticides, PAHs and PCBs was anticipated near Derby Wharf because of the proximity of the PG&E Plant, current waterfront pollution sources, and the historic sediment contamination in this area (Maguire Group 1997). This hypothesis was confirmed through sediment testing in 1997 within the Salem Port Development Plan. Tests revealed that the upper 2-4 ft of sediment contained concentrations of metals, primarily chromium. The following specific chemical concentration ranges were measured; chromium 29 – 1000 mg/kg, lead 11 – 1000 mg/kg, total polychlorinated aromatic hydrocarbons (PAHs) 148 – 8239 μg/kg, and total polychlorinated biphenyls (PCBs) 5 – 117 μg/kg.

Table 5-1: Salem Harbor Coastal Drainage Area - Water Quality Classifications / Restrictions

BOUNDARY	CLASS	OTHER RESTRICTIONS
Salem Harbor	SB CSO	Shellfishing (R)
Marblehead Harbor	SA	Shellfishing (O)
Massachusetts Bay	SA	Shellfishing (O)

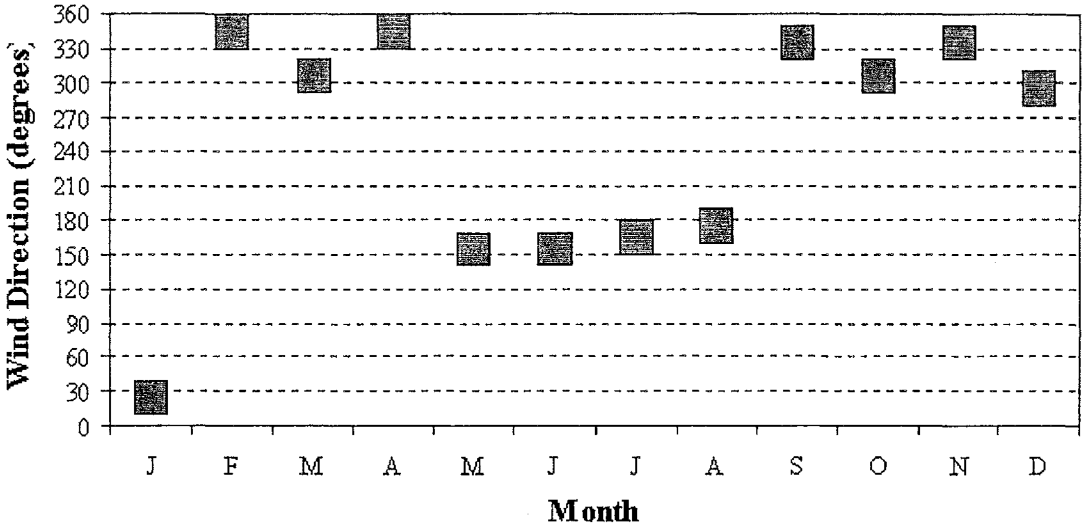


Figure 5-2: Prevailing Wind Direction by Month (1998) Recorded at Beverly Airport

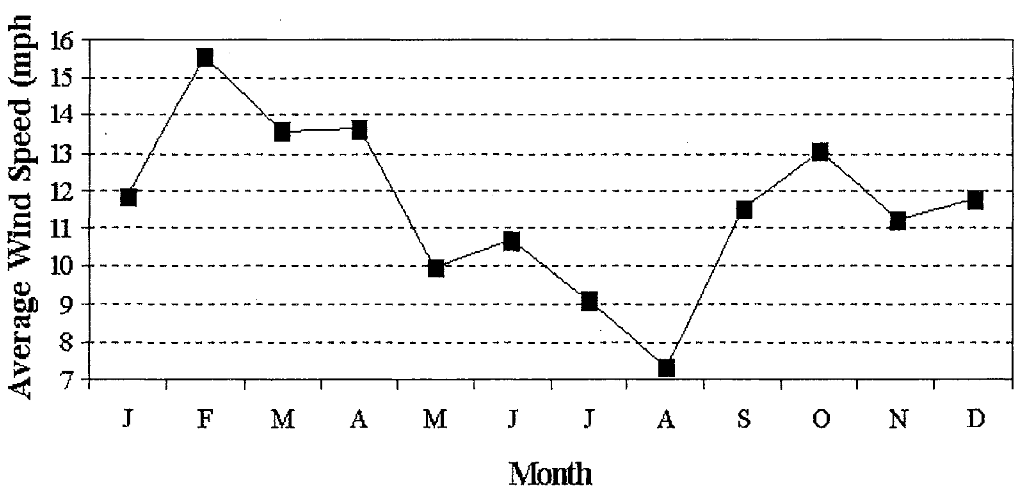


Figure 5-3: Average Wind Speed by Month (1998) Recorded at Beverly Airport

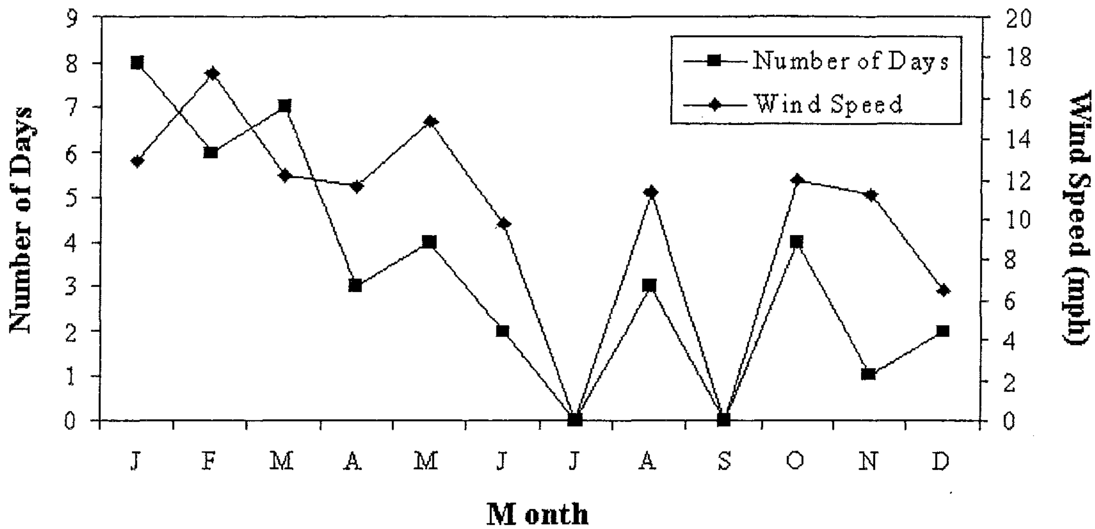


Figure 5-4: Number of Days/Wind Speed by Month (1998) for Winds from the NE Recorded at Beverly Airport

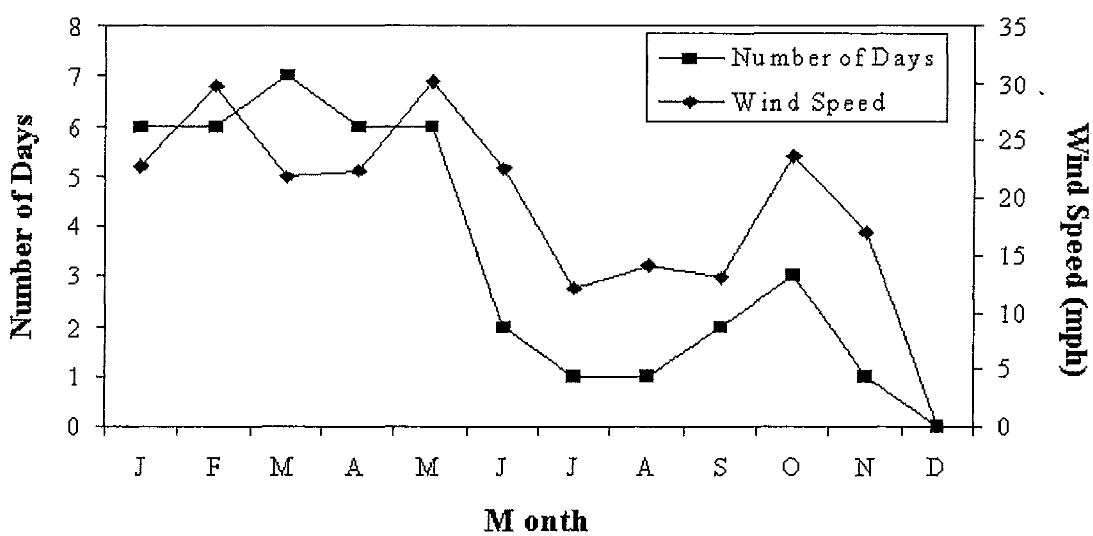


Figure 5-5: Number of Days/ Wind Speed by Month (1998) for Wind Gusts from the NE Recorded at Beverly Airport

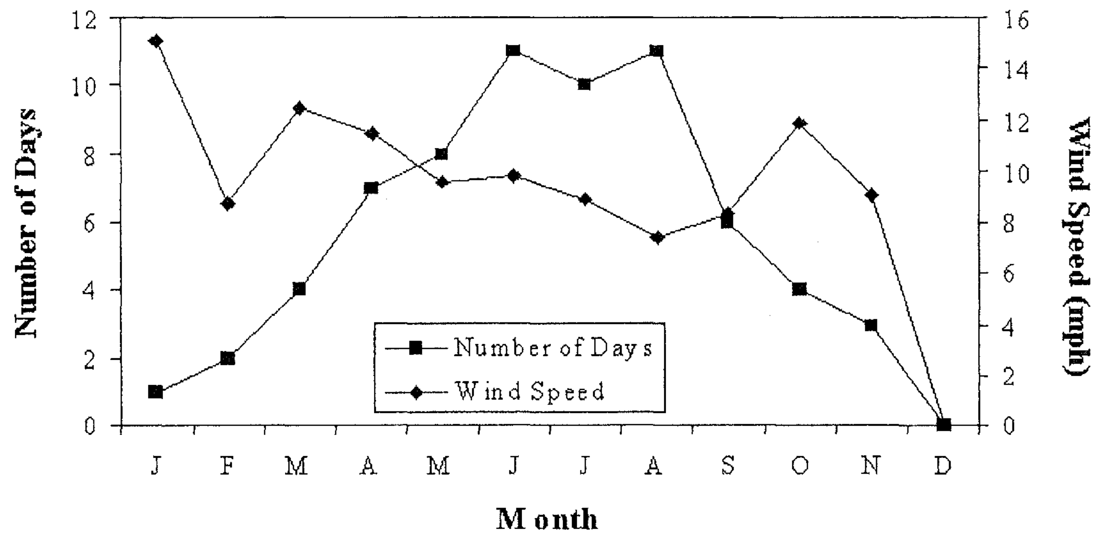


Figure 5-6: Number of Days/Wind Speed by Month (1998) for Winds from the SSW Recorded at Beverly Airport

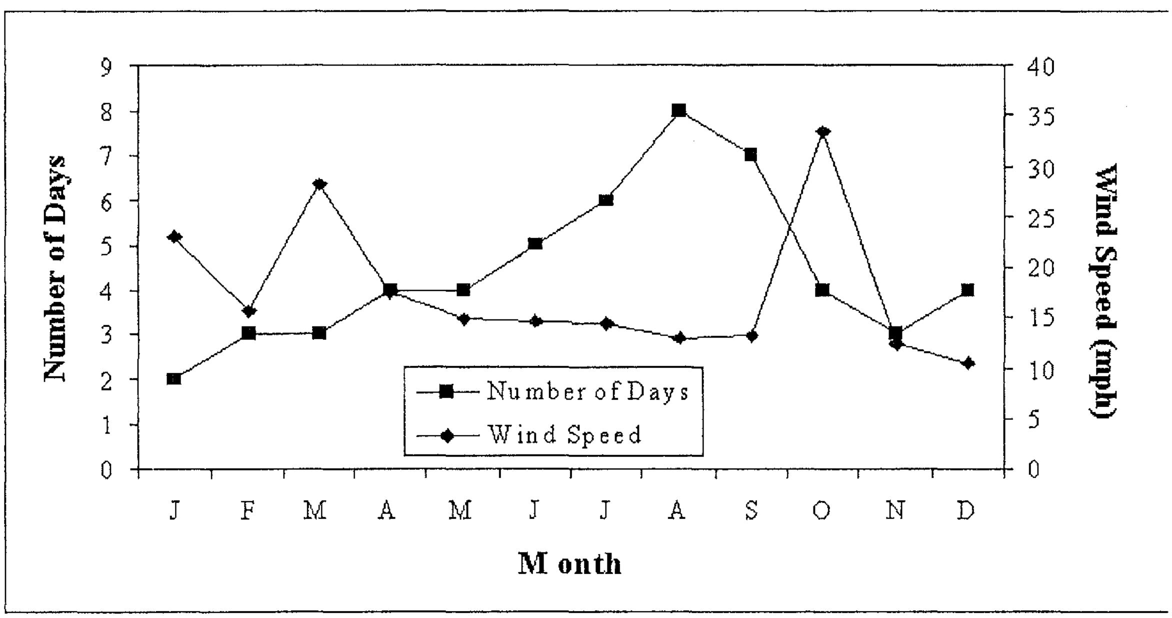


Figure 5-7: Number of Days/Wind Speed by Month (1998) for Wind Gusts from the SSW Recorded at Beverly Airport

Figure 5-8: Surface Water Classifications for Proposed Preferred Disposal Sites in Salem Harbor

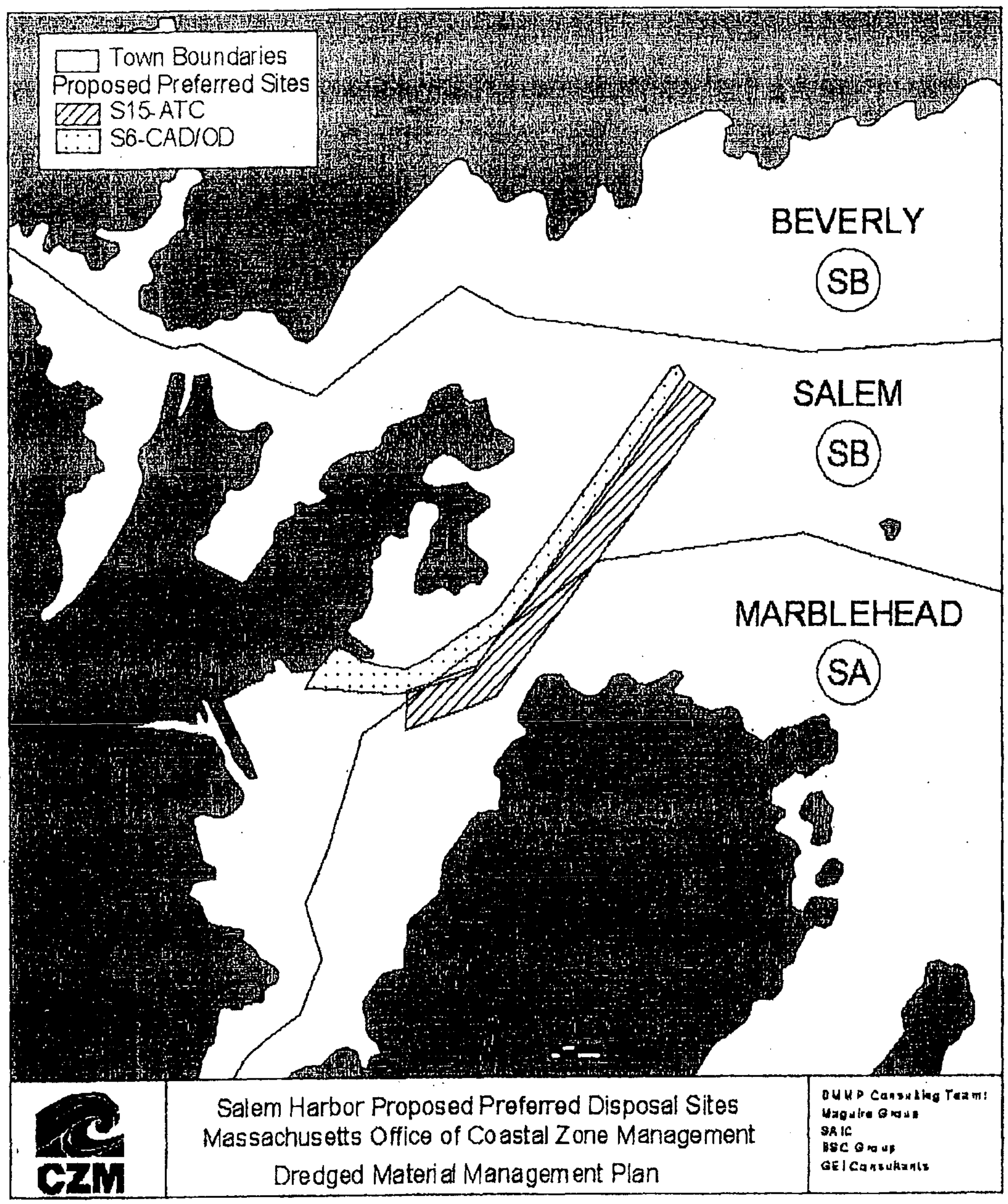


Figure 5-9: Water Quality Stations within Salem Harbor (Chase, In prep).

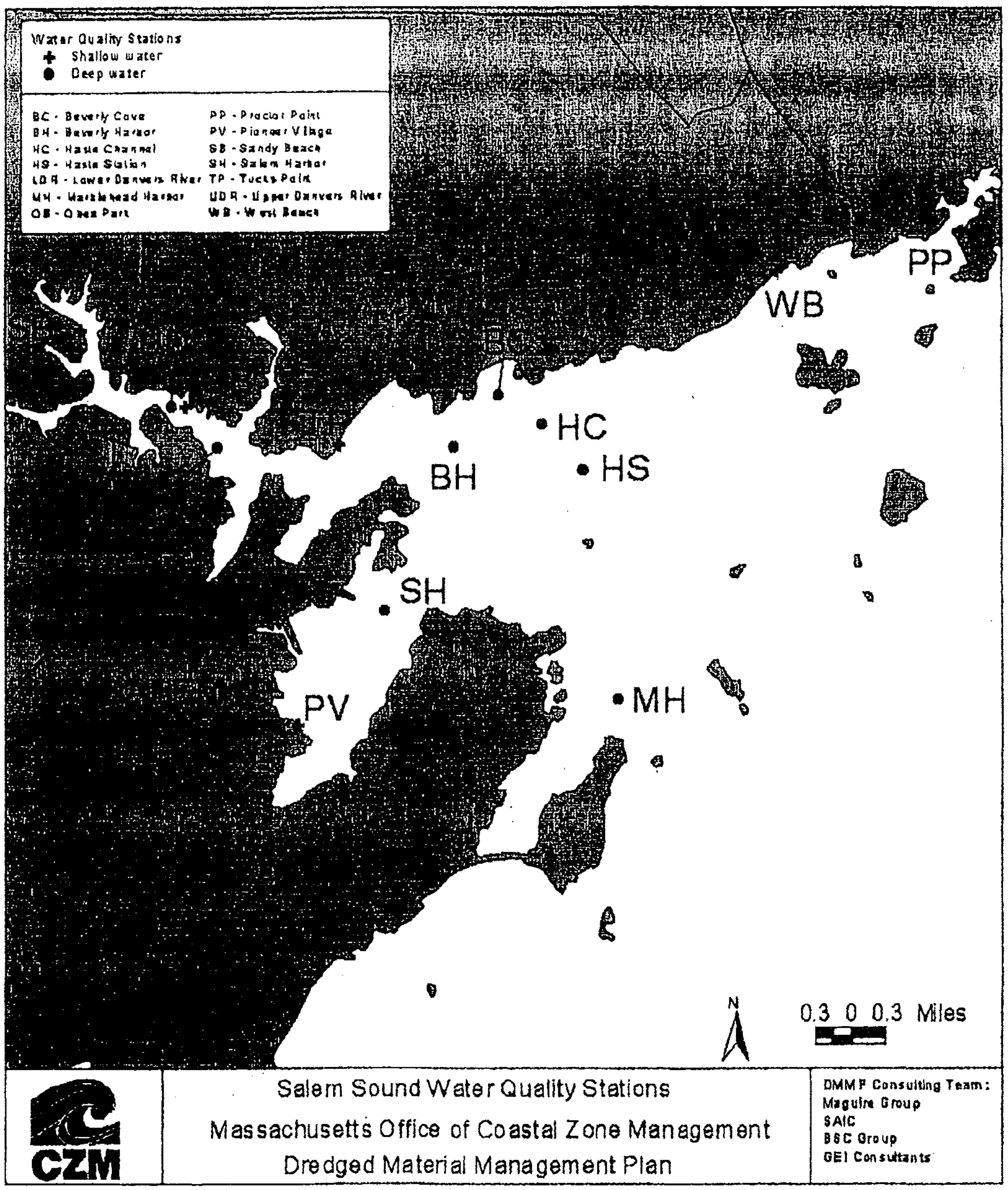
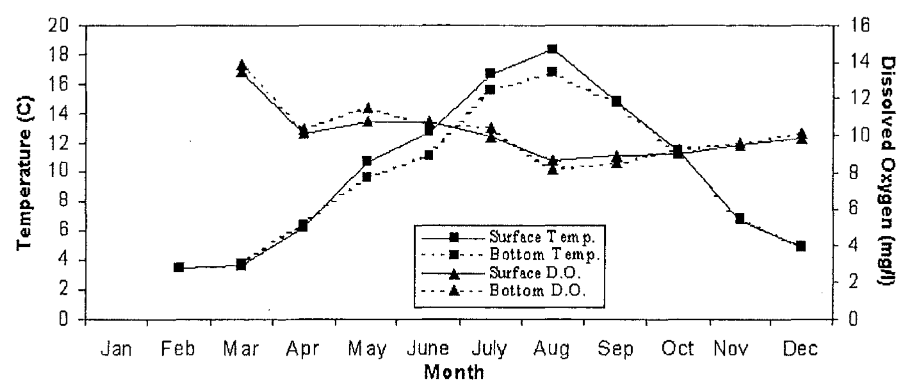
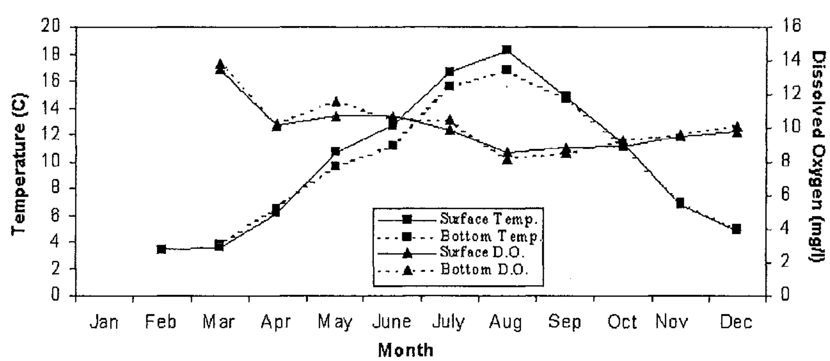


Figure 5-11: Temperature and Dissolved Oxygen Conditions by Month (1997) at Representative Water Quality Stations within Salem Harbor (Chase, In prep).

Beverly Cove (BC)



Haste Station (HS)



Salem Harbor (SH)

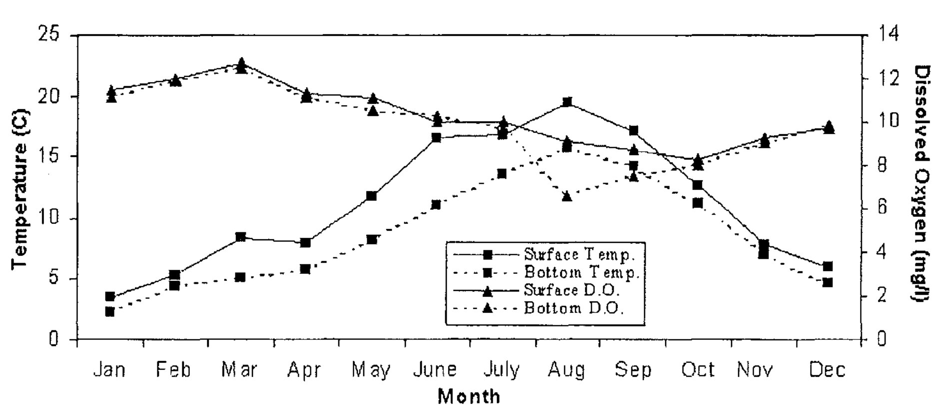
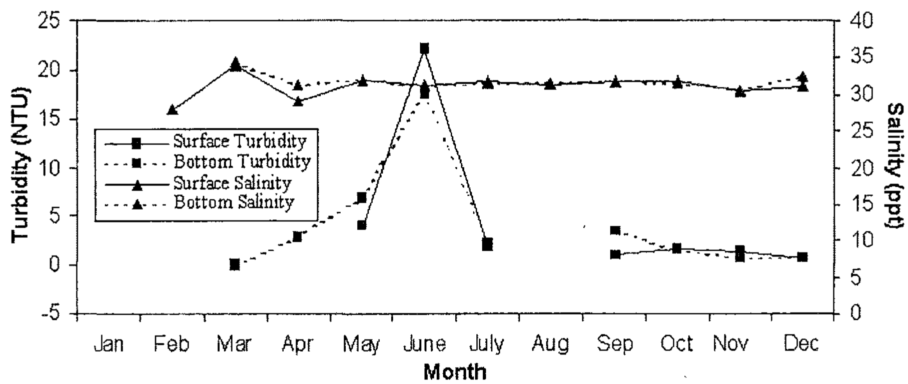
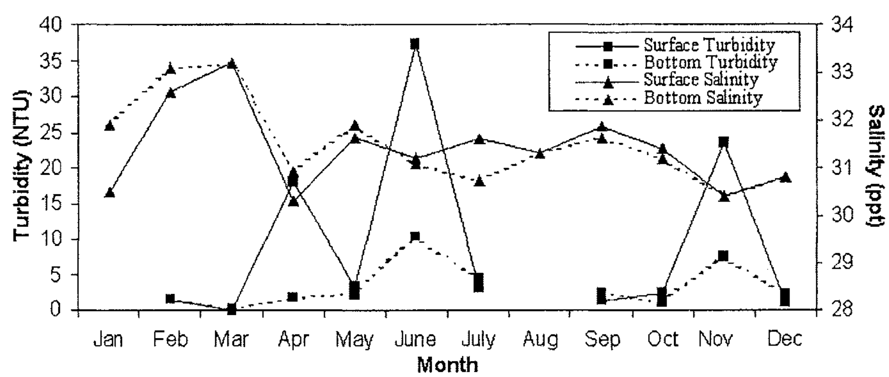


Figure 5-12: Turbidity and Salinity conditions by month (1997) at representative water quality stations within Salem Harbor (Chase, In prep).

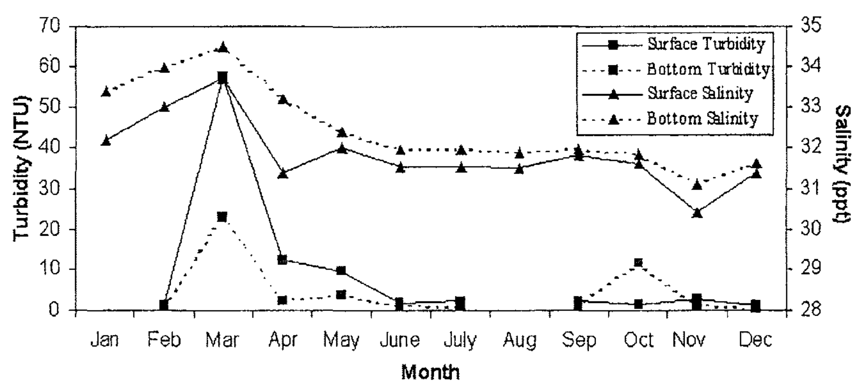
Lower Danvers River (LDR)



Upper Danvers River (UPR)



Haste Station (HS)



5.1.3 Benthos

General

The term benthos refers to the community of organisms living in the bottom sediments or directly on the bottom. For the purposes of this report, the term does not include finfish, although some of these may live on the bottom. Benthic organisms include those valued for human consumption such as lobsters and several species of bivalves, as well as many non-commercial species such as segmented worms, other bivalves, and crabs.

The benthic invertebrate fauna of the Massachusetts coast north of Cape Cod are characteristic of the boreal biogeographical region, which has colder temperatures and less summer warming, and therefore a smaller annual temperature range, than waters south of the Cape. Many northern species reach the southern limit of their abundance at Cape Cod, and many southern species reach their northern limit there. This means that the characteristic species of harbors north of Cape Cod will be very similar, and the abundance patterns of species in Salem will be practically identical, and even more similar to northern Europe than to areas south of Cape Cod, such as New Bedford and Fall River (Gosner, 1971).

Sources of information on benthic populations in Salem Harbor and vicinity are limited. Studies in Salem include a survey of the marine resources of Beverly-Salem Harbor by the DMF in 1965 (Jerome *et al.* 1967), sampling at 14 stations by the USACE in 1972 and 1973 (USACE 1975), benthic samples taken in 1987 in the Danvers River Estuary for the Massachusetts Department of Public Works, shellfish surveys done in Salem Harbor and parts of the Beverly Harbor-Danvers River system from 1995 to 1997 by the DMF, and evaluation of benthic habitat at candidate disposal sites through sub-bottom profiling performed in 1998 by SAIC.

In 1998, Science Applications International Corporation (SAIC) conducted an evaluation of benthic habitat at 27 potential aquatic disposal sites in the Salem area through sediment profile and planview photography.

Also in 1998, DMF biologists listed the following invertebrate species as warranting attention for potential environmental impacts associated with dredged material disposal in Salem:

Common Name	**Scientific Name**
American lobster	*Homarus americanus*
Rock crab	*Cancer irroratus*
Blue mussel	*Mytilus edulis*
European oyster	*Ostrea edulis*
Sea urchin	*Stronglyocentrotus drobachiensis*

Benthic Invertebrates

Previous Investigations

Most of the past benthic invertebrate samples were taken in relatively shallow, nearshore areas for purposes such as fisheries assessment or to study the impacts of other projects, and sampling was not within candidate disposal sites. The benthic habitat analysis by SAIC, however, was done for the current project and therefore targeted specifically at the disposal sites.

Jerome *et al.* (1967) sampled at intertidal flats only. They reported that the principal "associated fauna" found in their shellfish survey were duck clams (*Macoma balthica*), blue mussels (*Mytilus edulis*), and clam worms (*Nereis virens*). In samples taken at various locations from Salem Harbor and the tributaries of the Danvers River, duck clams were found at all areas sampled and were most abundant in the Porter River at $22/ft^2$ and at the extreme south end of Salem Harbor off the Forest River mouth at $18/ft^2$. Clams worms were found at nearly all areas sampled, generally at less than $10/ft^2$. Blue mussels were rare, probably because areas of abundant mussels were avoided in a survey directed at clams.

In 1972 and 1973, the Corps of Engineers sampled benthic stations in transects across Salem Harbor, and found the periwinkle (*Littorina littorea)* to be dominant intertidally, while three species of amphipods as well as the bivalve *Nucula delphinodonta* were most abundant subtidally (ACOE 1975). In intertidal samples taken by Normandeau Associates for the relocation of the Route 1A Bridge at the junction of the Danvers River and Beverly Harbor, deposit-feeding annelids constituted 99 percent of the total population (NAI 1987). Opportunistic species such as *Capitella capitata* and *Streblospio benedicti* were the most abundant species. The dominant species, the relatively low number of taxa collected compared to other New England estuaries, and the scarcity of crustaceans and molluscs suggests that the area is stressed or polluted.

REMOTS Sediment Profile Imaging

In 1998, benthic habitats at the potential aquatic disposal sites for Salem were characterized by REMOTS sediment-profile imaging (Valente *et al.*, 1999). The REMOTS system uses a specialized camera to take a photograph of a vertical cross-section of the sub-bottom to a depth of 15 to 20 cm. Data obtainable from the photographs include sediment type, presence of macrofauna, presence of methane bubbles, and depth of oxidized sediments. The depth of oxidized sediments is apparent in the photographs as the boundary between colored surface sediment and underlying gray to black sediment, called the apparent redox potential discontinuity (RPD). The depth of the RPD is increased by the presence of bioturbating macrofauna. The foregoing parameters can be used to determine habitat type and infaunal successional stages, and to calculate an Organism-Sediment Index (OSI), an indicator of habitat quality of soft-bottom benthic environments. OSI values of less than 0 indicate degraded habitat quality, values of from 0 to +6 reflect intermediate quality, and values greater than 6 are indicative of good quality or healthy benthic habitats.

REMOTS images were obtained from 35 stations within 13 potential disposal sites in Salem, and from 49 stations within 11 offshore sites being considered for disposal from Salem. The Salem sites include nine within or near Salem Harbor (Figure 5-9) and two in open water to the south of Marblehead (Figure 5-10). Two sites in Salem, S-1 and S-2, could not be sampled because they were in water too shallow for the survey vessel.

At all near shore sites examined within in Salem Harbor, including sites S-3, S-6, S-7, S-14, S-15, S-16, S-18, and S-19. Benthic habitat types were characterized as either unconsolidated soft mud or soft silty mud. The presence of fine-grained sediment suggests a depositional sedimentary environment.

The three Salem sites located in deeper, more open water, S-12, S-13, and S-17, exhibited sandier sediments. All stations at S-12 contained very fine sand, whereas S-13 contained a mixture of very fine and fine sand. S-17 exhibited a more varied environment, with very fine, medium, and coarse sand, as well as hard rocky bottom. The coarser offshore sediments are indicative of a higher energy environment. Benthic habitat at S-17 included a mixture of rocky and hard sand types, while Sites S-12 and S-13 contained both hard to medium sand and unconsolidated fine sand habitats.

The benthic infaunal community typically goes through predictable stages when colonizing an area. Successional Stage I consists of those organisms which first colonize an area following a disturbance, typically dense aggregations of near-surface-living , tube-dwelling polychaetes or opportunistic bivalves. These are eventually replaced by Stage II species, infaunal deposit feeders such as shallow dwelling bivalves or tubicolous amphipods. Stage III taxa are typically found in low-disturbance regimes. They are infaunal and many feed at depth in a head-down orientation, which results in distinctive excavations called feeding voids, detectable in the REMOTS images.

Planview images could not be obtained at Salem Sites S-6, S-14, S-15, S-17, and S-18 due to a camera malfunction. At all the stations where images were obtained, the surface sediment was silt-clay, with epifauna, worm tubes, and shell material common.

Infaunal successional stages from Salem could not be determined reliably at some sites, particularly S-17, because the penetration of the camera prism was inhibited by rocks or hard sand. The three sites located within and on each side of the channel leading into Salem Harbor all had a relatively high percentage of images with Stage III or Stage I on III successional designations. The presence of larger-bodied, deposit-feeding Stage III taxa is generally taken as one indicator of good overall benthic habitat quality. At the remainder of the Salem disposal sites, Stage I was dominant.

The REMOTS data from Salem indicate that the best benthic habitat quality is found in the main channel and immediately adjacent to it (Sites S-6, S-14, and S-15) and at Site S-13 outside the harbor. At S-6, S-14, and S-16, most RPD depths exceeded 5 cm, and at S-13 were from 3 to 5 cm. At the remainder of the sites, apparent RPD depths were intermediate (0.5 to 3 cm). The RPD depths and successional stages are reflected in the OSI values. More than half of the replicate images obtained at Sites S-6, S-13, S-14, and S-15 had OSI values greater than +6, suggesting good or healthy overall benthic habitat quality. These high values reflect the widespread presence of Stage I or Stage III organisms coupled with relatively deep apparent RPD depths at these sites. At the remainder of the Salem sites, mainly those located on shallower, more protected water close to shore, OSI values reflect intermediate RPD depths and the predominance of Stage I organisms only. The general absence of bioturbating Stage III organisms coupled with possible high inputs of organic matter from runoff and local point sources at the sites within Salem Harbor has resulted in somewhat shallower RPD depths. These factors are in turn reflected in intermediate OSI values suggestive of moderately degraded benthic habitat quality.

The Salem sites are to the east and southeast of Salem and from 660 yards to 6.7 miles (600 m to 10.8 km) from shore. At Sites SG-3, SG-7, SG-9, SG-11 and SG-12, silt-clay was the dominant sediment type; a combination of rocks and medium to very fine sand was present at Sites SG-2, SG-4, SG-6, SG-8, and SG-10, and the remaining site, SG-5, was predominantly rock. The five sites dominated by silt-clay were soft mud or silty mud habitats, with a few individual images showing hard rocky bottom, SG-5 had a hard rock habitat, and the remaining five sites had a combination of sandy and hard rock habitats.

Infaunal successional stages could not be determined reliably at some of the Salem-Gloucester sites, particularly SG-4 and SG-5, because the penetration of the camera was limited by rock or hard sand. Stage I was the dominant stage at the Salem-Gloucester sites. Most of these sites consist predominantly of dense assemblages of surface-dwelling tubiculous polychaetes. Several images showed Ampeliscid and Corophiid amphipod tubes as well as Caprellid amphipods occurring together with the surface polychaete tubes.

At stations where sufficient penetration was achieved so that RPD depths could be determined, the majority of values fell between 1 and 3 cm, which are intermediate levels which may reflect either moderate levels of organic loading or infrequent physical disturbance.

The OSI values at site SG-5 could not be determined because rocks prevented prism penetration. OSI values at most of the sites were between +1 and +6, indicating moderate degradation. However, because the surface-dwelling community at many of the Stage I sites appears to be well-developed and diverse, the low OSI values are somewhat misleading, and benthic habitat quality at these sites is considered better than indicated by the OSI values. Good or healthy overall benthic habitat quality is indicated by values of greater than 6 at Sites SG-9, SG-11, and SG-12.

Commercially and Recreationally Harvestable Mollusks

DMF 1965 and 1997 Surveys in Salem

In 1965, the Massachusetts Division of Marine Fisheries conducted a soft shell clam survey in Salem (Jerome *et al.* 1967) and found productive clam flats at the south end of Salem harbor off the mouth of the Forest River, at Pioneer Village on the west side of the harbor, next to Derby wharf, in Collins Cove, in the North River, adjacent to the Kernwood Bridge, and in Kernwood Cove at the Danvers line. Abundance of clams in these flats ranged from 4.3 per cubic foot at small, 2.7 acre flat next to Derby Wharf, to 81.4 per cubic foot at the smallest flat investigated, at Pioneer Village. Density of legal size clams (>50 mm) on these flats was 3.0 and 3.3 per ft^3, respectively. The highest density of legal size clams found during the investigation was 12 per ft^3 in the inner section of Kernwood Cove. All waters and flats of Salem were closed to the taking of shellfish for human consumption, except a small area in the harbor where clams could be harvested if purified before sale. No clams had actually been legally harvested for human consumption in Salem for four and one half years prior to 1965.

Of the productive clam flats identified by the DMF in 1965, only Collins Cove contains a candidate disposal site.

In 1997, the Massachusetts Division of Marine Fisheries conducted shellfish surveys in four areas tributary to Beverly Harbor, immediately to the north of Salem Harbor. Only one of these areas sampled, Collins Cove, contains a candidate disposal site. The other three areas sampled, the North River, Kernwood Cove, and the Crane River - Danvers River, are in the Beverly Harbor - Danvers River system, from 0.5 miles to 2.5 miles upstream of any candidate sites (Figure 5-11).

Collins Cove extends south of Beverly Harbor on the north side of the city of Salem. On July 11, 1997, personnel from the Division of Marine Fisheries conducted a brief population survey in Collins Cove for soft shell clams, *Mya arenaria,* using a combination of hole counts and square foot samples. Densities of clams were recorded as zero, low, medium, and high. The highest densities of clams in the cove extended across the southern end, precisely at the site designated for Confined Disposal Facility S1-CDF. Very little soft shell clam seed was found, and most individuals ranged in size from 1½" to 3½" (38 to 89 mm). Two other areas of high clam concentrations in the cove were a raised bar located approximately 50' off the eastern shore, and a small cove about midway along the western shore. The southern end of the raised bar may extend into the S1-CDF site. Most of the center of the cove had very soft bottom and no shellfish. Other species of shellfish found in the cove included blue mussels (*Mytilus edulis*), with large beds on either side of the cove entrance, European oysters (*Ostrea* spp.) along the northern shore at the outer end, and a few 1 ½" to 4" (38 to 102 mm) quahogs (*Mercenaria mercenaria*) at the south end with the high concentrations of soft shell clams. Also present in the CDF site at the south end of the cove were high concentrations of

½" seed of an unknown species, possibly quahogs. No shellfish concentrations are indicated at the S18-CAD site just off the mouth of Collins Cove.

Of the upstream areas sampled, only Kernwood Cove and the south shore of the Danvers River immediately to the east of the Kernwood Cove entrance had high densities of soft shell clams comparable to those in the south end of Collins Cove. Except for a few small, isolated pockets, the other areas surveyed had almost no soft shell clams. Anthropogenic influences such as siltation appeared to have decreased densities in some areas since a similar survey in 1991.

Other significant populations of shellfish reported on in the 1997 DMF surveys included large blue mussel beds on both sides of the North River at its mouth, along the south shore of the Danvers River from the North River to Kernwood Point close to one mile upstream, and at the mouth of Kernwood Cove. Intertidal and subtidal populations of quahogs are found at the mouth of the North River.

Salem Sound 2000 Soft Shell Clam Survey Data Sheets (1995 to 1997)

The results of soft shell clam sampling around the shore of Salem Harbor in 1995, 96, and 97 has been recorded by DMF in the form of maps with notations of shellfish abundance, and raw data sheets for some of the area sampled, with notations on the maps of other shellfish species found. The area sampled starts off Long Point, just south of the S16-CAD candidate site, and continues south along the west (Salem) side of the harbor, into the Forest River at the southern end of the harbor, and to the north along the east (Marblehead) side (Figure 5-11).

Raw data sheets are provided for Wyman Cove and the adjacent area on the east (Marblehead) side of the harbor only. Information for the other areas sampled, as well as for Wyman Cove, is provided in the form of outline maps with small areas marked off and labeled "HH","H", "M", or "L", and with notations of the bottom type and the presence of other species.

The area from Long Point to Pickering Point on the Salem side has very few soft shell clams, with only one very small area marked "low". Several mussel beds and one area of quahogs are designated in this stretch. Areas of high soft shell clam concentration are found scattered along the west shore from Pickering Point to the Forest River mouth at the south end of the harbor, within the Forest River, and in Wyman Cove. Clams per sample in Wyman Cove ranged from 0 to 48, with 22 legal size. Along the southeast side of Wyman Cove where clams are absent, the area was reported as being "dominated by European oysters/blue mussels". North of Wyman Cove on the east shore of the harbor, only two areas with quahogs are designated.

These data probably have limited value for the screening analysis because the areas sampled are not within any candidate disposal sites, but they do indicate that the known areas of high clam concentration in Salem Harbor are relatively remote from the candidate sites, and therefore probably unlikely to be affected even by indirect effects of dredge material disposal.

Other Shellfish Resources

Blue mussels, *Mytilus edulis*, were reported as occurring all around the shore of Gloucester Outer Harbor on rocky substrate in 1997, as well as at Kettle Island and adjacent to Brace Cove outside the harbor. Ocean quahogs (*Arctica islandica*) are found in a band located approximately 0.5 to 2 miles offshore and extending from off the mouth of Gloucester Harbor toward the northeast to the vicinity of Milk Island (DMF 1997). Surf clams are found in Western Harbor and in Magnolia Harbor approximately 0.8 miles (1300 m) to the west of the entrance of Gloucester Harbor (Knowles 1998).

In 1997, DMF fisheries biologists indicated on a map of the Salem area the locations where blue mussels (*Mytilus edulis*), ocean quahogs (*Arctica islandica*), quahogs (*Mercenaria mercenaria*), European oysters (*Ostrea edulis*), and sea scallops (*Placopecten magellanicus*) (Figure 5-12). Blue mussels are found on the bottom near the entrance to Collins Cove, and on rocky shores at several locations around the Salem area, including the end of Salem Neck, along the shore of Marblehead, on several islands in Salem Sound, and at three locations along the shore of Beverly. Ocean quahogs are limited to an area off Swampscott, to the south of any candidate disposal sites. There are small areas of quahogs on the Beverly shore opposite Collins Cove, at the head of Marblehead Harbor, and along the east (Marblehead) side of Salem Harbor. European oysters are found close to the shores of Salem and Marblehead harbors, and near in Collins Cove near its entrance, and sea scallops are located in a large area off the mouth of Marblehead Harbor as well as scattered through smaller areas associated with ledges.

The waters of Salem and its vicinity encompass several shellfish growing areas designated by the Massachusetts Division of Marine Fisheries, including Region N17.0 (Danvers River and tributaries), N18.0 (Salem Harbor in Marblehead), N18.1 (Salem Harbor in Salem), and N19.0 (water extending from the mouth of Salem Harbor to a point approximately six miles from the harbor mouth, and three miles from the islands in Salem Sound. As of February 1999, all these waters were classified as prohibited for shellfishing.

Lobsters

Both the whole Cape Ann area, including Gloucester Harbor, and the Beverly-Salem area were cited by Jerome *et al.* (1967, 1969) as areas which were extensively fished for lobsters and very productive. No specific locations within these areas were cited as being especially productive of lobsters, however.

The DMF has conducted a commercial lobster trap sampling program since 1981, breaking down statistics by six areas in Massachusetts, including Cape Ann and Beverly-Salem (Estrella and Glenn 1998). The catch per unit effort (per trap per 3-day set) for marketable lobster was 1.11 at Cape Ann and 0.419 in Beverly-Salem in 1997, compared to 0.776 for the state as a whole. Marketable lobsters include all those of 82.6 mm carapace length or greater and without eggs. The statistics indicate that there is heavy fishing pressure for lobsters in Beverly-Salem, probably more than elsewhere in the state. One index of fishing pressure is the percent of the legal catch composed of new recruits, i.e. lobster which reached legal size during their most recent molt. Beverly-Salem leads the six state areas in this statistic, with 96 percent, compared to 88 percent for Cape Ann and 86 percent for the state as a whole, indicating that very few lobsters escape being trapped as soon as they reach legal size. Other indicators of fishing pressure in which Beverly-Salem leads the state are instantaneous fishing mortality, which is the proportion of all deaths which are attributable to fishing, and the exploitation rate, the fraction of the population removed by fishing. Cape Ann is close to or just above the state average in these statistics.

Early Benthic Phase Lobsters: Salem Harbor Survey

Data and information on early benthic phase (EBP) lobsters, defined as those with a carapace length of from 5 to 40 mm, were collected in October 1998 by SCUBA divers swimming along transects within potential dredged material disposal sites. The main objective of the survey was to investigate soft sediments (silt, mud, etc.) for the presence of EBP lobsters, which are highly shelter dependent and may indicate areas of settlement habitat. Additional information was noted, such as number and diameter of burrows, substrate type, and species present. See Appendix G, for further detail of material and methods, results, and discussion of data (NAI 1999).

Table 5-2: Summary of suction and hand sampling of early benthic phase lobster (EBP) and scuba observations of potential dredged material disposal sites in Salem Harbor.

Disposal Site	Number of EBP Lobsters (mm CL)	Number of Burrows *	Burrow Diameter Range (mm)	Substrate Type	Benthic Characteristics
S6-OD CAD	None collected	196/500m	20 - 90	silt, silt/rocks, silt/mud	*Cancer* crabs, lobsters, mussels, skate, hake

** burrows represent biological activity, including the presence of fish, shrimp, crab, lobster, etc.*

Following is a summary of the findings of the EBP survey for each of the candidate disposal sites:

S6-CAD-OD: Surficial sediments along transects across the OD were primarily composed of soft silt / mud, to an approximate depth of 12". Surficial features were limited to a few ledge outcroppings along the channel edges. Numerous burrows (excavated and used by a variety of organisms) were observed along the transect (including the diver's field of view under and surrounding the line). Few burrows were occupied by lobsters. Burrows were irregularly spaced in small clusters of two to five, with 45-60 mm CL lobsters within or surrounding the burrows. No EBP lobsters were observed or collected. Green and Cancer crabs, gastropods, little skate, and small red hake were observed along the transects.

At site S6-CAD-OD the burrows appear to be transient-use shelters and the area appears not to be lobster settlement habitat.

<u>Summary</u>

Salem Harbor and vicinity contains benthic fauna typical of nearshore environments north of Cape Cod, modified by the congested, urban nature of the surroundings of the Harbors. Nearshore sites in both harbors contained fine sediments, characteristic of a depositional environment, while those outside the harbors contained coarser sediments, characteristic of a higher energy environment. Opportunistic species characterized most nearshore sites, while those in and adjacent to the channel and offshore contained more diverse fauna. Commercially valuable shellfish are found in a few well-defined areas around the perimeter of both harbors. Lobstering is an important fishery in Beverly-Salem area, although small-scale data does not exist to indicate that some candidate disposal sites are more important for adult lobsters than others. Statistics indicate that fishing pressure for lobsters in Beverly-Salem is the highest of any region of the state. The shallow, nearshore areas of Site S16-CAD appear to provide suitable habitat for EBP lobsters and juvenile winter flounder. Other Salem Harbor sites apparently contain transient-use shelters only.

5.1.4 Finfish

Fishery Resources

As with the invertebrate fauna, the fishes off Salem are part of the boreal biogeographical region, characterized by colder temperatures and less summer warming, and therefore a smaller annual temperature range, than waters south of Cape Cod. Many northern species of fish reach the southern limit of their abundance at Cape Cod, and many southern species reach their northern limit there. This means that the characteristic species of harbors north of Cape Cod will be very similar, and the abundance patterns of species in Salem will be practically identical, and even more similar to northern Europe than to areas south of Cape Cod, such as New Bedford and Fall River (Gosner, 1971).

In 1968, DMF biologists identified the following finfish species as warranting attention for potential environmental impacts associated with dredged material disposal in Salem:

Common Name	Scientific Name
Alewife	*Alosa pseudoharengus*
American eel	*Anguilla rostrata*
Atlantic cod	*Gadus morhua*
Atlantic tomcod	*Microgadus tomcod*
Blueback herring	*Alosa aestivalis*
Bluefish	*Pomatomus saltatrix*
Rainbow smelt	*Osmerus mordax*
Red hake	*Urophycis chuss*
Silver hake	*Merluccius bilinearis*
Striped bass	*Morone saxatilis*
Windowpane	*Scophthalmus aquosus*
Winter flounder	*Pleuronectes americanus*
Yellowtail flounder	*Pleuronectes ferrugineus*

Methods

In 1997, the Massachusetts Division of Marine Fisheries conducted a seine and trawl survey for finfish in Salem Sound, consisting of the Danvers River and tributaries, Salem Harbor, Marblehead Harbor, Manchester Harbor and the open water between Marblehead and Manchester (Figure 5-14). The study was designed to replicate at least some of the stations sampled in a similar DMF survey conducted in 1965 (Jerome et al. 1967).

Beach seine stations were established at Proctor Point in Manchester Harbor, at West Beach, Tucks Point, and Obea Park in Beverly, at Sandy Beach on the Porter River in Danvers, and at Pioneer Village in Salem Harbor. All these stations except Sandy Beach had been sampled in 1965. Sandy Beach replaced a seine station at the causeway at the head of Marblehead Harbor, which could be sampled only at the higher tide stages and had produced very low catches in 1965. A 50 foot seine with 4 foot depth and a 3/16 inch mesh was used. Hauls were made starting with the net parallel to shore at a depth of approximately one meter, then hauled toward shore covering a rectangular area. Two replicate hauls were made on each sampling date. All fish caught in the seine were counted and the commercially and recreationally important species were measured to total length.

Five trawl stations were established, at Beverly Cove and Haste Channel in the open water off the coast of Beverly, at the mouths of Salem Harbor and Marblehead Harbor, and in the Danvers River (Figure 5-15). The Salem Harbor and Haste Channel stations were also sampled during the 1965 study, and the Marblehead Harbor and Danvers River stations border those from the 1965 study. The trawl used had a 30 foot sweep, a 27 foot headrope, a 1½ inch stretch mesh in the wings and cod end, with a 1/4 inch knotless liner in the cod end. Five minute tows were conducted at a target speed of two knots, and trawl start and end locations were recorded in latitude and longitude with a Global Positioning System. All fish and selected invertebrates were identified, counted, and returned to the water. Length measurements were recorded from all commercially and recreationally important species.

Seine stations were sampled monthly from January through December 1997, except at Proctor Point, where sampling commenced in May. Trawls were made monthly at each station from January through April and twice per month from May through October.

The only seine or trawl station within a candidate disposal site is the Salem Harbor trawl station, located in the main channel into the harbor, Site S6-CAD/OD.

Port Specific Fishery Resources

A total of 22 species of finfish were caught in the 136 seine hauls made in Salem Sound from January through December 1997. The most abundant species sampled was Atlantic silverside, with 10,256 individuals caught. Next most abundant was menhaden (5754 individuals) followed by Atlantic herring (2148). The species listed in Table 5-4 comprise over 98 percent of the fish sampled in the seine in 1997. The total list of fishes sampled can be found in Appendix G.

Table 5-3: Five Most Abundant Fish Species Collected in Salem Sound Beach Survey, 1997 (Massachusetts Division of Marine Fisheries unpublished data).

Common name	Scientific name	Obea Park	Pioneer Village	Proctor Point	Sandy Beach	Tucks Point	West Beach	All Stations
Atlantic silverside	*Menidia menidia*	2201	2449	718	4438	218	232	10256
Atlantic menhaden	*Brevoortia tyrannus*	7	95	1397	6	4249	--	5754
Atlantic herring	*Clupea harengus*	1	--	--	390	1708	49	2148
winter flounder	*Pleuronectes americanus*	20	40	45	264	526	33	928
mummichog	*Fundulus heteroclitus*	80	61	15	238	2	--	396
all other species								345

The species sampled in 1997 are typical of nearshore environments north of Cape Cod, and the most common species sampled by Jerome et al. in 1965 were also common in 1998. For example, the first, second and third ranking species in 1965, mummichog, silverside, and Atlantic herring, ranked fifth, first, and third in 1997. A notable difference in the species lists of the two years is that menhaden, the second most abundant species seined in 1997, was not caught at all in the seine in 1965. Differences in the total species list and in some relative abundances were probably due to chance, as in both studies many species were represented by very few individuals and distribution was extremely patchy. For example, over 96 percent of the menhaden sampled were seined from two stations on a single date in September. At Tucks point, all but two of the 4249 individuals sampled were from September. It is possible that if that single date had been missed, menhaden would have been regarded as scarce in Salem Sound in 1997 rather that as the second most abundant shore species. The two stations at which the greatest numbers of fish were caught in the seine were Tucks Point at the mouth of the Danvers River in Beverly and Sandy Beach on the Porter River. These stations were dominated by menhaden and silverside, respectively, although good numbers of other species were also caught. The lowest numbers of fish throughout the 1997 survey were collected at West Beach, the only station exposed to the open ocean and therefore exposed to greater wave action than the others. In 1965 at West Beach, no fish at all were seined in 8 of the 12 months in which sampling took place, and if it were not for a single haul in May of 236 Atlantic herring, West Beach would have been the least productive station was in 1965 as well. The station with the lowest seine catch in 1965 was Tucks Point, which was the most productive in 1997. The station with the highest seine catch in 1965 was Proctor Point, due mainly to a large number of mummichogs on a single date. These results further illustrate the variable nature of seine samples, with the most consistent result being low numbers from West Beach, indicating that high-energy beaches have relatively few nearshore fishes.

In the trawl samples, 34 species were caught, with the most abundant species being winter flounder, followed by skates, Atlantic cod, and cunner. Table 5-5 indicates the most common species sampled in the trawls, comprising over 76 percent of individuals caught.

Table 5-4: Five Most Abundant Species Collected in Salem Sound Trawl Survey (Massachusetts Division of Marine Fisheries unpublished data)

		Beverly	Danvrs	Haste	Marblhd		SalemAl l
Common name	**Scientific name**	**Cove**	**River**	**Channel**		**Harbor**	**Harbor Stations**
winter flounder	*Pleuronectes americanus*	68	197	256	98	451	1070
skate spp.	*Raja* spp.	65	59	181	45	293	643
Atlantic cod	*Gadus morhua*	32	15	112	71	123	353
cunner	*Tautogolabrus adspersus*	240	34	19	22	25	340
windowpane	*Scophthalmus aquosus*	7	--	73	4	70	154
Total of 29 other species:							792

Sampling results in the trawls were more consistent than in the seine, with winter flounder and skates being among the most common species at every station and in the majority of the tows. The only station where winter flounder and skates were not first and second in abundance was Beverly Cove, where they were third and fourth after cunner and northern pipefish. The cunner and the pipefish are both fishes of shallow, more sheltered waters, and Beverly Cove is the shallowest station as well as the only one containing eelgrass.

Another recent observation of fish resources in Salem Harbor was made during the SCUBA survey for the early benthic phase lobster study, when abundant juvenile winter flounder were observed at Candidate Site S16 within the harbor.

The most extensive historic data on fishery resources in Salem Harbor and vicinity are from the study conducted by the Massachusetts Division of Marine Fisheries in 1965, which reported on a combination of otter trawls and beach seines in the waters of Beverly, Salem, Danvers, Manchester, and Marblehead. Thirty-one species of finfish were found in the Beverly-Salem area.

The most noticeable differences between the samples taken in 1965 and those taken in 1997 are the decrease in dominance by winter flounder, from 84 percent of individuals sampled in 1965 to 32 percent in 1997, and the appearance of large numbers of skates in the samples, which had been a very minor part of the catch (only eight individuals all year) in 1965. Also, yellowtail flounder had been the third most common species at the deeper stations in 1965, but was represented by only two individuals in 1997, and haddock, fourth most common in 1965, was absent in 1997. Skate have become a more common part of the local demersal fish fauna in recent years, and this is reflected in the 1998 samples.

Recreational Fishery

There is an extensive recreational fishery based in Salem Harbor and vicinity (Koutrakis 1997). Winter flounder is the principal species sought by recreational fishermen in nearshore locations. Flounder fishing can be productive from piers, and among the best areas for flounder accessible by boat are Beverly Channel and Monument Bar to the north of Salem Neck, and the channel into Salem Harbor and adjacent areas (Candidate Sites S6-CAD/OD, S14-ATC, and S15-ATC). The Middle Ground, which partially coincides with Site S17-CDF, is also described as productive for flounder. The once abundant populations of flounder have been reduced over the years by overfishing and pollution, but in recent years, with cleanup of the harbor and catch limits, the flounder are recovering.

Other fish species which are important recreationally at Salem include cod, mackerel (*Scomber scombrus*), bluefish (*Pomatomus saltatrix*), striped bass (*Morone saxatilis*), and tautog (*Tautoga onitis*). Some of these species, although common, were not recorded in the trawl survey, because mackerel, bluefish, and striped bass are pelagic species which are not caught in bottom trawls, and tautog remain close to objects such as rocks and wrecks and are therefore also not caught in trawls in open water. Table 5-6 lists some of the principal recreationally fished species at Salem, with known areas of concentration within the Zone of Siting Feasibility (Koutrakis 1997, with notes on habitat also from Bigelow and Schroeder 1953).

Table 5-5: Important Species in the Sport Fishery, their Habitat, and Principal Locations, including Candidate Disposal Sites.

Species	Habitat	Where common at Salem (Koutrakis 1997)
Winter flounder	Muddy sand, cleaner sand, eelgrass	Harbor channels **(S6, S14, S15)** Monument Bar, Middle Ground **(S17)**, Mingo Beach, Cat Island
Atlantic cod	Rocks and pebbles, gravel, sand, shells, ledges	Coney Island and Ledge, Eagle Bar (**SG5**), Cat Island. Chappel Ledge, Misery Shoal (**SG4**)
Atlantic mackerel	Pelagic, schooling	Throughout Salem waters
Bluefish	Pelagic, schooling	Surf, Danvers River, Marblehead shore, Salem channel **(S6)**
Striped bass	Islands, rocks, sandy beaches	All islands, including Coney Island (**S17**), Eagle Island (**SG5**), and Great Misery Island (**SG4**)
Tautog	Ledges, rocks, piers	Kernwood Bridge, Salem-Beverly Bridge, inside Tinkers Island, many other sheltered places

Anadromous Fish

The Danvers River, immediately to the north of Salem, is an anadromous fish run, because anadromous fish migrations have been observed in some two its tributaries, the Porter and Crane Rivers. The Porter River contains smelt and a small population of blueback herring, and the Crane River supports small numbers of bluebacks and alewives (Chase 1999). Although apparently minor, the presence of anadromous fish means that disposal of dredged material is prohibited in a fish run between March 15 and June 15 unless otherwise allowed by DMF.

5.1.5 Wetlands and Submerged Habitats

Coastal Wetlands

The Massachusetts Wetland Protection Act regulations, 310 CMR 10.21 through 10.37 includes numerous submerged and intertidal resource areas under the section on coastal wetlands (See Section 5.1.5.3). Salt marshes, however, are the area most closely fitting the general perception of a wetland, and the area with the most stringent protection under the Act (See Section 7.1.3). The Wetland Protection Act regulations define a salt marsh as "a coastal wetland that extends up to the high tide line, that is, the highest spring tide of the year, and is characterized by plants that are well adapted to or prefer living in, saline soils. Dominant plants within salt marshes are salt meadow cord grass (*Spartina patens*) and/or salt marsh cord grass (*Spartina alterniflora*) ".

Salt marshes are also protected under federal law because they are wetlands, one of the "special aquatic sites" designated in the Section 404(b)(1) Guidelines for Specification of Disposal Sites for Dredged or Fill Material (40 CFR 230, Subpart E). The regulations describe possible impacts on these sites from dredge disposal, and the applicant for a dredging permit must demonstrate compliance with guidelines for avoiding adverse impacts to these areas before a permit can be issued. (See Section 7.2.5.3 of this EIR).

Spartina alterniflora is characteristic of the low marsh, flooded daily by the tides, whereas *S. patens* dominates the high marsh, flooded only by the higher spring tides. Salt marshes are the most productive community of the coastal zone, with a normal productivity range of 200 to 400 $gC/m^2/yr$, compared to a productivity in temperate seagrass beds of 120 to 320 $gC/m^2/yr$, 10 $gC/m^2/yr$ on sandy beaches and 75 to 140 $gC/m^2/yr$ on mud flats (Parsons, 1992). The organic matter produced by salt marshes, as detritus, becomes the basis of a food chain leading to greater productivity of many estuarine organisms, including those important in fisheries. Marshes serve as spawning and nursery grounds for forage fishes, as well as important food, shelter and breeding areas for many wildlife species. Marsh vegetation stabilizes the substrate, and marsh plants and substrates remove pollutants from surrounding waters.

Although salt marshes exist on creeks connected to Salem Harbor, particulary on the Forest River at the south end of the harbor, National Wetlands Inventory mapping indicates that marsh borders the harbor only at two very small areas at the extreme southwest end of the harbor, and in Juniper Cove near the end of Salem Neck. There are also small patches of salt marsh scattered upstream in the Danvers River system, but none which appear to be in a position to be influenced by disposal at any of the candidate aquatic sites. It is possible that the harbor includes some areas of marsh too small to be included in the NWI mapping, which would be determined by on-site inspection before a final siting decision.

No salt marshes are mapped along the open coastline between Salem and Gloucester, and none would be expected there because of the exposed nature of the area.

Vegetated Shallows (Submerged Aquatic Vegetation)

Vegetated shallows are another of the special aquatic sites protected by the federal 404(b)(1) guidelines, where they are defined as "permanently inundated areas that under normal circumstances support communities of rooted aquatic vegetation". In marine settings north of Cape Cod, they are equivalent to eelgrass (*Zostera marina*) beds. Eelgrass beds increase species diversity and productivity by providing shelter and food for a variety of small fish and invertebrates. Eelgrass beds were mapped by the Massachusetts Department of Environmental Protection in 1997 from aerial photographs (Costello, 1997). Beds are located is three cove areas along the eastern side of the Outer Harbor: Southeast Cove, Lighthouse Cove, and a small area between the two, and in two areas in Western Harbor off the mouth of the Blynman Canal.

Two eelgrass beds were located within the Salem siting area, one at the southern tip of Winter Island in Salem Harbor, and a larger area extending along the Beverly shore from just east of Tuck Point to Curtis Point. The Winter Island bed is adjacent to the S19-CAD disposal area. The eelgrass bed off Beverly is not located in any candidate disposal site, although it could possibly be affected by turbidity from dredging at the end of the Salem Channel sites (S6, S14, and S15).

Other Submerged or Intertidal Habitats

Several natural areas not normally perceived of as wetlands are protected under the Massachusetts Wetlands Protection Act. These include land under the ocean, designated port areas, coastal beaches and dunes, barrier beaches, coastal banks, rocky intertidal shores, salt marshes, land under salt ponds, land containing shellfish, and anadromous and catadromous fish runs.

Salem Harbor contains designated port areas, two of twelve within the state, and the harbors and their vicinity contain most or all of the above-listed resource areas to varying degrees. Any activity within or adjacent to the water will take place within some wetland resource area, since all of the harbor below the mean low water level and out to the boundary of the municipality's jurisdiction is land under the ocean, and the shoreline is either rocky intertidal shore, coastal beach (including tidal flats), or coastal bank. Activity within any resource area other than salt marsh is generally permitable to some degree, subject to resource-specific and project-specific restrictions and conditions.

Federally, the only areas other than wetlands and vegetated shallows which are specifically protected under the 404(b)(1) guidelines and likely to be found in the Salem coastal area are mud flats, which are defined as follows in the guidelines:

> *Mud flats are broad flat areas along the sea coast and along coastal rivers to the head of tidal influence and in inland lakes, ponds, and riverine systems. When mud flats are inundated, wind and wave action may resuspend bottom sediments. Coastal mud flats are exposed at extemely low tides and inundated at high tides with the water table at or near the surface of the substrate. The substrate of mud flats contains organic material and particles smaller in size than sand. They are either unvegetated or vegetated only by algal mats.*

This definition differs from the state's definition of tidal flats principally in that mud flats are composed only of fine-grained material, whereas tidal flats may also include intertidal sand bars. Mud flats contain biota such as clams and marine polychaete worms, and may provide foraging and nursery areas for fish and habitat for shorebirds.

The NOAA navigation chart for Salem, Marblehead, and Beverly Harbors and the National Wetlands Inventory map for Salem indicate that Collins Cove contains extensive mud flats, including the area of Candidate Disposal Site S1-CDF at the end of the cove. Site S3-CDF on the west shore of Salem Harbor possibly contains a mud flat as well. No other candidate disposal sites appear to contain mud flats. Closer inspection of the margins of the siting area will be necessary to confirm the absence of any more extensive mud flats, but it is probable that, mud flats have developed only the more sheltered areas, such as upstream in the Danvers River system.

5.1.6 Wildlife

General

The coastal waters off Salem are inhabited by wintering waterfowl, and shorebirds to a limited degree. The areas within the harbor and immediately offshore are not known to harbor any significant concentrations of marine mammals or reptiles. All wildlife in the area is mobile and will avoid any areas of disturbance.

Shorebird Habitats

In the Salem area, beaches and tidal flats exist mainly in the Danvers River system, along the Beverly shore on the north side of Beverly Harbor, and at the south end and along part of the west side of Salem Harbor. Candidate Sites S1, S2, and S3 are located in intertidal areas and therefore possibly in shorebird habitat, although the value of the latter two as habitat may be limited by their close proximity to urbanized areas.

Marine Mammals

Marine mammals found in the waters in and around Stellwagen Bank, from 12 to 30 nautical miles to the east southeast of Salem, include thirteen species of cetaceans (whales and porpoises), and two species of seals (NOAA, 1993)(Table 5-7). Although five of the whale species are endangered, some, especially the large and conspicuous humpback and fin whales, have become common enough to support a whale-watching industry which as of the end of 1998 produces revenue of $20,000,000 per year and brings 860,000 people annually to the bank to view whales (Boston *Globe*, January 11, 1999). Most of these species may be expected to be found occasionally in the ocean waters closer to Salem, but rarely, if ever, in the harbors. An exception to this is the harbor seal, which from late September to late May is commonly seen in harbors, emerging from the water on sheltered and undisturbed rocky ledges in bays and estuaries from Maine south to Plymouth, Mass.

Other marine mammals found in significant numbers in the area, humpback whales, right whales, and fin whales, are mainly or exclusively summer residents, although an unusual sighting of right whales occurred on Cape Cod Bay in January 1999. Humpbacks migrate from calving and mating grounds in the eastern Caribbean, arriving in Massachusetts Bay in early March and remaining until mid-November. Right whales give birth to calves and overwinter off Georgia and Florida, entering Massachusetts and Cape Cod Bays by late winter or early spring and remaining until approximately July, when most begin moving further north, before returning to their southern wintering areas in October.

Table 5-6: Marine Mammals Found in the Waters over and around Stellwagen Bank (NOAA, 1993)

Common Name	Scientific Name	Remarks
Humpback Whale	*Megaptera novaeangliae*	March-Nov.,offshore, near Bank
Northern Right Whale	*Eubalaena glacialis*	Late winter - July
Fin Whale	*Balaenoptera physalus*	Peak Apr - Oct, offshore
Sei Whale	*Balaenoptera borealis*	Very rare
Blue Whale	*Balaenoptera musculus*	Very rare
Minke Whale	*Balaenoptera acutorostrata*	Peak spring - late summer/early fall
Pilot Whale	*Globicephala*	spp. (2 species)
Killer Whale	*Orcinus orca*	Peak mid-July - Sept
White-sided dolphin	Lagenorhynchus acutus	Common all year
White-beaked dolphin	*Lagenorhynchus albirostris*	Rare, April - Nov
Harbor porpoise	*Phocaena phocaena*	Peak in spring
Bottlenose dolphin	*Tursiops truncatus*	Late summer/fall, offshore
Common dolphin	*Delphinus delphis*	Occasional, fall/winter, offshore
Harbor Seal	*Phoca vitulina*	Common, nearshore
Gray Seal	*Halichoerus grypus*	Abundant in Canada, rare in Mass.

Reptiles

The only marine reptiles found in the project region are sea turtles. Although four species of sea turtles have been recorded in the Gulf of Maine, only two, the leatherback (Dermochelys coriacea) and the Atlantic ridley (Lepidochelys kempi), are seen with any regularity (Payne 1991). The leatherback, the largest living reptile, may grow to 11 feet in length and weigh up to 1900 pounds. Leatherbacks breed in Central and South America and are most frequently sighted off Massachusetts from June through September.

The Atlantic or Kemp's ridley is the most commonly reported turtle from Cape Cod Bay (Payne, 1991), but most of the sightings are of stranded juveniles. Individuals of this warm-water species breed in Mexico, drift or swim north as juveniles, and become trapped in Cape Cod Bay as temperatures fall, where they are killed by the cold. They are not an important part of the fauna near Salem. The other two species of turtles reported for the area, loggerheads and green turtles, are very rarely found north of Cape Cod.

5.1.7 Endangered Species

General

The Massachusetts Natural Heritage Atlas does not indicate any estimated habitat of state-listed rare wildlife in or adjacent to the marine waters of the Salem area with the exception of Tinkers Island to the southeast of Marblehead. It does not indicate any priority sites of rare species habitats or exemplary natural communities in this area. Tinkers Island is approximately 0.6 mile from the nearest candidate disposal site, S13-CAD. It is very unlikely that disposal in urbanized areas or others historically under heavy human influence will impact endangered species.

Of the marine mammals and reptiles reported on in Sections 5.1.6.3 and 5.1.6.4, five whales and two turtles are federally listed as endangered. These include the humpback whale, fin whale, sei whale, blue whale, northern right whale, leatherback turtle and the Atlantic or Kemp's ridley. These species, if they attain enough numbers to have centers of concentration at all, are found mainly at Stellwagen Bank off the northern tip of Cape Cod or at Jeffreys Ledge north of Cape Ann.

Impacts to Endangered Species

The marine endangered species occurring in the ocean off Salem are extremely rare, if at all present, at any area under consideration for dredge disposal. Barring the identification by the NHESP of a state-listed rare species at a disposal site, or the identification of an indirect impact on an endangered or threatened species from dredging activities, this project will have no impact on endangered or threatened species.

Methods

In order to determine the probability of sites, the location of any known remains, and information about previously investigated sites, the research team conducted interviews and inspected secondary and some primary archival material. To research all available primary material would take many months of time without any guarantee of added information. Therefore, extensive primary research was not required for this study.

The research team interviewed staff at the Massachusetts Board of Underwater Archaeological Resources, the local (Beverly) dive shop operator, and a local avocational shipwreck diver. They also conducted limited primary and secondary research at the Cape Ann Historical Association Library.

Histories of the New England region, Massachusetts, the North Shore, and the individual municipalities were studied for background historical information, and published material on the prehistory of the area was read for pertinent information. In addition, eleven published and unpublished lists of shipwrecks were inspected to determine how many ships were lost in the study area. The references included an "encyclopedia" of shipwrecks with many inaccuracies, excerpts from a federal Bureau of Land Management study of some primary sources, and three lists compiled by amateur shipwreck historians from Massachusetts. Little primary research was conducted, except for the study of historic charts of the area at the Mystic Seaport Museum chart archives and the interviews mentioned above.

Since most shipwreck locations cited in contemporary newspapers were quite general, such as "lost off Marblehead," and other sources gave exact locations, the team designated each reported shipwreck as being at a specific location, "off" a municipality, or in the general area.

To determine significance for each site we used the Department of the Interior's definition for eligibility to the National Register of Historic Places -- generally sites over fifty years old. However, most of the shipwrecks were over one hundred years old. We have accepted the recorded locations and dates of the shipwrecks, without enough time to research each shipwreck in depth, therefore the information for any particular site might be inaccurate. However, the approximate number of significant shipwreck sites in the Salem study area is accurate enough to allow the determination of recommendations for predredging planning.

5.1.8 Navigation and Shipping

Salem Harbor is the second deepest harbor in Massachusetts after Boston, with an authorized depth of 32 feet in the main Federal navigation channel. Existing deep draft navigation in Salem Harbor is entirely associated with the harbor's role as a petroleum and coal receiving port. Home heating oil (No. 2 oil) is received by tanker and barge at the existing PG&E Salem Station dock and stored in tanks owned by PG&E and leased by the Cargill Petroleum company, which operates a wholesale home heating oil business at the site. The home heating oil is distributed throughout the area by truck. Additionally, residual oil (No. 6), is received by PG&E to supply the adjacent Salem Station electrical generating plant. Over the past four years, an annual average of approximately 3.5 million barrels of oil has been shipped into Salem Harbor. The oil is generally delivered on five (5) tanker ships and twenty-five (25) oil barges per year, an average of one oil vessel approximately every eighteen days.

The PG&E Salem Station electrical generating plant is fueled by coal, as well as oil. Over the past four years, an annual average of 850,000 tons of coal have been delivered on seventeen (17) coal ships to the

PG&E Salem Station dock, where it is offloaded for on site storage in a large coal pile adjacent to the dock. This is an average of one coal ship every three weeks, or twenty-one (21) days. (Greer 1999)

Recreational vessel traffic also plays a large role in Salem Harbor. The harbor contains seven marinas and yacht clubs and a significant recreational fleet, with approximately 1,200 moorings distributed within five mooring basins. Salem Harbor is a significant recreational boating destination, due to the large number of historical and cultural attractions of the city, largely located adjacent to or in close proximity to the harbor.

In the past two years, a demonstration high-speed passenger ferry has operated during the summer tourist season from a temporary docking facility located at the site of the proposed New Salem Wharf, adjacent to the PG&E Salem Station property. The ferry provides service to Long Wharf in Boston, and has proven a popular draw for tourists to conveniently travel to Salem from Boston. The ferry service has been operated with a low draft catamaran.

The entrance to Salem Harbor is through the main Federal channel in the northern portion of the harbor, which extends from the general area of the PG&E Salem Station and extends towards Salem Sound between Winter Island in Salem and Naugus Head in Marblehead. The channel is approximately 2,591 meters (8,500 feet), or 2.4 kilometers (1.5 miles) long. The channel has a draft of 32 feet at Mean Low Water and ranges from 91.4 meters (300 feet) to 121.9 meters (400 feet) wide. The channel was originally constructed by the Army Corps of Engineers in 1905.

The second Federal Channel in Salem Harbor is located at the South River, and provides access to recreational vessels in the Pickering Wharf area. The South River channel has a navigation depth of 2.4 meters (8 feet). A 3 meter (10 foot) draft entrance channel connects the harbor to the South River channel, ranging in width from 91.4 meters (300 feet) to 27.4 meters (90 feet) in the vicinity of Derby Wharf.

5.1.9 Land Use

Land use along Salem Harbor in the vicinity of the potential aquatic disposal site in Salem Harbor, S6-CAD/OD, is primarily industrial, due to the proximity of the PG&E Salem Station electrical generating plant. Adjacent to the power plant to the west is the Cargill Petroleum bulk oil facility and further to the west is vacant land currently used during the summer season as the landing facility for the Salem to Boston high speed passenger facility, with the Hawthorne Cove Marina further to the west. To the east of the power plant is the South Essex Sewage District Secondary Wastewater Treatment plant, another heavy industrial use.

A popular open space and recreational use, Winter Island, is located at the east of the harbor. An actively used boat ramp and bathing area, Waikiki Beach, are located here. Residential areas of Marblehead on Naugus Head are approximately 1,000-feet to the south of the disposal site.

5.1.10 Air Quality and Noise

Air Quality

Air quality impacts for operations involving the disposal of dredged material are generally inconsequential. Air quality emissions for aquatic dredged material disposal operations are typically associated with heavy equipment emissions, such as that associated with dredges and dump scows and barges.

Existing Background Air Quality

Background air quality in Salem Harbor has been estimated using monitoring data reported by the Massachusetts Department of Environmental Protection (DEP) to the US EPA Aerometric Information Retrieval System (AIRS).

Although the DEP does not operate any air pollution monitors within the City of Salem, data collected at other DEP monitors in Essex County during the three-year period of 1996-1998 were used to determine existing air quality. The location of air quality monitoring stations within Essex County varies according to the parameter being measured and the year of data collection, and includes sites in Lawrence, Lynn, Newbury, Peabody, and Haverhill. This is a conservative approach, as the air quality in Salem is likely to be as good or better than that which exists near the monitoring sites. In particular, Salem is located further from major industrial sources of air pollution than Lawrence or Lynn, with the PG&E Generating Salem Station power plant being an exception. The Salem area also has significantly fewer mobile sources of air pollution, since its population density is less than that of Lawrence or Lynn.

Air Quality Standards and Attainment Status

The U.S. Environmental Protection Agency mandates monitoring of the following six criteria air pollutants: nitrogen dioxide (NO_2), particulate matter with diameters less than or equal to 10 microns (PM_{10}), sulfur dioxide (SO_2), ozone (O_3), carbon monoxide (CO), and lead. Ambient Air Quality Standards (AAQS) have been established for each of these pollutants to protect the public health and welfare, with a margin of safety. PM_{10}, O_3, and NO_2 emissions are those associated with operation of heavy equipment used in dredged material disposal operations. Ozone is not a pollutant emitted by heavy equipment, but is formed in the atmosphere when "precursor" elements and compounds such as nitric oxides, hydrocarbons (from unburned fossil fuels, e.g.), and oxygen are combined in the presence of sunlight.

A geographic area that meets or exceeds an AAQS is called an attainment area for that air pollutant standard. An area that does not meet an air standard is called a non-attainment area for that standard. The entire state of Massachusetts is in attainment of all criteria air pollutant standards except for ozone, for which it is classified as in serious non-attainment. A summary of existing air quality data for the Salem area is as follows:

Nitrogen Dioxide (NO_2): NO_2 data was collected from Essex County monitoring stations in Newbury, MA and Lynn, MA. An automated analyzer takes samples continuously at these sites to provide hourly averaged values. The primary standard for NO_2 is an annual arithmetic mean of 0.053 parts-per-million (ppm). For the period of 1996-1998, no violations were recorded at either monitoring location. The 1998 annual arithmetic mean for the Newbury monitor was 0.006 ppm, which is only 11% of the standard. The 1998 annual arithmetic mean for the Lynn monitor was 0.014 ppm, or only 26% of the standard.

Particulate Matter 10-Microns (PM_{10}): The only Essex County monitoring site for PM_{10} is located in Lawrence, MA. Between 1996 and 1998, there were no violations of the PM_{10} air quality standards, which are (1) an annual arithmetic mean of 50 g/m^3, and (2) a 24-hour value of 150 g/m^3. The Lawrence monitor had an annual arithmetic mean of 15 g/m^3, which was 30% of the standard.

Sulphur Dioxide (SO_2): The SO_2 monitoring site located closest to Salem is in Peabody, although no 1998 data was available from this site. SO_2 data was also collected from 1996-1998 at Essex County monitoring sites in Haverhill and Lawrence. The SO_2 standards are (1) 0.50 ppm (3-hour average, (2) 0.14 ppm (24-hour average), and (3) 0.03 ppm (annual mean). There were no violations of SO_2 standards in Essex county during 1996-1998. The 1997 annual mean in Peabody was 0.004 ppm, which is 1.3% of the standard. Similarly low measurements were recorded in Haverhill and Lawrence.

Ozone (O_3): During 1996-1998, O_3 was monitored in Essex County at sites in Newbury, Lawrence and Lynn. The air quality standard for O_3 is 0.12 ppm (one-hour standard). At Lynn, the monitoring site closest to Salem, the maximum value recorded in 1998 was .121 ppm, which is 101% of the standard. The new 8-hour standard (0.085 ppm) is calculated as a three-year average of the annual fourth-highest daily maximum 8-hour O_3 concentration. From 1995-1997, Lynn had an 8-hour value of 0.089 ppm (105% of standard), and Newbury had a value of 0.084 ppm (99% of standard). Statewide, Massachusetts continues to be in non-attainment of the O_3 standard.

Carbon Monoxide (CO): Among the nine CO monitoring sites in Massachusetts, the sites closest to Salem are located in Lowell and Boston. Both of these urban locations can be expected to have higher ambient levels of CO due to higher poulation density and greater CO emissions from mobile sources. The CO standards are 35 ppm (1-hour average) and 9 ppm (8-hour average). During 1998 and 1997, there were no violations of the CO standards in Massachusetts. In Lowell, the maximum 1-hour value in 1998 was 6.0 ppm (17% of standard) and the maximum 8-hour value was 4.1 ppm (46% of standard). In Boston, the maximum 1-hour value in 1998 was 6.7 ppm (19% of standard) and the maximum 8-hour value was 6.6 ppm (73% of standard). In 1996, one violation of the 8-hour standard was recorded in Lowell (10.5 ppm).

Lead: Although lead is a criteria air pollutant, monitoring for lead was not conducted in 1997 because concentrations in Massachusetts have been minimal in recent years. The most recent available data for Essex County was recorded at monitoring sites in Newbury, Haverhill and Lynn during 1994-1995. The standard for lead is 1.5 µg/m3 (quarterly mean). At all locations in Essex County, no value exceeded 0.01µg/m3, which is less than 1% of the standard.

Overall, the existing air quality in the Salem area is good and is in compliance with all state and federal air quality standards except for ozone. Statewide non-attainment for the ozone standard requires that Massachusetts continue to make progress on implementing a State Implementation Plan (SIP) for attaining the standard.

Noise

Salem Harbor is a heavily urbanized port, and as such nearshore areas in Salem exhibit noise levels typical of urban environments. Industrial noises, such as that associated with the power plant or traffic noise from busy urban streets and arterial highways, all contribute to the existing noise environment. Recreational areas, such as Winter Island at the east end of the harbor, and residential areas, such as areas of Marblehead abutting the southern end of the harbor, are generally quieter.

In the vicinity of the navigation channel and the potential Preferred Alternative disposal site, noise levels are typical of the urban environment, due to the proximity of the PG&E Salem Station power plant, the Cargill Petroleum bulk oil facility and the SESD sewage treatment plant and existing vessel traffic in the channel.

Figure 5-11: Land use in the vicinity of Salem Harbor

5.1.11 Historic and Archaeological Resources

Methods

In order to determine the probability of sites, the location of any known remains, and information about previously investigated sites, the research team conducted interviews and inspected secondary and some primary archival material. To research all available primary material would take many months of time without any guarantee of added information. Therefore, extensive primary research was not required for this study.

The research team interviewed staff at the Massachusetts Board of Underwater Archaeological Resources, the local (Beverly) dive shop operator, and a local avocational shipwreck diver. They also conducted limited primary and secondary research at the Cape Ann Historical Association Library.

Histories of the New England region, Massachusetts, the North Shore, and the individual municipalities were studied for background historical information, and published material on the prehistory of the area was read for pertinent information. In addition, eleven published and unpublished lists of shipwrecks were inspected to determine how many ships were lost in the study area. The references included an "encyclopedia" of shipwrecks with many inaccuracies, excerpts from a federal Bureau of Land Management study of some primary sources, and three lists compiled by amateur shipwreck historians from Massachusetts. Little primary research was conducted, except for the study of historic charts of the area at the Mystic Seaport Museum chart archives and the interviews mentioned above.

Since most shipwreck locations cited in contemporary newspapers were quite general, such as "lost off Marblehead," and other sources gave exact locations, the team designated each reported shipwreck as being at a specific location, "off" a municipality, or in the general area.

To determine significance for each site we used the Department of the Interior's definition for eligibility to the National Register of Historic Places -- generally sites over fifty years old. However, most of the shipwrecks were over one hundred years old. We have accepted the recorded locations and dates of the shipwrecks, without enough time to research each shipwreck in depth, therefore the information for any particular site might be inaccurate. However, the approximate number of significant shipwreck sites in the Salem study area is accurate enough to allow the determination of recommendations for predredging planning.

Historical Background

The history of the survey area is rich in maritime activities. Prehistoric Indians used the shore as a summer dwelling area to get away from the heat and bugs in the interior and to collect the bountiful food offered by the sea. Regionally, Indians were known to collect many types of shell fish which were smoked, dried, stored and traded for winter food. They used small dugout and bark canoes for fishing and hunting mammals, and for transportation along the shore and to nearby islands.

In most areas of New England, seasonal Indian dwelling sites are typically found near a beach and a fresh water source with a southeast exposure to the sea. In addition, shell middens, created by Indians processing bivalves, are often found in similar areas without the need of running fresh water (Bourque, 1980, IV-45-49 & Riess, 1989, 12). Since the last ice age, the net sea level change has placed the coastline of 6,000 BP under approximately 25 feet of water in the Cape Ann area (Bourque, 1980, IV-229).

When Europeans settled in the study area in the 1620s, they established fishing and timber businesses for regional and transatlantic commerce. The collection of natural harbors provided havens for inshore and offshore fishing vessels. The crews would fish for cod, mackerel, haddock and other species and bring their catch to port for processing. They would split and store the cod on salt in the ship or salt-dry the cod on stages and flakes set up on the slopes at the villages' shores (Lawson, 111-115 and Reynolds, 1856). Many types of historic vessels were used for fishing in the study area, including 1600s and 1700s shallops, ketches, pinkies, and schooners, plus 1800s schooners, Chebacco boats, and jiggers (Lawson, 1895; Reynolds, 1856). In the early 1800s, Jefferson's Embargo, the War of 1812, and other economic factors hurt the area's fishing industry.

Fishing in Salem probably began when the first group of humans settled in the area. Salem is a well-protected harbor with land on three sides and a short fetch at the northern entrance. Local, near shore, waters contained many edible species in quantities to sustain thousands of people, even with primitive fishing techniques. The area was called Naumkeag.

When English Puritan settlers came to Salem in the late 1620s they found few Agawams had survived the plagues which had decimated the local peoples. Large tracks of previously cleared and cultivated land were left for the Europeans to settle; so much so that in 1636 cutting trees for clapboards or cask staves was forbidden in Salem. The colonists were originally invited to settle in the area as protection from raids made by other tribes. They started a typical Massachusetts Puritan town based on religion, agriculture and fishing.

During the seventeenth century most Salem fishermen worked the near shore waters as far east as the settlers of New France (present day Canada) would let them. As markets and available capital expanded they used larger boats to fish the Grand Banks, as did most of the North Shore fishermen. Throughout the colonial period Salem was an important fishing port of Massachusetts, yet its merchant trade developed to overshadow all else on the waterfront.

Salem's merchant trade in the colonial period was generally confined to coastal, West Indies, and English voyages. British Empire trade regulations kept them from trading outside of the Empire, except for wine and salt from the Iberian Peninsula and its eastern-atlantic islands. During the Revolution, Salem retained its maritime importance through fishing and privateering.

As soon as the Revolutionary War stopped, Salem merchants began trading voyages to the Far East, a region formerly forbidden by the British trade laws. Salem's immediate prominence in the trade remained throughout the early 1800s, providing much wealth and commerce for the growing port. Coastal and West Indies trade and fishing also increased in Salem to support the Far East trade and growing population. However, forces were in motion to shift Salem away from the merchant trade.

With the advent of the railroads and steam tugs and ships, Boston, with its deeper channel, was able to gather much of the shipping away from smaller New England ports. Merchants left Salem to set up their business in Boston, while others began investing in manufacturing plants in and near Salem. Merchant ships continued to sail from Salem throughout the 1800s, but very few called there by the twentieth century. In the past one hundred years, the Salem waterfront mostly has been used by fishing and recreation boats.

Potential for Archaeological Sites

Since little is known of the prehistoric Indians of the study area, any remains, whether a village, fish processing site, or sunken canoe, would be of great importance. However, previous sub bottom profiling data indicate that the area has an irregular bed rock which is typically covered by 0-30 feet of glacially deposited medium sand and some organic and clay sediment. Remains of any sites would be extremely hard to locate under the sediment in the survey area. Remote sensing surveys will generally not indicate a prehistoric site in this type of topography. Locating prehistoric Indian sites would require archaeological trenching of each proposed impact area. Spot inspection by archaeological divers, while investigating remote sensing targets of possible historic remains, would be useful, but probably not productive.

In contrast, historic shipwreck sites are known to exist in the study area and are easier to detect. The number of vessel losses found in this study is smaller than the total losses that would be located with a complete study, but the results found are indicative of a large number of probable shipwreck sites in the study area. The lack of complete recorded evidence is typical for any locality along the New England shores. Until recently the loss of a vessel, even with the loss of life, was not considered newsworthy enough for the ubiquitous 4-page weekly newspaper in the 1700s and 1800s. State and federal government compilations of vessel losses, which are incomplete, date only from the very late 1800s. In addition, the parameters of this study only included some primary research with mostly the inspection of secondary compilations of data from the primary sources. The data located in this study indicate that there is a probability of encountering the remains of an historic vessel in most sections of the project area.

The survey-level historical research located a total of 349 shipwrecks in the Salem study area, including vessels listed lost in Salem Harbor, or "off" Salem, Marblehead, Beverly, Manchester, or Gloucester. Eliminating those vessels known to be outside of the disposal sites presently considered, we are left with 9 shipwreck sites known to be in, or close to, one of the possible disposal sites and 303 at some unknown spot in the general study area. Of the latter two groups, 298 would fit the Department of the Interior's eligibility for the National Register of Historic Places. Located wrecks are listed in Table 5-7 and shown on Figure 5-12.

Table 5-7: Shipwrecks with Known Locations Within the Study Area (Approximate Locations)

Vessel Name	Date	Latitude	Longitude
AVALON	1899	4,613,760	352,460
CITY OF ROCKLAND	1,924	4,711,750	352,360
COLLYRIA	1839	4,708,700	345,240
GLANCE	1834	7,706,750	354,200
HARRIOT	1805	4,709,500	346,480
MAHONEY	1898	4,709,150	347,050
MAY QUEEN	1877	4,709,640	349,500
MARGUERITE	1897	4,712,560	350,720
NANCY	1813	4,712,220	349,380
NORTHERN LIGHT	1867	4,707,100	354,200
PEIRCE	1876	4,710,100	349,020
R.B. PITTS	1866	4,709,400	349,400
SAMUEL	1835	4,706,900	354,200
TWO BROTHERS	1831	4,711,820	351,900
VESPER	1827	4,712,140	349,140

In addition to those vessels found in the historical records, we must assume many others were lost in the study area and not recorded. Before radios and radar, vessels were surely lost with all hands on the numerous ledges in the area during storms and fogs. Others could only record them as missing at sea, whether they had just left the harbor, were returning after a long voyage, or were blown in while trying to sail past the shore. No one would know what happened to them. They would include small and large fishing boats, coasters, and transoceanic merchantmen and warships.

Besides those vessels lost while underway, a number would have been lost at their moorings or abandoned in shallow water, such as the abandoned 1800s fishing vessel seen at low tide on the western shore of Manchester Harbor and the 1690s Hart's Cove shallop in Newcastle, New Hampshire. Some of the shipwrecks would have been salvaged shortly after wrecking or more recently.

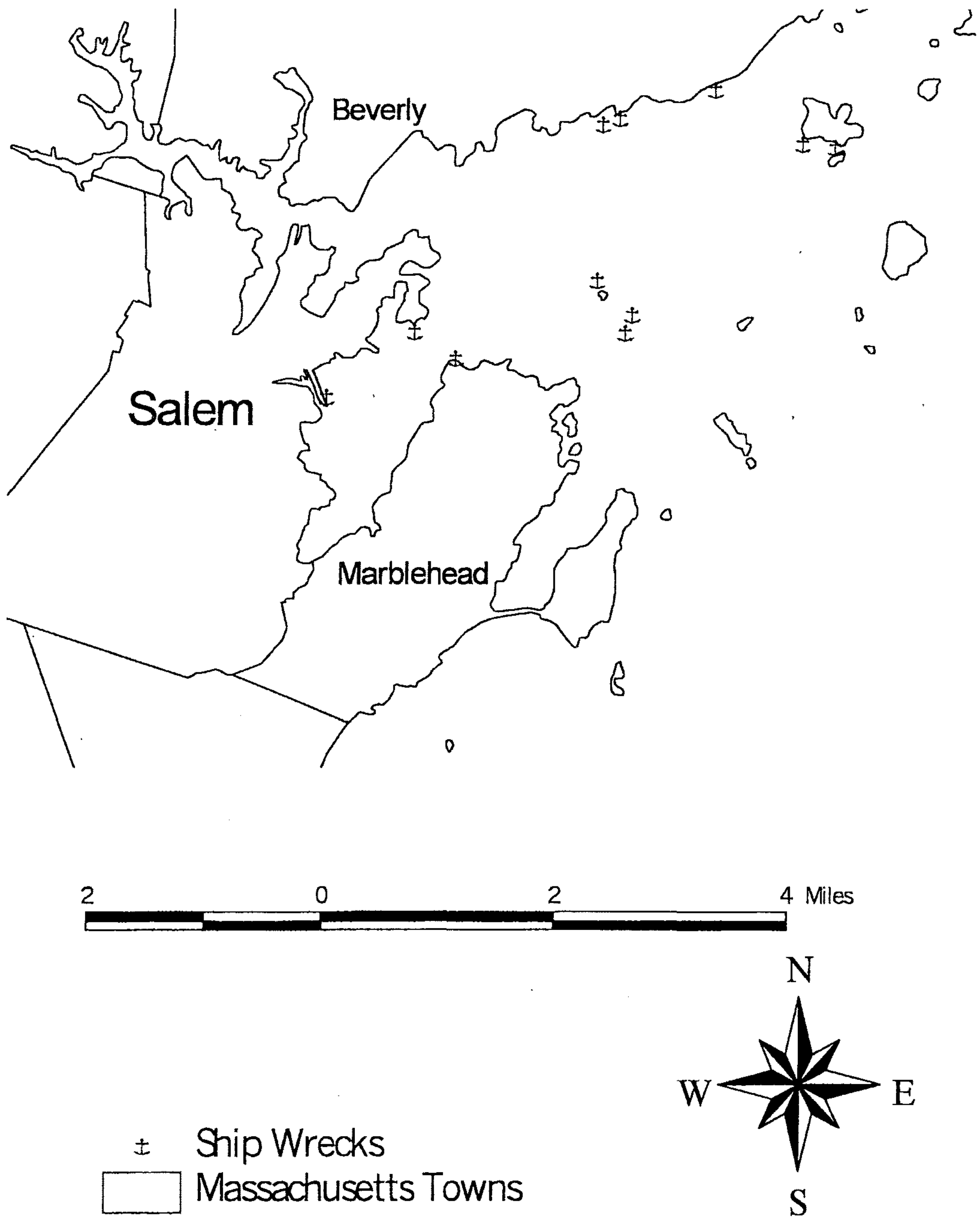


Figure 5-12: Location of Shipwrecks in Salem Harbor

Since we know so little of the early vessels, the onboard fishing processes, and life aboard the early merchant vessels, the remains of any historic ship or boat would be archaeologically and historically significant on a local, regional, and national level. Locating remains of these vessels with remote sensing will require a precise survey because of their peaceful utilization. Warships, and larger merchantmen sailing to dangerous places, carried many iron guns and a large quantity of iron shot. The iron disturbs the earth's magnetic field and can usually be detected with a magnetometer survey. Most of the vessels which might have been lost in the study area would have had few, if any, large guns or ammunition. However, they had iron anchors and sometimes small iron guns which produce a smaller magnetic anomaly. Therefore, they can only be detected with a careful and precise magnetometer survey.

Consequences for Historic and Archaeological Resources

[list specific disposal sites which impact mapped shipwreck sites]

5.1.12 Recreational Resources

Recreational resources in Salem Harbor are abundant, and reflect a wide range of passive and recreational activities. Predominate among the recreational uses of the harbor are recreational boating and sailing, swimming, and passive uses such as picnicing and walking.

There are four recreational marinas and one yacht club located in Salem Harbor, and five major mooring basins with approximately 1,200 single point moorings available in Salem waters.

Recreational fishing is a significant activity, with Winter flounder, cod, mackerel, bluefish, striped bass and tautog the most important recreational species. Section 5.1.4 provides a more complete description of recreational fishing in Salem Harbor.

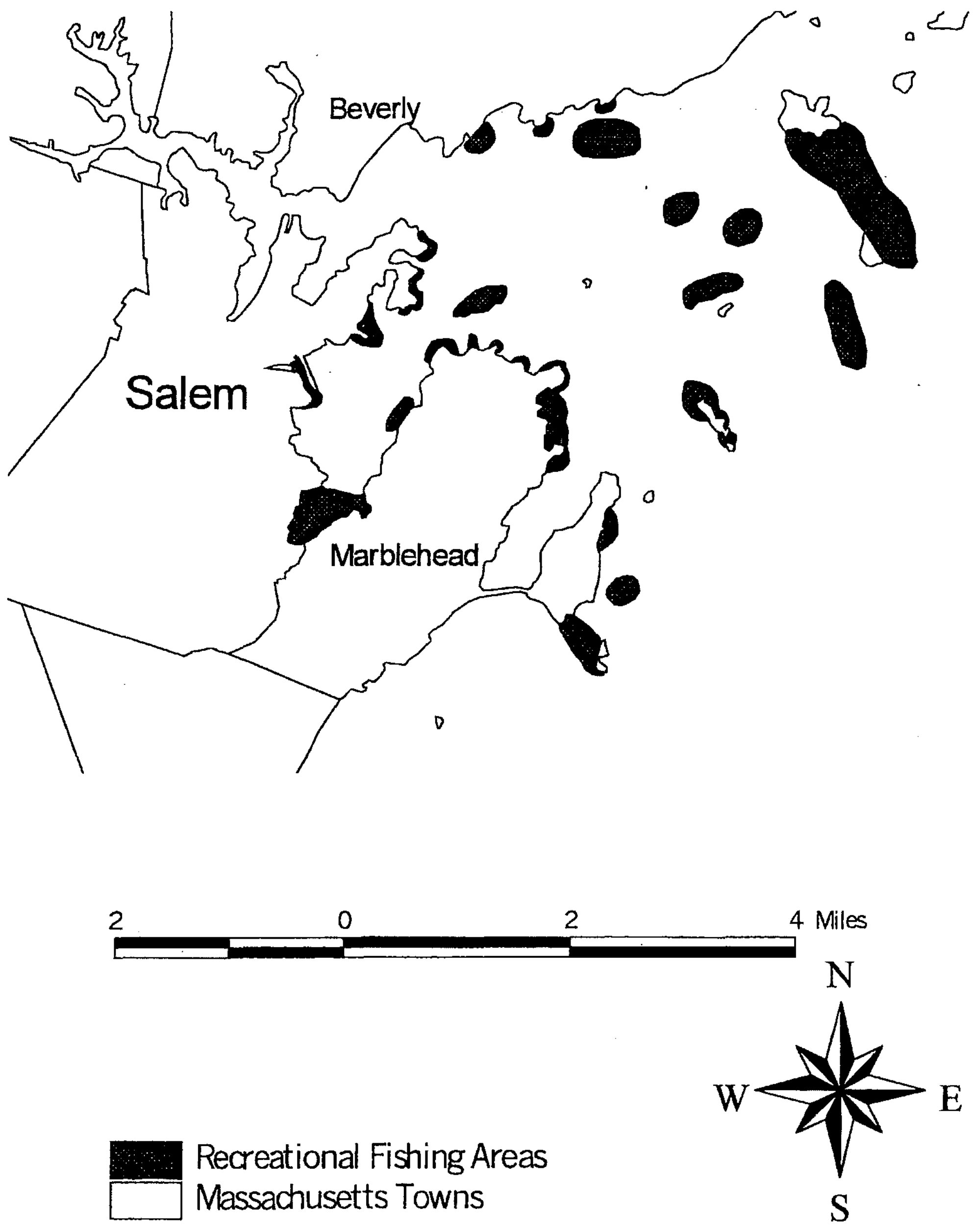


Figure 5-13: Recreational Fishing Resources in Salem Harbor

Public parks abutting Salem Harbor include areas in both Salem and Marblehead. In Salem, park areas include Winter Island and Waikiki Beach at the eastern end of the harbor, which includes a public boat ramp and a popular bathing beach with picnic areas. At the southern end of the harbor are located Palmer Cove Park, a neighborhood playground and Forest River Park, with a small sandy beach area, sports fields and picnic areas.

In the inner harbor, Central Wharf, part of the Salem Maritime National Historic Site, is an important passive recreational resource, providing walking access to the activity in the harbor.

In Marblehead, park areas abutting Salem Harbor include: Danger Beach, a small swimming area and boat landing; Gerry Playground, a neighborhood park with a sandy beach, picnic areas, sport fields and a playground; and Waterside Cemetery, providing scenic views of the harbor along a rocky coastline.

5.1.13 Economic Environment

Cost of the Proposed Alternative

Cell #	Quantity of Dredge Material (cu. yd.)			Disposal Costs	
	Unsuitable	Cap	Total	Unit Cost	Total
Cell #1	164,933	22,493	187,426	$40	$7,499,711
Cell #2	88,000	33,982	121,982	$40	$4,932,024
Cell #3	9,600	31,963	41,563	$42	$1,741,778
Cell #4	24,000	33,563	57,563	$40	$2,329,178
Totals	287,333	121,201	408,534		**$16,502,691**

5.2 Affected Upland Environment

5.2.1 General

The following section describes the existing environment of, and near, the two proposed preferred upland disposal sites, Bardon-Trimount Quarry (SLM-06) and Westminster Landfill (WSM-01).

Location and Topography

SLM-06 - Bardon Trimount Quarry

The Bardon Trimount Quarry, SLM-06, is located south of Swampscott Road in southern Salem and west of Danvers Road in northern Swampscott (Figure 5-16). It is a 113-acre site with approximately 60 percent of the site used as an active gravel pit and asphalt batching operation. The quarry is a historic landmark. The site has a relatively flat topography outside of the quarry on the property, with the exception of some slopes in the northeast corner. The gravel pits, themselves, are very deep, with steep walls.

WSM-01 - Fitchburg-Westminster Landfill

The Fitchburg-Westminster Landfill, WSM-01, is located in the southeast corner of Westminster east of Fitchburg Rd, with a small portion in Leominster. The topography slopes to the northwest in the southern section of the site, while there is a relatively steep slope that leads to Sawmill Pond in the north. The landfill has been in operation since 1971. The present disposal area is planned to be used until 2002, but an application is being considered by DEP for the extension of this disposal area to extend the life of the landfill.

Regulatory Process

SLM-06 - Bardon Trimount Quarry

The Bardon Trimount Quarry site in Salem and Swampscott is zoned as industrial, and presently contains active quarrying and asphalt batching facilities. In order to accept the DMMP dredged material, the property would have to be sited and permitted as a solid waste facility. To do this, it must go through the solid waste facility site assignment process, with applications going to Salem and Swampscott Boards of Health (if parcels in both towns are used) as outlined in the Site Assignment Regulations for Solid Waste Facilities (310 CMR 16.00) and the solid waste facility permitting process, with an application going to the DEP as outlined in the Solid Waste Management Regulations (310 CMR 19.00).

WSM-01 - Fitchburg-Westminster Landfill

The Fitchburg-Westminster Landfill is an active landfill. It presently accepts municipal sold waste, but its disposal areas will be filled to capacity and closed by 2002. The DEP is reviewing an application to extend the disposal area, and therefore the life, of the landfill, and it is in this area that sediment could potentially be placed. The application for expanding the disposal area has no connection to the DMMP and has been submitted by the municipalities that own the landfill so that the landfill can receive more municipal waste.

Resource Characterization Overview

SLM-06 - Bardon Trimount Quarry

The Bardon Trimount site presently contains industrial facilities for quarrying, as well as those for converting contaminated sediments to asphalt. These facilities cover approximately 70% of the site, and the land in these areas is sparsely vegetated. The rest of the property is wooded and there are forested and wetland areas adjacent to the site. The wetlands to the north of the site contain a habitat for a rare or endangered species. There are residential areas near the site, though most have undeveloped land between them and the industrial activities on-site. The surrounding receptors have likely already been impacted by increased truck traffic, gas emissions, and petroleum releases related to the present industrial activities on the site. Even so, the surrounding undeveloped and residential areas could potentially be impacted by increased noise, dust, or odors associated with the disposal of contaminated sediments in the quarry, as well as potentially more truck traffic than is now present.

WSM-01 - Fitchburg-Westminster Landfill

The active landfill at the site is surrounded mostly by forest that extends offsite to the Leominster State Forest. There is also a sparsely-developoed residential neighborhood to the northwest and a stream that runs through the site to Sawmill Pond, which abuts the site to the north. Even though the site currently has trucks bringing waste to the landfill, it is likely that this traffic will increase if large amounts of dredged sediment are brought to the site. This increase in truck traffic, as well as the risk of potential contaminant releases and the odor, noise, and dust sometimes associated with the disposal of dredged material, could impact the undeveloped and residential areas surrounding the disposal site. The proposed disposal areas would also be extending the landfill into forested areas on-site and would move the landfill closer to the state forest to the east.

5.2.2 Soils and Groundwater

Water Quality

SLM-06 - Bardon Trimount Quarry

The nearest surface drinking water source to the Salem/Swampscott site is the Class A water supply Spring Pond, which is 1.25 miles northwest of the site. Other surface bodies in the area include Foster Pond, which abuts the site to the southwest, and the Forrest River, which at its closest point to the site is approximately 150 ft north of the site, and empties into Salem Harbor more than a mile northeast of the site.

There are no Zone II aquifers, IWPAs, or Sole Source Aquifers within one mile of the SLM-06. There is a Potentially Productive Aquifer 500 ft northeast of the site, and a non-community well 1300 ft to the east.

WSM-01 - Fitchburg-Westminster Landfill

Two Class A water supplies are relatively close to WSM-01. Rocky Pond is located 0.6 miles to the southeast, and Notown Reservoir is 0.8 miles to the east. Sawmill Pond, an unclassified water body, abuts the site to the north, and Flag Brook runs through the site and into the pond.

There is an IWPA west of Fitchburg Road, but no Sole Source Aquifers within one mile. There is also a Potentially Productive Aquifer 0.3 miles south of the site.

Soil Quality

SLM-06 - Bardon Trimount Quarry

With industrial quarry and asphalt batching operations active at the site, it can reasonably be assumed that the soils at, and potentially near, the site have been impacted. For example, there have been three petroleum spills within the last five years that have required a 2-hour notification to the DEP. All of these have Release Action Outcome (RAO) Statements on file, however, indicating that they were cleaned up to the relevant DEP standards. The quarry itself is composed of rock with no soil development.

WSM-01 - Fitchburg-Westminster Landfill

Even though it is a lined facility, it is possible that soils on-site have been impacted by the landfill actively operating at the site. There have been no releases at the site that have been reported to the DEP, but the activities associated with disposing solid waste at a landfill could potentially have impacted the site surrounding the disposal area. The soils on-site could have been impacted by the increased truck traffic and waste released during transfers. As a result, ground water could have been impacted by leaking truck fluids and contaminants from waste if these are able to seep to the water table. Surface water may have been impacted if any contaminants were released near the on-site stream or adjacent pond.

Impact of Effluent

Both sites have a surface water body that abuts the property. In Westminster, the Flag Brook runs through the site into Sawmill Pond to the north. Foster Pond is southwest of the Bardon Trimount Quarry. In both cases, these water bodies could be impacted if effluent from the disposal area for the dredged material was released into the environment, and there is a high potential for degradation.

SLM-06 - Bardon Trimount Quarry

Even though the dredged sediments would likely be placed below the water table within the quarry, it is not likely that water resources would be impacted. Due to the ease with which contaminants could reach ground water through the walls of the quarry, a more elaborate than normal engineered system lining the walls of the quarry would be built to contain effluent. A monitoring system would also be in place, to monitor for contaminants that escape the barrier. There is the potential for contaminants to be released to Foster's Pond to the west, but this is not likely, because the dredged sediments would be place below grade within the quarry, and the entrance to the site is to the east. It is likely that there will be strict requirements if sediments are placed in the quarry, so there may not even be a significant amount of contaminants to be released.

WSM-01 - Fitchburg-Westminster Landfill

With an IWPA across Fitchburg Road from the landfill, care would need to be taken to keep effluent from coming into contact with the ground, particularly on the western border of the site. The protected groundwater is upgradient of the site however, so it should not be impacted by activities at the site. If effluent was to be released, either before the dredged sediments could be placed within the lined facility or if fluid escapes the lined barrier, contaminants could potentially enter the Flag Brook on-site and be carried to Sawmill Pond to the north. Surface water, as well as ground water, would therefore need to be monitored for contaminants.

5.2.3 Wetlands

SLM-06 - Bardon Trimount Quarry

According to NWI mapping, there are no large wetlands at the quarry site proper, however, there are remnant excavated pits that may qualify as wetlands according to DEP and/or ACE definition. A site-specific field survey would be needed to make this determination.

The site is bordered by an extensive wetland system known as Thompson Meadows, to the northeast and northwest. Also, Fosters Pond abuts the southwest perimeter of the property. Thompson Meadows is classified as a palustrine emergent, seasonally inundated wetland. Some forested areas occur within this meadow. West of the quarry, and part of the Thompson Meadows system, is an extensive palustrine shrub-scrub broad leaved deciduous swamp. Fosters Pond is categorized as a palustrine unconsolidated bottom, permanently inundated and diked waterbody.

WSM-01 - Fitchburg-Westminster Landfill

Flag Brook runs from south to north, along the western edge of the property, into Sawmill Pond. According to NWI mapping, there are no other wetlands on the Westminster Landfill property, however site-specific field investigations would need to be done to confirm this assumption. Abutting the property, to the north is Sawmill Pond, although the landfill proper is located about one-half mile from the pond's southern perimeter.

5.2.4 Wildlife

General

SLM-06 - Bardon Trimount Quarry

Because it is an area that has been, and continues to be disturbed, the quarry itself has relatively low value as wildlife habitat. Vegetation is extremely sparse, therefore there is little food source for birds or mammals, although the quarry cliffs could provide nesting for birds, particularly birds of prey such as hawks.

Amphibian/Reptile Habitats

The quarry would a viable habitat for amphibians, due to lack of suitable shallow-water habitat. Certain terrestrial reptiles, however, may inhabit crevices within the quarry, however, the constant disturbance of the site would likely limit the habitat value for reptiles.

5.2.5 Endangered Species

SLM-06 - Bardon Trimount Quarry

There is a rare or endangered species habitat located in the northern section of the quarry site, according to the Massachusetts Natural Heritage Atlas. The species is not specified in the Atlas, so as to protect it from being potentially damaged (as per DEP policy). The species is in an area that was indicated by a Salem town official as being in the vicinity of the asphalt batching operations on the property. This section of the site is set back from the quarry where the dredged material would be deposited, and access roads are south of this potentially sensitive area, along Danvers Road.

WSM-01 - Fitchburg-Westminster Landfill

Even though there is abundant habitat available for wildlife in areas on and around the site, there are no rare or endangered species habitats within or near the landfill site.

5.2.6 Land Use

General

When determining the effects of disposing contaminated dredged sediments at a site, it is not only the destruction of resources in the vicinity of the site that must be evaluated, but also whether future disposal activities would alter or degrade the current use of the property or surrounding lands.

Land Use in the Vicinity of Disposal Sites

SLM-06 - Bardon Trimount Quarry

On-site land use would be irreversibly altered by the disposal of dredged materials in the quarry at this site. With the quarry filled with contaminated sediment, gravel could no longer be removed from the ground. The magnitude of loss from the inaccessibility of this resource would depend on how much gravel is left in the ground when disposal operations begin. The asphalt batching facilities could potentially continue operation, but the area may be needed as a staging area for the disposal site or it may be included in the disposal area itself.

The quarry area is almost entirely surrounded by undeveloped forests and wetlands, with residential areas beyond. Recreational use of the undeveloped areas may have to be restricted if odors, dust, or noise become a problem. The residential areas would most likely be buffered from these disturbances by the undeveloped land that is between them and the quarry.

WSM-01 - Fitchburg-Westminster Landfill

The disposal of sediments would not change the use of land at this site, which is now an active landfill. The dredged material would be a new source of solid waste, however, and it would fill capacity in the landfill that would otherwise have been used for municipal sold waste. The dredged sediments could potentially be used as daily cover to overcome this. Unfortunately, the site could not take as much of the sediment as cover, and the sediments, due to their consistency and potential contaminants, are not ideal as cover material.

This active landfill is just about completely surrounded by a state forest. There are some residences that abut the site to the northwest, and the other adjacent land is undeveloped forest. If the production of odors, dust, or noise from the sediment disposal activities become a problem, recreational activities in the state forest may have to be restricted. The residential area should be far enough removed from the disposal areas in the southeast parts of the site that these problems should not affect people living there.

Consistency with Port Plan

Even though both of the preferred upland disposal alternatives proposed are outside of the study area of the

Salem Harbor Plan, they are consistent with it, in that the alternatives will facilitate the implementation of identified dredging projects. The ability to dredge the harbor is a key component to implementing the preferred development alternative specified in the port plan.

5.2.7 Air Quality/Noise

Air Quality

SLM-06 - Bardon Trimount Quarry

The quarry is located in Salem and Swampscott, which, along with the entire Commonwealth of Massachusetts, is in serious non-attainment for ozone. Ozone is a compound formed by the reaction of volatile organic compounds and nitrous oxides with air. Most of the northeastern United States has been declared a non-attainment zone for ozone by EPA. The principal cause of ozone is vehicle tail pipe emissions and industrial discharges.

The nearest air quality monitoring station is in Lynn. The 3-year average daily maxima for ozone recorded at this station was .089 ppm, which is slightly higher than the EPA primary health standard of .085 ppm.

Locally, there may be elevated levels of particulate matter in the air during quarry operations and temporary elevated carbon monoxide levels at the site while trucks and other equipment are running.

WSM-01 - Fitchburg-Westminster Landfill

The landfill is located in the north-central portion of Massachusetts, which is in serious non-attainment for ozone. The nearest monitoring station is in Worcester, where the 3-year average daily maxima measurement of ozone was .087 ppm, which is slightly higher than the EPA primary health standard of .085 ppm.

Locally, there may be elevated levels of particulate matter in the air during solid waste disposal operations and temporary elevated carbon monoxide levels at the site while trucks and other equipment are running.

Noise

SLM-06 - Bardon Trimount Quarry

Noise levels at the quarry itself are expected to be relatively high, but during operations only. There is a significant distance between the operation itself and surrounding sensitive land uses (residences to the south and cemetery to the east), so noise levels at these locations are relatively low.

WSM-01 - Fitchburg-Westminster Landfill

Noise levels at the landfill itself are only elevated when trucks dispose of solid waste. Otherwise, the site is in a quiescent setting, surrounded by forest on all sides.

5.2.8 Historic and Archaeological Resources

SLM-06 - Bardon Trimount Quarry

The Bardon Trimount Quarry is listed in the Massachusetts Historical Commission's (MHC) Inventory of the Historic and Archaeological Assets of the Commonwealth (MHC #SWA.903). It is an early twentieth-century stone quarry and is currently being evaluated by MHC staff for it's eligibility for listing in the National Register of Historic Places.

WSM-01 - Fitchburg-Westminster Landfill

The Fitchburg-Westminster Landfill is located near Notown District, Leominster which is listed in MHC's Inventory of the Historic and Archaeological Assets of the Commonwealth (MHC #LEO.HA.1). This is an extensive area of scattered farmstead and rural industrial sites. The district, however, does not include any recorded features sucha s cellar holes or mill foundations within the property boundary of the landfill proper.

Portions of the landfill property are archaeologically sensitive and are likely to contain archaeological sites associated with the Native American settlement of the area. The western portion of the site contains areas of level well-drained soils in proximity to water (Flag Brook). Review of the MHC's Inventory of Historic and Archaeological Assets of the Commonwealth indicates that Native American archaeological sites are often found in similar settings.

5.2.9 Recreation

SLM-06 - Bardon Trimount Quarry

The area of the site that is described by MassGIS as Recreational Open Space is where the active quarry is now located, but any recreational activities that the area hosted have already been interrupted by the quarrying. The undeveloped land that surrounds the site has limited to no protection. To the south, the land is considered recreational open space, and the wooded areas have potential to be used for activities such as hiking and biking. The wetlands to the north are listed as conservation land and rare or endangered species habitat, and they are potentially good for birdwatching and fishing, as well as other activities.

WSM-01 - Fitchburg-Westminster Landfill

Protected open space, primarily a state forest, surrounds the landfill property. These forested areas are likely to be used for a variety of outdoor activities. Sawmill Pond to the north offers opportunities for fishing and boating with good access from the road.

5.2.10 Economic Environment

Recreation and Tourism

SLM-06 - Bardon Trimount Quarry

The quarry itself is not a site for recreation or tourism. The nearest area of recreation is Jackson Park, located along the southern perimeter of the property. This park contains two baseball fields and tennis courts.

WSM-01 - Fitchburg-Westminster Landfill

The landfill itself is not a site for recreation or tourism, although the surrounding forest (Leominster State Forest) and Sawmill Pond offer numerous passive recreational opportunities for hiking, fishing and boating.

Figure 4-12: Universe of Dewatering Sites

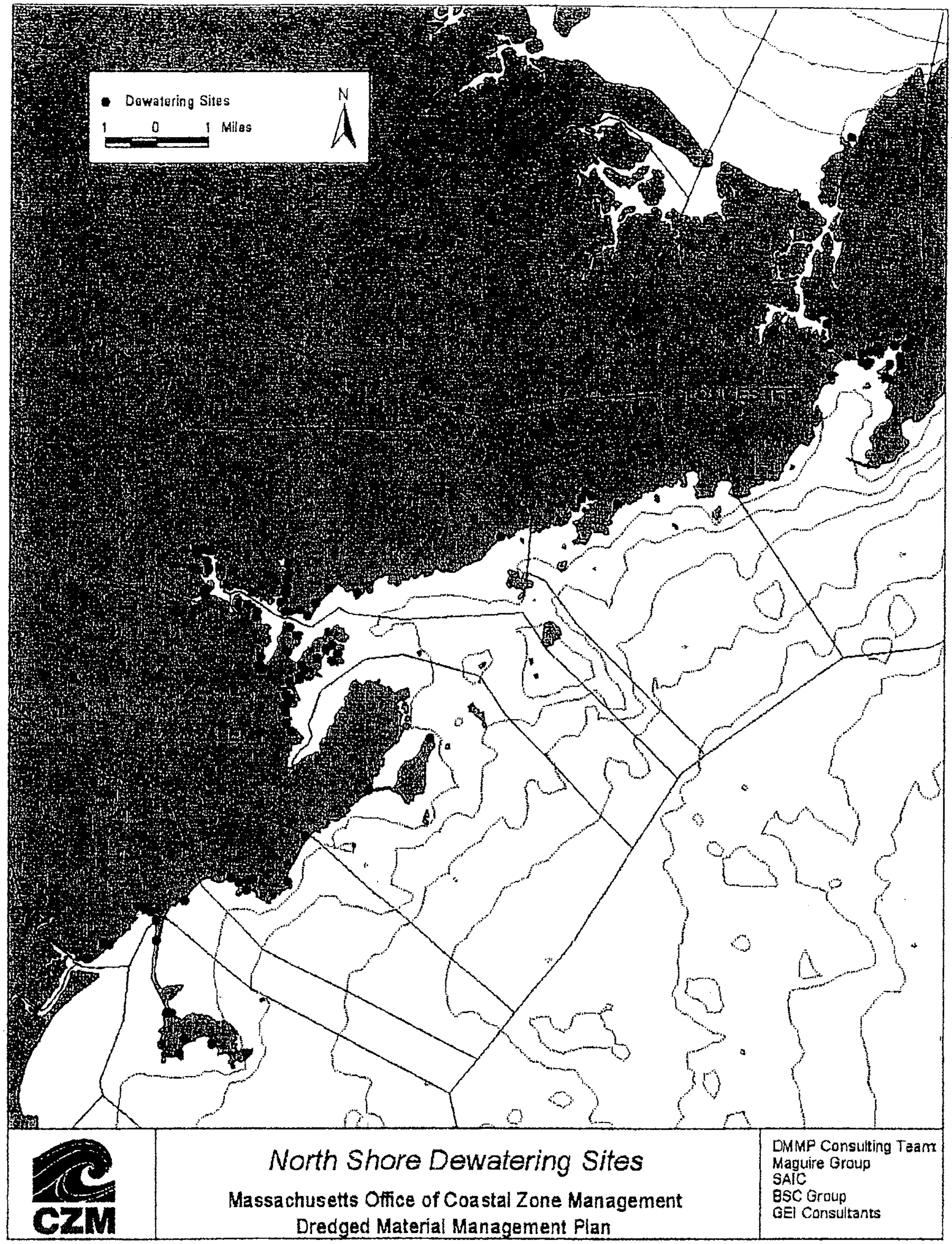
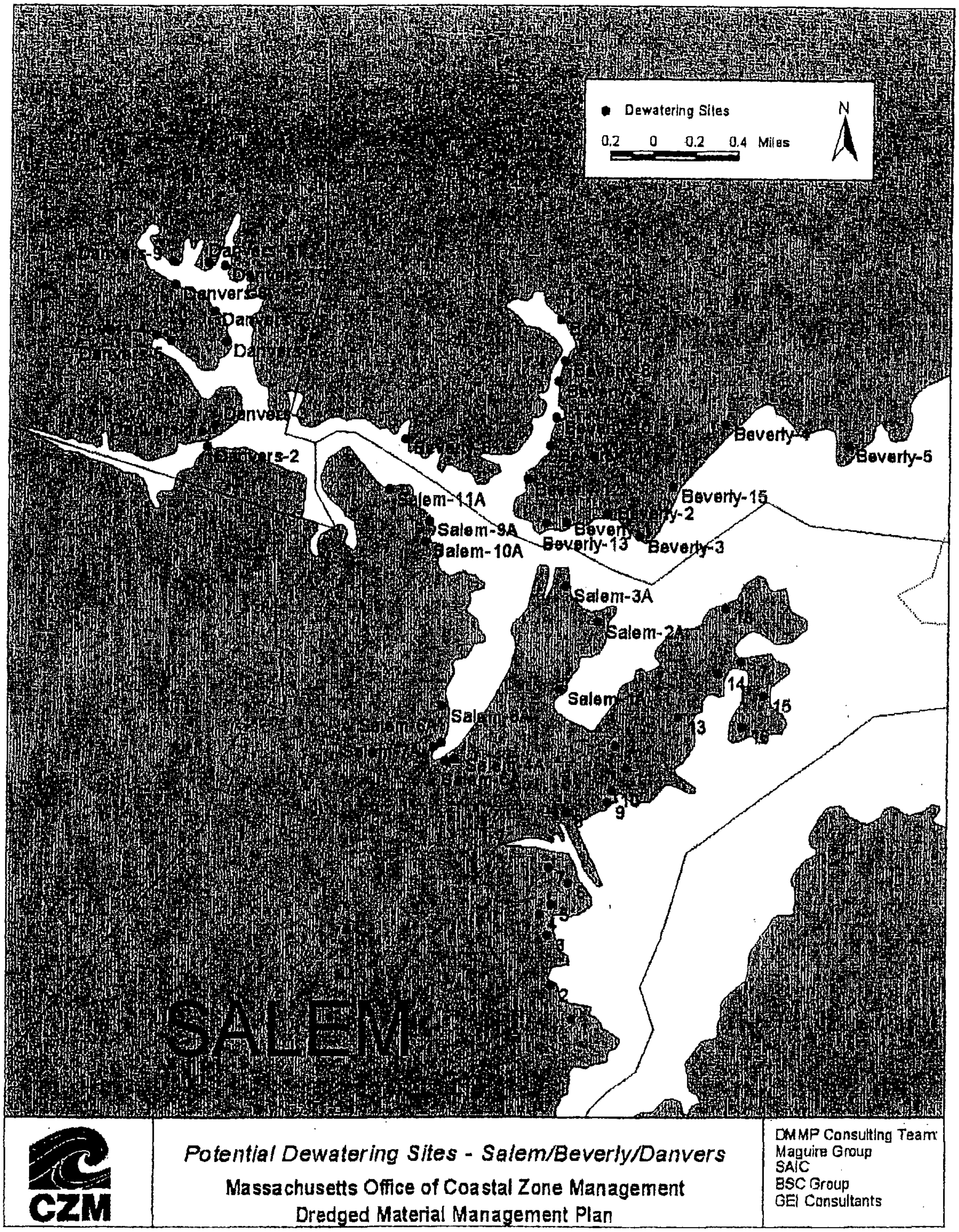


Figure 4-13: Potential Dewatering Sites in Salem



SECTION 6.0 - ENVIRONMENTAL CONSEQUENCES

6.0 ENVIRONMENTAL CONSEQUENCES OF PREFERRED ALTERNATIVE

This Section is a detailed evaluation of the environmental and cultural impacts and benefits associated with the implementation of both the Aquatic and Upland Preferred Alternatives.

6.1 Aquatic

Section 6.1 describes the impacts and benefits of Disposal Site SA-6, the preferred alternative aquatic disposal option for the Salem Harbor DMMP DEIR.

6.1.2 Sediments and Water Quality

Existing Sediments

The process of dredging and disposal of dredged material is intrinsically a high disturbance process. The primary potential repercussions of dredged material disposal on existing sediments include the mortality of benthic organisms occupying pre-disposal sediments and the alteration of the existing sediment composition at the disposal site. Both of these impacts are temporary in nature. The long-term sediment character is more dependant upon the grain size of the final sediments at the surface of the CAD cells relative to the pre-existing sediments. The expected type of sediment at the surface of the cells is discussed further in this section.

Benthic organisms have an important ecological role in creating and maintaining ecosystem health, and as such serve as one of the primary indicators for measuring the status of marine environments. Past and present field studies have documented the presence of large aggregation of benthic bivalves in the vicinity of the Salem Harbor disposal sites. The presence of high successional stage benthic organisms such as blue mussels (*Mytilus edulis*), european oysters (*Ostrea edulis*), hard clams (*Merceneria mercenaria*), and soft-shell clams (*Mya arenia*) may play in important role in maintaining ecosystem health by facilitating the removal of suspended solids in the water column through filter-feeding, reduced sediment resuspension by enhancing sediment adhesion, and providing an important food source to higher trophic levels. Lower successional stage organisms, which were also present within all the preferred alternatives, also play an important biological role in maintaining sediment quality through stimulating bioturbation and aeration of benthic sediments. The strong relationship between organisms that occupy the sediments and the sediments themselves is part of a biological-physical feedback loop. Thus the succesional stage, species diversity, and abundance of benthic organisms is a derivative of existing sediment quality, but benthic organisms serve a fundamental role in maintaining and enhancing sediment quality (Rhoads et al. 1977, Officer et al. 1982, SAIC 1997).

The alteration to sediments at any of the preferred alternative disposal sites must viewed in the context of the dredging disturbance process. The process of selecting the preferred alternative sites from the larger list of candidate sites was largely influenced by the realization that these sites would be heavily impacted by the processes of dredging, thus additional impacts by disposal are likely to be trivial. Thus sites within the channel will already be heavily disturbed, and those sites adjacent to the channel are likely to experience some, though probably less, degree of disturbance from the process of dredging, therefore the net overall impact would be reduced through utilization of the preferred alternative disposal sites.

The final character of the sediments overlying the CAD cells will be dependent upon the construction of the disposal site. If the CAD cells require capping, typically a coarse-grained sand is used because coarser grained sediment provides better resistance against resuspension and stronger armoring capabilities. Because the sediment at all of the preferred alternative disposal sites contain fine-grained sediment, it is possible that capping will permanently alter the existing sediment type, which may influence the present physical, chemical, and biological conditions. If the final topography of the CAD cells is recessed below the existing bottom, however, active sedimentation will likely fill the cell so that the surface sediments eventually reflect that natural sediment deposited in the area. For example, in the case of Boston Harbor, consolidation of the sediments in the pit resulted in a recessed topography in the short-term, suggesting faster sedimentation at the top of the pits as compared to the surrounding area. At the surface of a coarse-grained cap, it is unlikely that species that prefer unconsolidated sediments, as is present in Salem Harbor, will recolonize sand material as quickly or thoroughly, thus some change in species composition could result through capping. Sand-capped mounds in other projects showed that recolonization does occur, although slower than in fine-grained areas (SAIC 1998). Therefore, recolonization may be slower than normal as fine-grained sediment begins to cover the surface of the sediments. The advantage of a coarser grained cap is that it is more likely to resist resuspension, thus suspended sediment concentrations during storm-events may be reduced.

Several indicators from the sediment profile imaging data suggest that replacement of existing sediments in Salem with uncontaminated cap material at S15-ATC-1 may improve existing sediment conditions (Figure 6-1). The RPD depth within S15-ATC-1 was of intermediate length (1.51-2.25 cm) with no Stage III organisms present. Lower RPD values and Stage I organisms are normally indicative of high-disturbance regimes. The OSI at S15-ATC-1 was between 0 and +6, suggesting sediments of intermediate quality (i.e., moderately degraded or recently disturbed). However, data at S6-CAD/OD-1 suggests that additional improvement to the present status is unlikely. For instance, the sediment profile sample station within S6-CAD/OD-1 showed high RPD values (>3.75 cm), indicating good sediment aeration, good tidal flushing, and bioturbation by Stage III organisms (subsurface deposit-feeders). The mean Organism Sediment Index (OSI) was greater than +6 at S6-CAD-OD-1, suggesting good or healthy overall benthic habitat quality. No sample stations were located within S6-Extension, although it is likely that the sediment composition and quality will be similar to S6-CAD/OD-1 due to their close proximity.

Sediment Transport/Circulation in the Vicinity of the Disposal Sites

The circulation of water in coastal embayments such as Salem Harbor is influenced by a complex combination of forces produced by tidal fluctuations, wind, and density gradients. Factors such as wave height, geomorphology, and water-column stratification influence harbor current velocities, localized circulation patterns, and sediment transport. These factors are of particular concern in the management and siting of dredged material disposal, since these factors will directly influence the integrity of the cap material and the ability to isolate the contaminated sediments from the aquatic environment. The following discussion of potential impacts to sediment transport conditions from dredged material disposal is based on analysis of historical hydrodynamic data collected from Salem Harbor (see Section 5.0). A more accurate and complete understanding and prediction of impacts will be possible once site-specific circulation field studies have been conducted.

Hydrodynamic data, albeit limited, collected within Salem Harbors suggests that the areas in the vicinity of the preferred alternative sites are low energy, depositional areas. In depositional areas, fine-grained sediments accumulate and tend to be stable for long periods of time. Disposal sites located in these areas should effectively contain dredged material in properly designed facilities. In contrast, boulders, rock outcrops, and coarse-grained sediments have been detected in erosional or non-depositional areas. These erosional forces, due to a combined action of tidal currents and waves, may transport sediment away from disposal sites. Insuring the confinement of sediments over time is difficult in turbulent environments, therefore disposal sites in depositional areas is of primary importance.

Given the level of information available, it is difficult to assess the impact of storm-induced circulation patterns within Salem Harbor. Conditions such as long expanses of open water and moderate water depth (approximately 35 ft) are conducive for the development of large waves, particularly those originating from Massachusetts Bay. Sites located in shallower regions may be exposed to the effects of current scouring then locations of greater water depth which are relatively protected from meteorological conditions and surface wave-action. If storm-induced erosion does occur, the effects appear to be temporary as the sediment data suggest long-term depositional environments. In addition, the placement of a sand cap will reduce the potential for sediment resuspension over the CAD cells. Sites located in protected coastal embayments are less likely to be exposed to significant storm-induced conditions because of the protection provided by surrounding land masses. Thus sites located further within harbor such as G2-OD and S6-CAD/OD-1 (Figures 6-1 and 6-2) offer more protection than sites farther offshore.

The Salem Harbor sites are more exposed to waves from Massachusetts Bay driven during the winter from the north/east, so therefore may be most exposed during northeasters that occur in New England in the fall and winter. Data collected from NOAA's National Weather Service, Beverly Station, indicates that prevailing wind from the S to SSW occur mostly during summer. However, above average wind speed and gusting winds from the S to SSW, conditions most likely to contribute to sediment resuspension, are highest during winter and fall.

Water column depth at the disposal sites may play an important role in determining localized current velocities. Current velocities typically behave in a logarithmic relationship with water column depth. Therefore, currents further from the surface experience increasing frictional retardation, particularly as currents approach the sediment boundary layer. Given this phenomena, in-channel CAD/OD sites located at greater depth will be exposed to smaller current velocities and less potential sediment resuspension forces than ATC sites at shallower depths. Coarser grained cohesive material also has the effect of greater frictional and gravitational forces holding the grains on the seabed. Thus a greater critical shear stress would be required to resuspended coarse grain cap material than fine grain silty sediments.

Hydrodynamic conditions may also be influenced by the construction of the containment cell created to dispose of dredged material. In the case of Boston Harbor, an overdredged channel site was created which was moderately recessed from the surrounding channel sediments. The effect of this recessed pit was reduced water column mixing with surrounding waters, and active sedimentation within the pits.

Navigational channels often experience some degree of reduced mixing via stratification due to temperature or salinity gradients. Bottom sediments within navigational channels may often experience hypoxic or anoxic DO conditions due to the reduced vertical mixing and higher BOD from the accumulation of organic material.

It is possible that a similar scenario may occur within Salem Harbor if dredged material is disposed of in channel sites. Reduced circulation may be beneficial from the standpoint of cap integrity since resuspension is less likely, but by the same effect this localized condition may also contribute to reduced water quality (see next section).

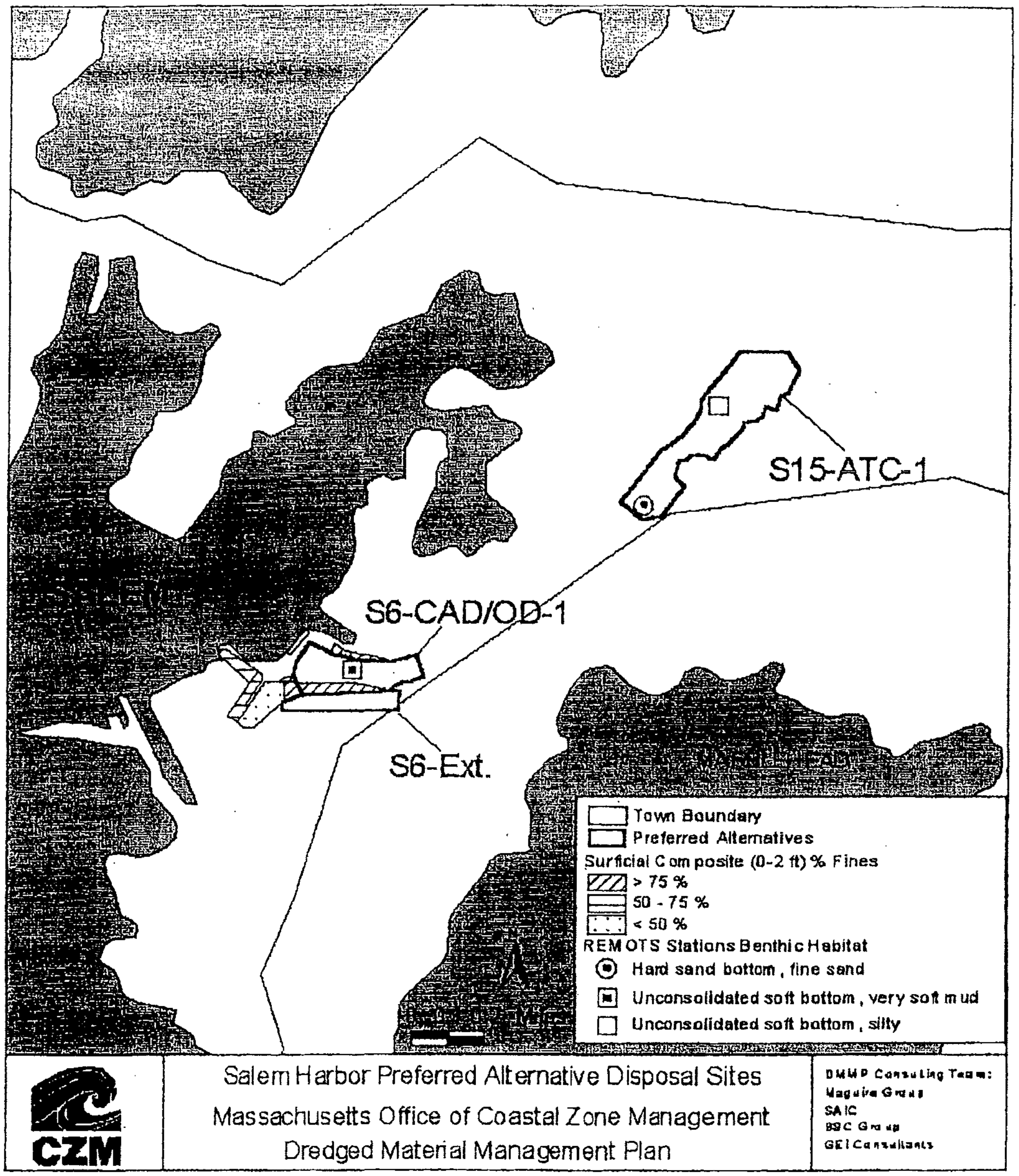
Water Quality

From prior projects, evidence suggests the impact to water quality from dredged material disposal is short-term. These impacts typically include localized degradation in DO, TSS, pH, light penetration, and contaminant concentrations. Conditions typically return to ambient conditions within hours to days, depending on the amount, composition, and frequency of the disposed material. Total suspended solids may increase dramatically due to the entrainment of fine material in the water column. A plume typically forms whereby material may be advected short distances from the disposal site. A reduction in DO is typical as common constituents of sediments are oxidized and organic material is metabolized by microbial activity at the sediment-water interface. High suspended solid concentrations have the effect of attenuating ambient light, thereby reducing penetration. Finally, contaminants sorbed to sediment particles may be dissolved by the aquatic environment through physical disturbance of the material as the sediment stream is released from the scow.

Water quality was extensively monitored in the Boston Harbor project during both dredging and disposal (e.g., ENSR 1997). The results showed that the plume was limited to an area that was monitored within 300 of the dredging and disposal activity. No increases in TSS were measured at the reference area 1000 ft from the dredge, although excursions were noted due to vessel passage. There was no apparent differences in DO between the monitoring stations and the reference areas. All of the contaminants measured were below chronic levels except for mercury, which was measured at above chronic but below acute values during a limited number of monitoring events. Bioassay data also showed no difference in impacts between the area dredged and reference. The final results from Phase 1 of the project showed that the project stayed within the Water Quality Certification compliance standards, and data collected during Phase 2 have suggested similar results.

One primary concern for the long-term impact to water quality was raised during the Boston Harbor dredging project. Due to the fluid, unconsolidated nature of the dredged material, capping was less effective than originally planned, and therefore sediment apparently from below the cap as well as from the area surrounding the cells quickly covered the cap to thicknesses of several feet. Because the top of the cell was recessed below the channel, a fluid mud layer, potentially exacerbated by ship passage, was constantly on top of the cell. Studies evaluating the potential resuspension of these sediments out of the pit and into the channel are currently being conducted. These results will be used to evaluate long-term adverse impact to water quality in Salem Harbor.

Figure 6-1: Sediment Characteristics of Salem Harbor Preferred Alternative Disposal Sites.



6.1.3 Benthos

Benthic Invertebrates

Any impacts to benthic organisms at a disposal site will be temporary and reversible. Immediately after disposal, the site will be devoid of benthic populations, because the benthos will have been removed by overdredging or buried under disposed sediments.. However, most benthic species are capable of rapid dispersal and colonization by means of planktonic larvae, and will quickly recolonize disturbed areas. The post-disposal benthic populations at the preferred sites may be healthier and more diverse than those existing at present, since contaminated sediments at these in-harbor locations will have been removed or buried and the new populations will be growing in the cleaner surface sediments.

The only benthic invertebrate data which are site-specific enough to distinguish between the preferred sites were obtained by the REMOTS sediment-penetrating camera, and the discussion of environmental consequences to benthic organisms is therefore based mainly on this information.

The only REMOTS stations within the proposed preferred alternative sites in Salem for regional disposal are Station 162 in Site S6-CAD/OD-1 and Stations 8 and 9 in Site S15-ATC-1. The Organism-Sediment Index (OSI) (See Section 5.1.3.2) for these sites indicates a somewhat better benthic habitat quality at S6-CAD-OD-1 than at S15-ATC-1. The OSI at Station 162 is over 6, indicative of good habitat quality, whereas the OSI value at Stations 8 and 9 is 4, indicating intermediate quality. No REMOTS sample was taken at Site S6-Ext., adjacent to S6-CAD/OD-1, but its habitat quality is probably similar to that of the nearest station, 162.

Stations 8 and 9, within S15-ATC-1, are an anomaly within the channel and ATC sites, because they are the only two of the 15 stations within these sites to have less than good habitat quality. Also, Station 8 is the only one with a hard, fine sand bottom, as opposed to a soft , silty or muddy bottom. This means that the temporary detrimental impact on benthic organisms from disposal at S15-ATC-1 may be somewhat less than at S6-CAD/OD-1, and probably at the adjacent S6-Ext., but both locations would have good habitat when the clean sediment cap is recolonized.

There are two possible alternatives for disposal within Salem of dredged material only originating in Salem:

a. Disposal at S6-CAD/OD-1. Bottom area disturbed = **12.5 ac.**

b. Disposal in Subcell S15-ATC-1. Bottom area disturbed = **10.7 ac.**

Since the benthic habitat quality is somewhat lower at S15-ATC-1 than at S6-CAD/OD-1, and the area disturbed is slightly smaller as well, it appears than there would be a lower impact on benthic invertebrates with disposal at S15-ATC-1. However, impact with any alternative will not be significant for the harbor and region as a whole, and recovery should be complete in the cleaner surface sediments of the cap.

Commercially and Recreationally Harvestable Mollusks

None of the proposed disposal sites in Salem contains any known shellfish beds. These are generally found in more shallow, nearshore locations than are being considered for dredge disposal. Since no disposal locations directly impact shellfish, there is no difference between alternate scenarios in terms of their impact on harvestable mollusks.

Lobsters

The survey of early benthic phase and juvenile lobsters in Salem in October 1998 did not cover the S6 site at the inshore edge of the channel, but two transects intersected the area of the S15-ATC-1 subcell. The outer channel and adjacent areas, including the area of S15-ATC-1, did not contain newly-settled lobsters. Some juveniles of 31 to 60 mm carapace length were found, but these are considered capable of movement toward suitable cover in the event of disturbance of their habitat, and their presence therefore does not preclude the use of this area as a disposal site (Malkoski 1999). It is not known to what extent the inner channel and adjacent sites may be used by lobsters, but early benthic phase lobsters were found at Site S16 to the south of S6, but not in S19 to the north. Local lobstermen have reported recently high abundance of lobsters in an near site S15-ATC-1.

Adult lobsters should be less of a concern in siting, because although they are a very important species economically in Salem, they are not found in significant concentrations in any proposed dredge disposal site, and are mobile enough to avoid areas of disturbance until the completion of disposal, after which they can move back into the disposal area. The immediate area of disposal will be temporarily removed from the area of lobster habitat, but it does not appear that lobsters will eliminate any of the currently proposed sites from consideration or favor one scenario over another.

Vegetated shallows / Submerged Aquatic Vegetation

Vegetated shallows, equivalent to eelgrass beds in this area, are not located near any of the proposed disposal sites, and should not be affected by dredge disposal. There are eelgrass beds south of Winter Island in Salem Harbor, but there is no reason to suppose that turbidity or sedimentation would be carried to these areas in sufficient amounts to affect the beds, regardless of the disposal scenario implemented.

If No Action

If there is no action, sediments will remain in their present condition, with surface materials containing contaminants and, in some areas, habitat of intermediate quality. The nature of the benthos will not change in any predictable way.

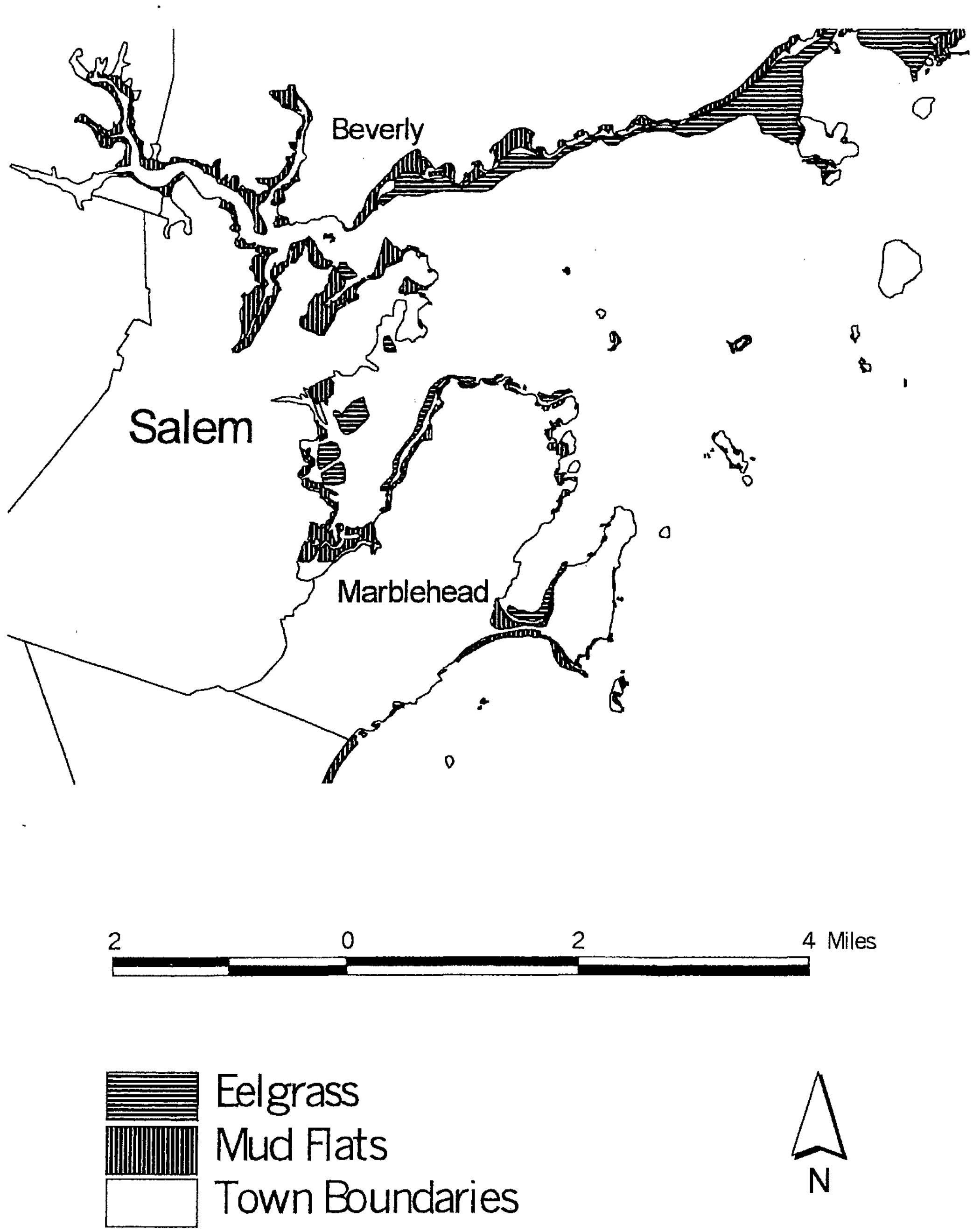


Figure 6-2: Submerged Aquatic Vegetation and Mud Flats in Salem Harbor

6.1.4 Finfish

General Fishery Resources

Dredge disposal will have an impact mainly on those activities and life stages of fishes which are dependent on the bottom. There should be little impact on ichthyoplankton or on any life stages of pelagic fishes, since these are very mobile and can readily avoid the temporary areas of turbidity in the water column. Also, many fish popular with sport fishermen, such as cod, striped bass, and tautog are found mainly near shoal, rocky areas and ledges, rather than in the relatively featureless and muddy channel and adjacent-to-channel areas proposed for dredge disposal (Koutrakis 1997), so that disposal should have little if any impact on these species. Flounder, one of the most important species in the fishery of the area, are bottom spawners with demersal eggs and, although they have pelagic larvae, live on the bottom for most on their life cycle. They spawn during February and March in the Massachusetts Bay region, and the eggs hatch in about 15 to 18 days (Bigelow and Schroeder 1953). There could be an adverse impact on spawning and egg development from dredge disposal unless disposal is restricted during this time.

Fishery Resources of Disposal Sites

Little is known about the specific fishery resources of the disposal sites, as opposed to those of the harbors in general. Some winter flounder were observed at Site S15 in Salem during a SCUBA survey by Division of Marine Fisheries divers in October 1998, but juveniles, observed in great numbers at Site S16 (not a preferred alternative) were not seen at S15. Bigelow and Schroeder (1953) report that winter flounder are most often caught on muddy sand, but may be found on a variety of bottom types. They spawn on sandy bottom. According to Koutrakis (1997) the general area near Subcell S15-ATC-1 is a productive area for flounder fishing. The area covered by the disposal cells in S15-ATC-1, however, is a very small fraction of the many productive areas for flounder fishing reported in and around Salem, and the temporary impacts of disposal in this area should not have a significant effect on the resources of flounder or other fishery resources, regardless of the alternative disposal scenario chosen.

If No Action

If there is no action, fisheries will remain as at present, with the exception of changes not caused by dredge disposal, such as those caused by natural cycles or over-fishing.

6.1.5 Wetlands

Coastal Wetlands

As reported in Section 5.1.5.1, no coastal wetlands, or salt marshes, are in the vicinity of the disposal sites, and marshes will not be affected by any of the preferred alternative dredging scenarios.

Disposal Site Wetland Resources

The only wetland at the disposal site is the harbor bottom itself, which is designated as "land under the ocean" and regulated as wetland by the Massachusetts Wetlands Protection Act. The disposal of dredged material, as well as the dredging itself, will be required to be carried out using the best available measures to minimize adverse effects on marine fisheries, wildlife habitat, and storm damage prevention or flood control. Protection of this underwater "wetland" habitat is therefore discussed in the context of protection of fisheries and wildlife.

If No Action

If there is no action, the nature of the bottom will not change beyond long-term natural effects such as siltation. There will be no impacts on wetlands

6.1.6 Wildlife

Shorebird Habitats

Shorebird habitat is generally equivalent to tidal flats, and no tidal flats are located in proximity to the preferred alternative disposal sites. The only way that disposal at these sites could impact shorebird habitat is if currents carried turbidity to tidal flats and caused siltation there, but the preferred sites are sufficiently removed from shorebird habitat in Salem so that any effect will be insignificant for any disposal scenario.

Marine Mammals

As discussed in Section 5.1.6.3, the marine mammals of the region, with the exception of the harbor seal, are unlikely to be found in the vicinity of the disposal operations, and will not be affected by any of the alternative scenarios. The sheltered and undisturbed rocky ledges preferred by harbor seals will not be impacted by disposal operations, and seals are very mobile and easily able to avoid the limited area of the harbor impacted by disposal. The fish on which they feed will tend to be most abundant near the rocks and ledges where sport fishing is most productive, rather than near the proposed disposal sites. All alternative disposal sites will have equally little effect on marine mammals.

Reptiles

Sea turtles, the only marine reptiles of the area, are not an important part of the fauna in the Salem area and not normally seen in the harbors. Any effect on the water column from dredge disposal will not extend to the open ocean where these animals live, therefore none of the preferred alternative disposal scenarios will affect marine reptiles.

If No Action

If there is no action, there will be no effect on wildlife, which will probably be no different from the situation if dredging does occur.

6.1.7 Endangered Species

General

As discussed in Section 5.1.7, five whales and two turtles federally listed as endangered occur in the ocean off Salem. These species are not known to occur at any of the preferred alternative sites for dredge disposal, or close enough to be affected by any indirect impacts of the project, such as turbidity or release of contaminants. The project will therefore have no impact on any endangered or threatened species.

If No Action

If there is no action, endangered species would continue a recovery made possible by their protected status. This is the same situation as will occur if the project takes place.

6.1.8 Navigation and Shipping

General

Construction and use of the Proposed Preferred Alternative aquatic disposal site in Salem Harbor would pose minimal impacts to existing navigation and shipping in the harbor. As detailed in Section 5.1.8, existing commercial navigation in the harbor is largely related to receiving of home heating oil and fuel oils and coal to fuel the PG&E Generating Salem Station power plant.

Construction of the Proposed Preferred Alternative aquatic disposal site, located in the turning basin at the end of the federal channel, could result in interference with coal and fuel oil ships as they enter the area of the PG&E Generating dock, and are turned and docked by harbor pilots. Many of these ships are deep draft when fully loaded, and enter the harbor during higher tide conditions to ensure adequate navigation depths. Construction or dredge material disposal activities at the Proposed Preferred Alternative aquatic disposal site during the tidal periods when fuel oil or coal barges are active in the area will interfere with safe navigation of these vessels.

Construction or dredged material disposal activities at the proposed disposal site may also impact navigation of vessels at the New Salem Wharf and its proposed turning basin, which directly abut the existing federal turning basin and the site of the Proposed Preferred Alternative aquatic disposal site. As the design of the New Salem Wharf project is not complete, and the type and number of vessels that may use the wharf is not known at this time, these impacts cannot be identified.

To mitigate these impacts, construction or dredge material disposal activities can be scheduled or suspended when the vessels are navigating the area. Given the relative infrequency of these vessel operations at the PG&E Generating docks, the impact to efficient construction or dredge material disposal activities is expected to be relatively minor. These activities can be undertaken during all tidal conditions at the site, and are not dependent on high tide conditions.

<u>If No Action</u>

If the Proposed Preferred Alternative aquatic disposal site in Salem Harbor is nor constructed and unsuitable dredged material from dredging projects in the harbor are not able to cost-effectively dispose of unsuitable dredged material, maintenance and planned improvement dredging projects may not be undertaken. Historical rates of sediment accumulation will continue and navigation channels and turning basins, marine terminals and marinas and boat ramps in the harbor may eventually silt in and navigation would be increasingly unavailable in the harbor.

Potential direct impacts to existing commercial navigation would be avoided and vessel traffic would be able to travel unobstructed through the existing federal turning basin.

6.1.9 Land Use

There are expected to be no direct or indirect impacts to land use in Salem Harbor as a result of construction or dredged material disposal activities at the Proposed Preferred Alternative aquatic disposal site. The proposed disposal site is an aquatic site, constructed entirely under water and therefore not visible from near shore areas.

Land use in the vicinity of the Proposed Preferred Alternative aquatic disposal site in Salem Harbor is illustrated in Figure 6-5. Land use along the nearest Salem Harbor shoreline is industrial, with the Cargill Petroleum and PG&E Generating Salem Station power plant facilities.

Indirect impacts from the construction of the Proposed Preferred Alternative aquatic disposal site in Salem Harbor are expected to be positive, in that the presence of the disposal site will enable the cost-effective disposal of unsuitable dredged material from harbor dredging projects, maintaining the economic viability of the existing marine facilities and existing land use patterns along the Salem harbor shoreline.

Consistency with Port Plan

Construction of the Proposed Preferred Alternative aquatic disposal site in Salem Harbor is consistent with the stated goals of the Salem Harbor Plan. The presence of the proposed disposal site will encourage the anticipated public and private dredging projects in the harbor to be undertaken and will provide a cost-effective, local disposal option for the unsuitable dredge material from those dredging projects. The Salem

Harbor Plan encourages the DMMP objective of siting a disposal site for the disposal of unsuitable dredged material.

If No Action

If the Proposed Preferred Alternative aquatic disposal site is not constructed, the existing industrial land use in the vicinity of the disposal site will likely remain unchanged for the foreseeable future. Over the long term, if planned private and public dredging projects in Salem Harbor are not undertaken due to the lack of a cost-effective disposal option for unsuitable dredged material, then water side land uses may decline, and possibly changing land use patterns along the Salem Harbor shorefront.

6.1.10 Air Quality / Noise

General

Air quality and noise impacts from the construction of and dredged material disposal activities at the Proposed Preferred Alternative aquatic disposal site in Salem Harbor are expected to be minor, and temporary in nature. Impacts will result from the operation of heavy construction equipment, such as dredges and tugboat engines, and from potential releases of volatile organic compounds and odors from temporary storage of dredged material on barges.

All dredging equipment will be equipped with proper air pollution control equipment and mufflers as required by DEP regulations.

Figure 6-5. Land Use in the Vicinity of the Salem Harbor Proposed Preferred Alternative Aquatic Disposal Site.

Air Quality

Air quality impacts from the construction of the Proposed Preferred Alternative aquatic disposal site is Salem Harbor will be minor and temporary. During construction, operation of the clamshell dredge will result in emissions from the diesel engine of the dredge. These emissions are minimized through the use of proper emission controls on the diesel engine, the use of equipment that complies with emission standards, and by the temporary nature of the activity.

To construct the proposed aquatic disposal site, silts from the harbor bottom must be dredged and temporarily stored on barges or on land until this material is disposed of in the CAD cell. This material is assumed to be unsuitable for unconfined ocean disposal. The construction process for the CAD cell is illustrated in Figure 4-2 in section 4. Depending on the location of the temporary stockpile and the length of time it is necessary to stockpile the material, minor air quality impacts may result. Other factors that determine the degree of air quality and odor impacts include temperature (colder temperatures slow bacteria growth on dredge material and lessen odor impacts), wind direction, and proximity of residential areas.

Odors, primarily as a result of the anaerobic decomposition of organic materials in the dredged sediments, may pose objectionable impacts. This can be controlled, if necessary, with the mixing of lime into the dredged material, neutralizing the odors.

Volatilization of organic compounds in the dredged material may occur if the temporary stockpiling occurs over a period of time sufficient to result in the drying of the dredged material. A covering of water over the dredged material prevents the volatilization of organic compounds in the dredged material. Overall, volatilization is not expected to be a concern as the duration of the temporary stockpiling activities is expected to be minimal, preventing the complete drying of the dredged material stockpiles.

Noise

CAD/OD cell construction and dredged material disposal activities will result in temporary and localized minor noise impacts at the Proposed Preferred Alternative aquatic disposal site location and nearby shore front locations. Given the abutting industrial land use and the distance to residential areas, these impacts will be minor. Use of construction and dredging equipment that is properly equipped with mufflers will reduce the impacts.

The noise levels at nearby shore front locations is expected to be similar to existing noise levels typical of the urban environment, including truck and heavy vehicle traffic. By conducting CAD/OD cell construction and dredged material disposal activities during daytime hours, these impacts will be minimized.

If No Action

If the Proposed Preferred Alternative aquatic disposal site is not constructed in Salem Harbor, there will be no additional temporary air quality, odor and noise impacts in the vicinity of the disposal site.

6.1.11 Historic and Archaeological Resources

Historic Resources

The Proposed Preferred Alternative aquatic disposal site will be constructed entirely underwater in Salem Harbor. This fact, combined with the distance to the nearest significant historic resource, the Salem Maritime National Historic Site, will result in no impacts to historic resources.

Archaeological Resources

Salem Harbor has a long maritime history and the harbor is considered to be an area of archaeological sensitivity. The Proposed Preferred Alternative aquatic disposal site is not located in the vicinity of any known ship wrecks or other underwater archaeological resources in Salem Harbor, see Figure 6-6. In addition, the proposed CAD/OD site is located within the confines of the existing federal navigation channel and turning basin, an area that has been previously dredged. The dredging activities deepened the area, and likely resulted in the destruction of any extant underwater archaeological resources.

Given these factors, it is expected that the construction of the Proposed Preferred Alternative aquatic disposal site in Salem Harbor will not result in impacts to underwater archaeological resources.

If No Action

If the Proposed Preferred Alternative aquatic disposal site in Salem Harbor is not constructed, there would be no further disturbance of the site and therefore no impacts to extant underwater archaeological resources.

6.1.12 Recreation

General

Construction of the Proposed Preferred Alternative aquatic disposal site in Salem Harbor will not directly impact existing recreational areas. The closest recreational area to the proposed CAD/OD site location is Winter Island, which includes the public boat ramp at the mouth of Cat Cove and the popular Waikiki Beach swimming area. Recreational resources in the vicinity of the Proposed Preferred Alternative aquatic disposal site are illustrated on Figure 6-7.

Impacts to both recreational boaters and recreational fisheries resources may result during the construction of the CAD/OD cell and the dredged material disposal operations. Recreational boaters are numerous in Salem Harbor, and the boaters would have to avoid the dredge and dump scows during activities at the proposed disposal site.

Although the proposed disposal site is not located within an area known to be favored by recreational fisherman, it is adjacent to the PG&E Generating Salem Station discharge channel, where recreational fish species are attracted to the warm water. The presence of the dredge equipment used to construct the CAD/OD site and dump scows used for disposal of dredged material at the site may temporarily drive fish away from the area. The temporary duration of these activities and the presence of other nearby recreational fishing areas in the harbor will minimize these impacts.

<u>If No Action</u>

If the Proposed Preferred Alternative aquatic disposal site in Salem Harbor is not constructed, there will be no direct impacts to recreational resources in the harbor. Over time, the lack of a cost-effective disposal site for the disposal of unsuitable dredge material from dredging projects in the harbor may result in the loss of moorings at harbor mooring areas and slips at local marinas or access to public boat ramps, impacting recreational boaters in the area.

Figure 6-3: Known Underwater Archaeological Resources in the Vicinity of the Proposed Preferred Alternative Aquatic Disposal Site.

Figure 6-4: Recreational Areas in the Vicinity of the Proposed Preferred Alternative Aquatic Disposal Site in Salem Harbor.

6.1.13 Economic Environment

Implementation of the preferred aquatic disposal alternative S6-CAD/OD-1 for Salem Harbor is projected to cost approximately $16.5M over the twenty-year planning horizon. The average unit cost over the twenty year planning horizon is $40.50 per cubic yard of material to be disposed. A detailed cost estimate for the preferred alternative is included at the end of Appendix D - Aquatic Disposal Site Data Sheets.

6.2 Upland

The potential impacts from dredged material disposal at the two proposed preferred upland disposal sites are presented below. In order for disposal to occur, the site would need to be engineered and operated in accordance with DEP's Solid Waste Management Regulations. Best Management Practices (BMPs) typically employed at solid waste facilities would also be used at these facilities and additional BMPs would likely be used to specifically handle the dredged material.

Therefore, it is assumed that the following BMPs would be a routine part of the engineering and operation of the facility. The discussion of impacts below assumes that these measures will be employed to minimize impacts to the natural and man-made environment.

- Operation during weekdays and daylight hours;
- Dust control using water trucks;
- Groundwater monitoring;
- Surface water monitoring (if streams, ponds nearby);
- Bottom liners (synthetic or clay);
- Wall liners (for Quarry only);
- A leachate collection system; and,
- Final cover with topsoil and vegetation

Also, the exact footprint and cross-sectional area of the disposal site cannot be calculated at this time, so gross assumptions have been made as to the configuration of the disposal area and any necessary ancillary facilities (access roads, staging areas, etc.).

6.2.1 General

SLM-06 - Bardon Trimount Quarry

The disposal of dredged materials at this site would entail filling a quarry, which is presently active, with sediments. The primary resources of concern would be groundwater, because leaching of contaminants through the fissures in the rock walls is possible if wall-liners fail. Impacts to nearby residential and parks could occur during the transport of sediments, although the neighborhood is already experiencing these impacts because of the existing quarry operation. However, odor and dust generation could increase as a result of disposal and eventual drying of organically-rich sediments.

WSM-01 - Fitchburg-Westminster Landfill

The owners of the landfill are presently applying for an extension of the disposal areas on-site, in an effort unrelated to the DMMP. It is these areas that would be used for the disposal of dredged material on the property. If not filled with dredged sediments, the area would be used to dispose of municipal solid waste, so the area would be impacted by disposal whether or not the DMMP sediments are brought to this site. If the landfill accepts the sediments, however, it loses its capacity to accept the municipal waste, and another disposal option would have to be found for that waste.

6.2.2 Soils and Groundwater

Soil

SLM-06 - Bardon Trimount Quarry

The asphalt batching facility on the Bardon Trimount property already accepts contaminated sediment to be treated, therefore, the effects from transporting contaminated sediment may either already be present or there are protocols and facilities in place to minimize these effects. In either case, efforts would be made to minimize impacts to soil during the transportation of the sediments. Because the sediments would be disposed of in the gravel quarry below grade, it is unlikely that effluent from the disposal area would impact the surrounding soil, but a liner system would be used to protect the ground water.

WSM-01 - Fitchburg-Westminster Landfill

There is the potential that the soil at this site could be impacted both during the transport and after the disposal of the dredged materials. Trucks would likely have to travel across the site, around the present landfill, to reach the extended disposal areas where the sediments would be placed. Care would have to be taken not to spill sediments while on the roads, and during the removal of the sediments from the trucks. The disposal area would be lined, with a drainage system to take away leachate from the sediments, and the soil would be monitored to ensure that there are no breakthroughs in the system.

Groundwater

Groundwater at a disposal site could be contaminated if leachate from the dredged material was allowed to seep into the ground, carrying pollutants below the water table. However, as discussed above, a lining system would be designed to avoid potential groundwater contamination.

SLM-06 - Bardon Trimount Quarry

Groundwater beneath the quarry is not part of a potentially productive aquifer. Even so, the water would be particularly susceptible to being contaminated by the dredged materials, because the sediments would be placed in the quarry, below the water table. An elaborate lining and leachate collection system would be required as a physical barrier to separate the sediments from the ground water. This engineered system would line the walls of the quarry as well as the bottom. Wells surrounding the quarry would be monitored to determine if contaminants have move through the barrier. Further testing of the sediments would be needed to determine the leachibility of contaminants prior to disposal.

WSM-01 - Fitchburg-Westminster Landfill

Dredged materials brought to this site would be placed within a lined landfill facility in order to reduce the risk of any contaminants reaching the ground water. There is an IWPA west of the site, but it is upgradient of the landfill property, so it would not be vulnerable to contaminants from the disposal area. The groundwater would be monitored to ensure that the liners are intact and no contaminants escape to the ground water.

If No Action

SLM-06 - Bardon Trimount Quarry

Once the gravel supply in the quarry is depleted and removal activities cease, it is likely that, for safety reasons, the pits will need to be filled in. If the quarry is filled with clean soil instead of contaminated sediments within a lining system, it is less likely that contaminants could reach ground water through the walls of the quarry. It is probable, however, that there will be requirements that the sediments placed in the quarry meet the same standards as clean soil. In this case, if only clean sediments were brought to the site, there would be no greater risk to the ground water.

WSM-01 - Fitchburg-Westminster Landfill

If the dredged material is not placed in the extended disposal areas at the Fitchburg-Westminster Landfill, the space would be filled with municipal solid waste. If there was a break in the lining of the landfill, municipal waste could release contaminants into the ground water. Moisture is needed to carry the contaminants from the disposed material into the groundwater. The fact that the dredged sediments would likely have a higher moisture content, even after the dewatering process, than the municipal waste means that they would be more likely to contaminate the ground water if the lining system was breached.

6.2.3 Wetlands

SLM-06 - Bardon Trimount Quarry

The remnant excavated pits may qualify as wetlands according to DEP and/or ACE definitions, however, a site-specific wetlands survey would need to be conducted before a determination can be made. Therefore, it is not known at this time if wetlands would be impacted by disposal of UDM in the quarry.

The disposal operation would occur within the quarry pit itself, therefore, none of the perimeter wetlands, such as Thompson Meadows would be affected.

WSM-01 - Fitchburg-Westminster Landfill

Disposal of UDM within the existing footprint of the landfill would not affect wetlands that surround the landfill to the west (Flag Brook) or to the north (Sawmill Pond). Site-specific surveys of any proposed landfill expansion associated would likely require a wetlands survey to verify the presence/absence of wetland resources.

6.2.4 Wildlife

SLM-06 - Bardon Trimount Quarry

Because the site is continuously disturbed by the quarrying operations, there is little wildlife habitat value. Use of the site as a dredged material disposal repository would constitute a similar type and intensity of use, therefore, there should be no significant impact on wildlife in and near the quarry.

Dredged material will contain some amount of benthic organisms that will act as an amended food source for birds, therefore, there could be increased bird activity within the quarry itself.
Gulls would likely be the dominant bird type, as they will congregate around such food sources. Waders, such as herons and egrets, could potentially utilize pockets of water that may develop during the dredged material disposal process. Small mammals could also take advantage of the new food source.

WSM-01 - Fitchburg-Westminster Landfill

Diposal of UDM would not result in any significant impact to wildlife, as the site is already disturbed by the landfill operations. Small mammal and bird activity associated with the existing site will likely continue and, perhaps, increase as a result of UDM disposal. The dredged material contains a host of benthic organisms that would be an amended food source for mammals and birds, particularly in the early stages of disposal. Over the long term, as the UDM piles are scavenged and the food source becomes depleted, bird and mammal activity should decrease.

6.2.5 Endangered Species

General

SLM-06 - Bardon Trimount Quarry

There is rare and endangered species habitat on a small portion of the Bardon Trimount property. This area has probably already been impacted by the industrial activities now on-site, but if it has not been entirely destroyed, it is not likely that it would be further disturbed by the disposal of dredged material within the quarry. The habitat is in the northern portion of the site, close to where the asphalt batching facilities are, but removed from the quarry itself, and the access roads for the quarry are not in the vicinity of the habitat.

WSM-01 - Fitchburg-Westminster Landfill

There are no rare or endangered species habitat within 0.5 miles of the Fitchburg-Westminster Landfill, so there would be no more likelihood of impacting a protected habitat if the dredged sediments are brought to the site.

<u>If No Action</u>

If dredged material were not disposed of at either site, then the status of the rare and endangered species at the Bardon Trimount property would be unaffected.

6.2.6 Land Use

<u>General</u>

In choosing a disposal site for dredged material, it is important to consider the effects of disposal on land uses at, and near the sites.

Land Use in the Vicinity of Disposal Sites

SLM-06 - Bardon Trimount Quarry

On-site, the major impact that the disposal of dredged materials would have is the closing of the quarry. The sediments would be placed in the pits of the quarry, making it difficult to continue removing gravel from the ground. There are undeveloped areas surrounding the quarry that include forests and wetlands, both on and off the property. These lands could potentially host various recreational activities, but due to their proximity to the quarry, they may be impacted by disposal activities already. Odor, noise, and dust produced by the disposal of dredged materials could negatively affect recreational activities at the park immediately south of the property, if proper BMPs, as outlined in Section 6.2.

Depending on the frequency and intensity of truck traffic, there could be increased noise, air emissions, and odor in the residential areas surrounding the site. If the site were to accepts it's maximum capacity (849,400 cy), then approximately 40,000 one-way truck trips would be generated over the next 20 years.

WSM-01 - Fitchburg-Westminster Landfill

There would be no change in the use of the property if dredged sediments were deposited on-site, because there is already a landfill on-site. The Leominster State Forest surrounds the site on three sides, and this vast area is host to many types of outdoor recreation. The disposal of dredged material at the landfill could affect these activities, if odor, dust, and noise become a nuisance. This would likely only affect the areas directly adjacent to the landfill property, because the forest would tend to buffer these effects.

Depending on the frequency and intensity of truck traffic, there could be increased noise, air emissions, and odor in the residential and open space areas surrounding the site. If the site were to accepts it's maximum capacity (282,400 cy), then approximately 14,000 one-way truck trips would be generated over the next 20 years.

Consistency with Port Plan

Both proposed preferred upland disposal sites are outside the geographic scopes of the Port Plan and, therefore, their potential use as dredged material disposal sites neither supports nor is in conflict with these Port Plans.

If No Action

SLM-06 - Bardon Trimount Quarry

Once the quarrying activities cease, the gravel pits will likely be filled as part of the closure plan to make the area safer. If there are no other adverse effects from using the dredged material, filling the quarry with dredged sediments would be mutually beneficial as it would provide a place for 77% of the sediments dredged from the north shore and it would provide fill material for the quarry closure. If dredged material is not used to fill the quarry, then other material such as soil, may be used as fill. Soil would have less odor and potential groundwater quality impacts than dredged material, however, truck traffic to and from the site would be as intense as if the site were used for dredged material disposal. Therefore, the impacts from trucks and other heavy equipment would be similar.

WSM-01 - Fitchburg-Westminster Landfill

The Fitchburg-Westminster Landfill property already has an active landfill, and the area where the dredged material would be disposed of is presently being proposed as a disposal site for municipal waste. Because there are no standards in Massachusetts for the disposal of dredged sediments, they are treated as solid waste. Therefore, the same regulations apply to both the sediments and municipal waste, so the same lined facility would be required for each. The use of the site as a sediment disposal area would not be changing the use of the land, just the material being deposited. The recreational activities in the surrounding forest would probably be affected by both the sediment disposal operation and the present and future municipal waste landfilling operations. Both operations can potentially produce noise, odors, and dust.

6.2.7 Air Quality / Noise

SLM-06 - Bardon Trimount Quarry

The air quality impacts associated with upland disposal at the quarry would involve increase VOC, CO and NO_x tailpipe emissions from trucks unloading the UDM and trucks used to move and grade the UDM once it is deposited in the quarry. Also, increases in particulate matter may result from the release of dried dredged material.

These impacts are occurring at the site today, as quarrying operations are on-going, therefore, the cessation of quarrying activities and the initiation of UDM disposal operations should result in no significant net change in emissions.

Dredged material that is highly organic can often emit a noxiuos odor, however, treatment of the UDM with lime, as per DEP policy, should control any undesirable odor associated with the dredged material.

Sediments containing high concentrations of volatile organic compounds, when exposed to oxygen, can emit these VOCs to the air. The federal agencies that developed the testing plan for sediments to be dredged from the federal channels and the Salem PD sites (i.e. the majority of UDM sediments to be dredged from Salem Harbor) determined that the presence of VOC in the sediment is unlikely, therefore, releases of VOC from the sediment in the quarry would be unlikely.

Noise impacts would be associated with the truck activity, but since these impacts are occurring today, there should be no net increase in noise level or frequency of exposure to nearby residents.

WSM-01 - Fitchburg-Westminster Landfill

Air quality impacts associated with disposal of UDM at the Fitchburg-Westminster Landfill would be similar to those experienced today as a result of solid waste disposal operations. Tailpipe emissions of VOC, CO and NO_x from trucks would occur as well from disposal of UDM.

As discussed above, any potential noxious odor would be mitigated by lime treatment. Potential VOC emissions from the sediment would be minimal due to the lack of VOC in'the in-situ sediment.

Noise impacts would be associated with the truck activity, but since these impacts are occurring today, there should be no net increase in noise level or frequency of exposure to nearby residents.

6.2.8 Historic and Archaeological Resources

General

Historic and archaeological sites and structures could be impacted by being in the vicinity of the disposal of dredged materials. The vibrations of trucks bringing the sediments to the disposal area may disturb structures close to truck routes. Dust created from dryed sediments could become airborne and deposit on nearby historic structures. Increased truck traffic could negatively effect historical tourism through increased road congestion, noise and air emissions.

Disposal Site Historic and Archaeological Resources

SLM-06 - Bardon Trimount Quarry

The quarry on the Bardon Trimount property is a historic site. If sediments are disposed of in it, the pits would be filled and the historic quarry would be buried. There are no known historic buildings associated with the quarry that are included in the historic designation, so it would only be the historic resource of the quarry that would be lost. There is another historic site and two archaeological sites within 0.5 miles of the site. None of these would likely be affected directly by the disposal of sediment at the site.

WSM-01 - Fitchburg-Westminster Landfill

There are no historic sites within 0.5 miles of the landfill property, but the only archaeological site within 0.5 miles is an 18th Century village that abuts to the east. It is 3 miles by 2 miles in size and contains standing ruins. The proposed extension of the disposal area is likely in the southeast section of the property, which is closer to the village than present disposal areas are. Disposal in this new area could potentially have more impact on the archaeological site than previous activities at the landfill. The increased truck traffic on-site could potentially increase vibration, noise and air emissions near the village.

<u>If No Action</u>

SLM-06 - Bardon Trimount Quarry

When the quarry activities end at the Bardon Trimount Quarry, it is likely that the deep pits on the property would need to be filled with some material to remove the safety hazards associated with deep quarries, including the steep walls. This will probably be done regardless of whether or not dredged sediments are used as quarry fill.

WSM-01 - Fitchburg-Westminster Landfill

The proposed disposal areas that would affect the historic village ruins, if approved, will be used whether or not dredged sediment is sent to this site. The increase in truck traffic in this area of the site, and the increased likelihood of air pollution and odors, would be present if either dredged sediments or municipal wastes are placed in the landfill.

6.2.9 Recreation

General

Recreational activities in the vicinity of the disposal of dredged materials could be impacted due to increased truck traffic, nuisance odors, noise, or dust that may be produced during the disposal and drying of sediments at a site.

Recreational Resources

SLM-06 - Bardon Trimount Quarry

A majority of the Bardon Trimount site is listed by MassGIS as Recreational Open Space, and this is mostly where the active quarry is now located. Although this site has this land use designation, it does not function as a recreational area.

There is undeveloped land surrounding the site; Thompson meadows to the north and west, and wooded areas to the south. To the south, the land is considered recreational open space, and the wooded areas have potential to be used for activities such as hiking and biking. The wetlands to the north and west are listed as conservation land and rare or endangered species habitat, and they are potentially suitable for birdwatching and fishing, as well as other passive nature-related activities. These surrounding undeveloped areas could potentially lose some of their attractiveness as recreational areas due to the disposal of dredged materials in the quarry, if noise, odors, or dust become a nuisance. The park to the south of the property contains two baseball fields and tennis courts. The primary impact to the park would be from increased truck traffic during daylight hours.

WSM-01 - Fitchburg-Westminster Landfill

The landfill property is surrounded on three sides by protected open space. This land, the Leominster State Forest, is a recreation and conservation resource. These forested areas are likely to be used for a variety of outdoor activities including hiking and bird watching. Some of these recreational areas could be impacted by the disposal activities, however large expanses of undeveloped forest that surrounds the site would buffer the recreational area against any potential negative impacts such as noise, odor and dust.

Description of Disposal Site Resources

SLM-06 - Bardon Trimount Quarry

The site is mostly barren of vegetation, having been cleared for the quarry and asphalt batching facilities. The primary resource at the site is the gravel being quarried. If the site is used for the disposal of dredged material before the supply of gravel is exhausted, it is likely that access to the resource will be drastically limited.

WSM-01 - Fitchburg-Westminster Landfill

Outside of the landfill area, there are forests on the property that likely provide food, shelter, and breeding opportunities for a variety of wildlife. Extending the disposal area would remove some of this forested habitat. The Flag Brook and the shoreline of Sawmill Pond are also probably home to much wildlife, and increased traffic on access roads that must cross the brook could impact these resources, as well.

If No Action

SLM-06 - Bardon Trimount Quarry

As stated in Section 6.2.9.2, any recreational activities that were enjoyed in the quarry area are now being interrupted by the quarrying. The surrounding recreational areas are probably impacted by the industrial activities on-site, with truck traffic and noise being the most likely problems. A solution to this could be to turn the site into a recreational area, once the quarry activities are complete. Waiting until quarry activities are finished would enable the gravel resources to be used to their potential and the subsequent filling of the pits with clean dredged sediments or other sediments would improve the safety of the site. The property could then be left as a recreational area.

WSM-01 - Fitchburg-Westminster Landfill

Because the property is presently used as a disposal site, and the planned expansion of the disposal area, if approved, would go forward whether or not dredged sediment is sent to the site, it is not likely that there would be a difference in the impacts on the surrounding recreational areas. The forest habitat in the new disposal area would be destroyed no matter what material is disposed of at the landfill. With any disposal activities, it is likely that there will be some interruption of recreational activities nearby. Even so, this would probably remain only a localized problem, because the forests would buffer areas that are not directly adjacent to the site.

6.2.10 Economic Environment

SLM-06 - Bardon Trimount Quarry

The quarry and surrounding area are not tourist attractions, however there are some small neighborhood parks near the site. As these sites are already affected by truck activity associated with the quarry operation, trucks handling dredged material would exhibit the same type of impact such as temporary increases in noise, air emissions, odor.

The transport of sediments dredged from Salem Harbor could have a negative, but temporary, adverse impact if trucks were to travel through active tourist and recreational areas. The truck route chosen will depend on the location of the dewatering site and it's proximity to major streets and highways. At this time, no dewatering site has been identified, so the impact of truck traffic on recreational resources cannot be made. However, if a dewatering site is identified and permitted, then the trucks should be directed to using the limited access highway system as much as possible to avoid recreational and tourist areas.

WSM-01 - Fitchburg-Westminster Landfill

The landfill is not located within a recreational or tourist area. Surrounding land, however, is used for passive recreation. Leominster State Forest and Sawmill Pond are used for hiking and boating. The existing landfill, and potential expansion for dredged material disposal is buffered from these areas by dense forest vegatations, so there should not be any negative impact to recreational activities.

As discussed above, a dewatering site has not been identified, so the possible truck routes for transport of the dredged material to the landfill are not known at this time. If a dewatering site is identified and permitted, then the trucks should be directed to using the limited access highway system as much as possible to avoid recreational and tourist areas.

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SECTION 7.0 - REGULATORY COMPLIANCE

7.0 COMPLIANCE WITH REGULATORY STANDARDS AND REQUIREMENTS

This section includes a description of the primary regulations associated with the implementation of the preferred alternatives. Compliance with state standards and regulation, and federal standards and regulations for both aquatic and upland preferred alternatives. Section 7 also contains an analysis of potential secondary impacts associated with the preferred alternatives.

7.1 Compliance with State Standards/Regulations - Aquatic Sites

7.1.1 Wetlands Protection Act and Regulations (310 CMR 10.00)

The Proposed Preferred Alternative aquatic disposal site, S6 CAD/OD, is located in resource areas protected by the Massachusetts Wetlands Protection Act (WPA), specifically Land Under the Ocean (LUO) and Designated Port Areas (DPAs). The WPA is administered on the local level by the Salem Conservation Commission, which implements the Massachusetts Wetlands Regulations at 310 CMR 10.00. A Notice of Intent (NOI) application to the Salem Conservation Commission will be required for disposal activities. An Order of Conditions will be issued by the Salem Conservation Commission to permit the work.

<u>Designated Port Areas</u>

The main federal channel into Salem Harbor, in which the Proposed Preferred Alternative site S6-CAD/OD is located, is included within the Salem Harbor Designated Port Area. The Wetlands Regulations at 310 CMR 10.26 state that LUO in DPAs is likely to be significant to marine fisheries, storm damage prevention and flood control. LUO in DPAs often serves to provide support for coastal engineering structures such as seawalls and bulkheads, which have replaced natural protection for upland areas from storm damage and flooding. Projects affecting LUO in DPAs should not result in alteration of wave and current patterns so as to affect the stability of such structures.

Construction of the Proposed Preferred Alternative aquatic disposal site, S6-CAD/OD, is not expected to result in adverse effects on marine fisheries caused by changes in water circulation. The bottom elevation at the disposal site following construction of the disposal site, disposal activities and final placement of capping materials, will not be higher than the existing bottom elevation, and will likely be slightly recessed compared to existing bottom elevations. The effect of this recessed pit is expected to be reduced water column mixing with surrounding waters, and active sedimentation within the pit. In addition, the location of the overdredge CAD site within the main navigation channel will also minimize localized changes in water circulation. Navigational channels often experience some degree of reduced mixing via stratification due to temperature or salinity gradients.

Water column depth at the disposal site may play an important role in determining localized current velocities. Current velocities typically behave in a logarithmic relationship with water column depth. Therefore, currents further from the surface experience increasing frictional retardation, particularly as currents approach the sediment boundary layer. Given this phenomena, the channel CAD/OD site will be exposed to smaller current velocities and less potential sediment resuspension forces than sites at shallower depths. Coarser grained cohesive material also has the effect of greater frictional and gravitational forces holding the grains on the seabed. Thus a greater critical shear stress would be required to resuspend coarse grain cap material than fine grain silty sediments.

Reduced circulation may be beneficial from the standpoint of cap integrity since resuspension is less likely, but by the same effect this localized condition may also contribute to reduced water quality. Typically, the impact to water quality from dredged material disposal is short-term. These impacts typically include localized degradation in dissolved oxygen (DO), total suspended solids (TSS), pH, light penetration, and contaminant concentrations. Conditions typically return to ambient conditions within hours to days, depending on the amount, composition, and frequency of the disposed material. Total suspended solids may increase dramatically due to the entrainment of fine material in the water column. A plume typically forms whereby material may be advected short distances from the disposal site. A reduction in DO is typical as common constituents of sediments are oxidized and organic material is metabolized by microbial activity at the sediment-water interface. High suspended solid concentrations have the effect of attenuating ambient light, thereby reducing penetration. Finally, contaminants sorbed to sediment particles may be dissolved by the aquatic environment through physical disturbance of the material as the sediment stream is released from the scow. Modeling of dredged material disposal events will be performed for the FEIR to more conclusively determine short term local water quality impacts.

The Proposed Preferred Alternative CAD/OD site has been located so as to provide a sufficient distance to the nearest coastal engineering structure, the PG&E Generating wharf and the power plant discharge canal bulkhead. The nearest point of the proposed CAD/OD cell is at least 200-feet from the wharf, so as to provide sufficient water depths for vessels moored at the wharf. There is expected to be no impact in the stability of the harbor bottom that would affect the support of the nearby coastal engineering structures, and therefore no adverse effect on the structure's ability to serve a storm damage prevention or flood control functions.

Land Under the Ocean

All areas between the mean low water line and the limit of the municipality's jurisdiction are defined as (LUO) within the Wetlands Regulations at 310 CMR 10.35, "Banks of or Land Under the Ocean, Ponds, Streams, Rivers, Lakes, or Creeks That Underlie an Anadromous/Catadromous Fish Run". LUO is significant to the protection of marine fisheries and projects which affect LUO shall not cause adverse effects by altering the bottom topography so as to increase storm damage or erosion of coastal beaches, banks, dunes, of marshes. They must, among other things, also have no adverse effects on marine fisheries or wildlife habitat caused by alterations in water circulation, destruction of eelgrass beds, alterations in the distribution of sediment grain size, changes in water quality, or alterations of shallow submerged lands with high densities of polychaetes, mollusks, or macrophytic algae.

As described above, the Proposed Preferred Alternative CAD/OD site is expected to have no adverse effect on marine fisheries caused by localized alterations in water circulation, sediment grain size or changes in water quality. The site is not located in or adjacent to existing eelgrass beds.

Any impacts to benthic organisms at the disposal site will be temporary and reversible. Immediately after disposal, the site will be devoid of benthic populations, because the benthos will have been removed by overdredging or buried under disposed sediments.. The existing Organism-Sediment Index at the CAD/OD site is greater than 6, indicative of a healthy benthic environment. However, most benthic species are capable of rapid dispersal and colonization by means of planktonic larvae, and will quickly recolonize disturbed areas. The post-disposal benthic populations at the Proposed Preferred Alternative site may be healthier and more diverse than those existing at present, since contaminated sediments at this in-harbor location will have been removed or buried and the new populations will be growing in the cleaner surface sediments.

7.1.2 Water Quality Certification (314 CMR 9.00)

The federal Clean Water Act gives states the authority to review projects that must obtain federal licenses or permits and result in a discharge to state waters, and requires a 401 Water Quality Certification to ensure that the project complies with state water quality standards and other appropriate requirements of state law. As a project which will require disposal of more than 5,000 cubic yards of dredged material, the DMMP will require a major dredge project certification (BRP WW 07) from the Department of Environmental Protection, Division of Wetlands and Waterways. The application will require a description of the proposed activity, detailed plan view and section, sediment analysis, and description of the characteristics of the proposed disposal site. The DEP may then put conditions on the dredging and disposal process designed to ensure compliance with water quality standards.

Per the provisions of 314 CMR 9.06(1), no discharge of dredged material will be allowed if there is a practicable alternative to the proposed discharge which would have less adverse impact on the aquatic environment than the proposed discharge. As documented in this DEIR, the Proposed Preferred Alternative aquatic disposal site in Salem Harbor is the least environmentally damaging practicable alternative for the aquatic disposal of unsuitable dredged material from the dredging projects in Salem Harbor.

Per the requirements of 314 CMR 9.06(2), the proposed discharge of dredged material will not be permitted unless the "appropriate and practical steps" are taken to minimize potential adverse impacts to land under water. The discharge of unsuitable dredged material and subsequent capping of the material at the Proposed Preferred Alternative aquatic disposal site in Salem Harbor will result in the cleanup and capping of contaminated sediments at the site, and will result in a cleaner harbor bottom.

Per the requirements of 314 CMR 9.06(3), no discharge of dredged material will be allowed in Outstanding Resource Waters. The Proposed Preferred Alternative aquatic disposal site in Salem Harbor is not located in Outstanding Resource Waters, as the water quality classification of Salem Harbor is Class SB, dur tot he presence of combined sewer overflows in the harbor (314 CMR 4.06, Table 28).

As specified in 314 CMR 9.06(4), no discharge of dredged material to vernal pools, Outstanding Resource Waters within 400-feet of a drinking water supply reservoir and other areas designated in 314 CMR 4.06(1)(d), is allowed. The Proposed Preferred Alternative aquatic disposal site in Salem Harbor is not located in any of those areas identified.

Finally, no discharge of dredged material will be allowed, per the provisions of 314 CMR 9.06(7), where the discharge meets the criteria for evaluation as specified above, but would result in "substantial adverse impacts" to the physical, chemical or biological integrity of surface waters of the Commonwealth. As described in this DEIR, disposal of unsuitable dredged material at the Proposed Preferred Alternative aquatic disposal site in Salem Harbor will not result in substantial adverse impacts to surface waters in Salem Harbor.

7.1.3 MGL Chapter 91 (Public Waterfront Act) and Waterways Regulations (310 CMR 9.00)

Dredging activities to create a subaqueous disposal site and disposal of dredge material, involving the subaqueous placement of unconsolidated material below the mean low water mark, requires a waterways permit, under the provisions of the Waterways Regulations at 310 CMR 9.05(2). Regulatory requirements for a Waterways permit are less stringent than those for a Waterways License, required for activities involving fill or structures in tidelands. Dredging activities for purposes such as navigation channels, boat basins, and other water-dependent purposes, and the subaqueous placement of unconsolidated material from those dredging projects below the mean low water mark, is considered a water-dependent project, under the provisions of 310 CMR 9.12(2)(a).

Waterways permits are issued only if certain requirements specified in the Waterways Regulationa at 310 CMR 9.31 to 9.40 are met. Section 9.31 states that no permit shall be issued unless the project serves a "proper public purpose which provides greater public benefit than detriment to the rights of the public" in tidelands. As a water-dependent use project, the construction and use of the Proposed Preferred Alternative aquatic site in Salem Harbor is presumed to meet this standard.

Because the proposed aquatic site requires a Waterways permit, the provisions of 310 CMR 9.32, Categorical Restrictions on Fill and Structures, does not apply. As required under section 9.33, Environmental Protection Standards, construction and use of the proposed aquatic site will comply with the applicable environmental regulatory programs of the Commonwealth, including: MEPA; the Wetlands Protection Act; the Massachusetts Clean Waters Act (MGL c. 21, s. 26-53 and the regulations for Water Quality Certifications, 314 CMR 9.00); Marine Fisheries Laws (MGL Chapter 130); and the Underwater Archaeological Resources

Act (MGL c. 91 and c. 6, s. 179-180 and 310 CMR 22.00).

The Proposed Preferred Alternative aquatic site is not located on private tidelands or filled Commonwealth tidelands and does not need to be determined to comply with the Salem Zoning Ordinance. The Proposed Preferred Alternative aquatic disposal site in Salem Harbor conforms to the provisions of Salem Harbor Plan, in that the construction and use of the site for the disposal of unsuitable dredged material from the dredging projects in Salem Harbor supports the stated goals of the Harbor Plan to encourage identified maintenance and improvement dredging projects in the harbor. The provisions of 310 CMR 9.34, Conformance with Municipal Zoning and Harbor Plans, are met by construction and use of the site.

The provisions 310 CMR 9.35, Standards to Preserve Water-Related Public Rights, are applicable to the proposed aquatic site in Salem Harbor. Construction and use of the disposal site will not interfere with existing navigation. Use of the site will also not significantly interfere with the public rights of free passage over the water, nor will it interfere with access to any city landings, easements or any other form of public access to Salem Harbor. Use of the aquatic site will not significantly interfere with the public rights of fishing and fowling, and being a subaqueous site, will not interfere with on-foot passage, swimming or boating across the site.

Section 9.36, Standards to Protect Water-Dependent Uses, also applies to the Proposed Preferred Aquatic site in Salem Harbor. Construction and use of the aquatic site will result in the preservation of the availability and suitability of tidelands in Salem Harbor which are reserved as locations for maritime industrial uses, such as the PG&E Generating Salem Station power plant, and other water-dependent uses in the harbor. The site is located so that there will be no interference with private access to littoral property from Salem Harbor, or to approach the harbor from the private property. Use of the disposal site will not result in disruption to existing water-dependent uses in Salem Harbor, nor will it displace any existing water-dependent use. The aquatic site does not include fill or structures for nonwater-dependent or water-dependent non-industrial uses which preempt any water-dependent industrial use in the Salem Harbor

Designated Port Area..

The provisions of section 9.37, Engineering and Construction Standards, will be met through the development of a sound engineering design for the disposal site. Construction and use of the proposed aquatic site will not interfere with the ability to perform future maintenance dredging of the main federal channel and the turning basin.

The Proposed Preferred Alternative aquatic disposal site is neither a Recreational Boating Facility nor a Marina, Boatyard or Boat Ramp, therefore the provisions of 310 CMR 9.39 and 9.39 do not apply.

Finally, the provisions of Section 9.40, Standards for Dredging and Dredged Material Disposal, also apply to the Proposed Preferred Alternative aquatic disposal site in Salem Harbor. As the site is located with the Salem Harbor DPA, the prohibition on dredging to a mean low water depth greater than 20 feet in 310 CMR 9.40(1)(a) does not apply. The project also serves a commercial navigation purpose of federal and state significance, allowing the maintenance dredging of the main federal channel. The site has been located so as to avoid shellfish beds, significant fisheries resources, and submerged aquatic vegetation such as eelgradd beds. Dredging activities necessary to construct the disposal site will comply with the operational requirements specified in section 9.40(3), in that the depth of the disposal site will be that necessary to accommodate the anticipated volume of unsuitable dredged material from Salem Harbor, therefore accommodating the navigational dredging needs of the harbor users.

Operational procedures will be established for use of the aquatic disposal site which will meet the intent of the requirements specified in section 9.40(4), Operational Requirements for Dredged Material Disposal and 9.40(5), Supervision of Dredging and Disposal Activity. [incorporate language from Section 9 here]

7.1.4 Coastal Zone Management (301 CMR 21.00)

This project will be required to complete a federal consistency certification for review by the Massachusetts Office of Coastal Zone Management (CZM), describing the project and demonstrating consistency with CZM's program policies and management principles.

The CZM Program Plan establishes program policies which embody coastal policy for the Commonwealth of Massachusetts. Recognition of these statements as Massachusetts coastal policy is formalized in Memoranda of Understanding between CZM and state environmental agencies. Projects subject to federal consistency review must be consistent with CZM program policies. CZM enforces its program policies through existing Massachusetts statutes and their implementing regulations.

In addition, the federally-approved CZM Program Plan lists management principles. These policy statements are not currently enforceable through existing state statutes and regulations. They are published as guidance to proponents of activities in the Coastal Zone and represent the preferred policy direction of CZM.

Program policies cover issue areas such as Water Quality, Habitat, Protected Areas, Coastal Hazards, Port and Harbor Infrastructure, Public Access, Energy, Ocean Resources, and Growth Management. Construction and use of the Proposed Preferred Alternative aquatic disposal site in Salem Harbor involves the CZM policies on Water Quality and Habitat.

Water Quality

Water Quality Policy #1 - Ensure that point-source discharges in or affecting the coastal zone are consistent with federally approved state effluent limitations and water quality standards.

Water Quality Policy #2 - Ensure that nonpoint pollution controls promote the attainment of state surface water quality standards in the coastal zone.

Water Quality Policy #3 - Ensure that activities in or affecting the coastal zone conform to applicable state and federal requirements governing subsurface waste discharges.

Conformance: Use of the Proposed Preferred Alternative aquatic disposal site in Salem Harbor will not be inconsistent with the Water Quality Policies. Disposal of unsuitable dredged material at a subaqueous site is not considered to be a subsurface discharge of waste.

Habitat

Habitat Policy #1 - Protect coastal resource areas including salt marshes, shellfish beds, dunes, beaches, barrier beaches, salt ponds, eelgrass beds, and fresh water wetlands for their important role as natural habitats.

Habitat Policy #2 - Restore degraded or former wetland resources in coastal areas and ensure that activities in coastal areas do not further wetland degradation but instead take advantage of opportunities to engage in wetland restoration.

Conformance: The proposed aquatic site has been located in an area of the harbor which avoids protected coastal resource areas, including subtidal resources such as shellfish beds and eelgrass beds. There are no nearby salt marshes, dunes, beaches or barrier beaches, salt ponds or freshwater wetlands which would be affected by use of the disposal site.

7.2 Compliance with State Standards/Regulations - Upland Sites

7.2.1 Solid Waste Technical Regulations (310 CMR 19.000)

The Solid Waste Management Regulations, 314 CMR 19.00 apply to all solid waste management activities and facilities. While dredged material disposal sites are not specifically listed, it is DEP's position that a facility designed for disposal of dredged material (a.k.a. "monofill") would constitute a solid waste management facility and, therefore, would be subject to the Commonwealth's Solid Waste Management and Site Assignment Regulations.

The Solid Waste Management Regulations specify the permit requirements (19.020), closure schedules (19.022), procedures for review of applications for new facilities or major expansions (19.032), the criteria for review of applications (19.038), and landfill design and operational standards (19.100 - 19.221)

7.2.2 Massachusetts Contingency Plan 310 CMR 40.0000 for disposal of material on contaminated sites; includes anti-degradation policy.

Under Chapter 21E of the Massachusetts General Laws and the Massachusetts Contingency Plan (MCP) at 310 CMR 40.0000, DEP is authorized to address releases, or the threat of a release, to the environment of oil or hazardous materials. Notification thresholds have been established called Reportable Concentrations (RCs) and Reportable Quantities (RQs), which are chemical-specific standards for contaminated media. Only releases that exceed applicable RCs and RQs are subject to the phased assessment and cleanup process described in the MCP. In essence, the MCP delineates the universe of contaminated upland areas subject to DEP's oversight as 21E sites; the areas where releases of oil or hazardous material have come to be located.

In addition to providing for remediation and subsequent reuse of contaminated sites, the MCP also has the goal of preventing the creation of new 21E sites through the "anti-degradation provisions of the MCP (40.0032). This provision essentially prohibits the placement of soil or other media at a 21E site, where the disposed-of soil has higher concentrations than that of the existing soil at the receiving site. Therefore, dredged material would have to: 1) be below the RCs or RQs for all chemicals; and, 2) not further degrade conditions at the receiving site.

7.2.3 Policy #COMM-97-001 Reuse and Disposal of Contaminated Soils at Massachusetts Landfills

This DEP Policy is intended as a guidance document for the regulated community on the resue and disposal of contaminated soils at Massachusetts landfills. The policy does not apply to hazardous waste but it does apply to media that has chemical concentrations above the RCs. Contaminant levels for acceptable soil reuse at landfills are specified. Testing, transport, record-keeping, reporting, landfill operations, and management of treated TCLP soil requirements are summarized in this document.

7.2.4 DEP Interim Policy #COMM-94-007

Because dredged material (i.e. marine sediments) are not specifically mentioned in many DEP laws, regulations and policies, specific procedures for sampling, testing, handling and tracking are needed because of the unique properties of the material. This guidance document deals with proposed disposal at existing landfills and but does not address the requirements for disposal at a dredged material-only "monofill".

7.2.5 DEP Policy #WSC-94-400 Interim Remediation Waste Policy for Petroleum Contaminated Sites

This document represents DEP's interim approach for managing petroleum contaminated soil, and soils from urban and industrialized settings. The goals of the policy are to: discourage the land disposal of petroleum contaminated soils; encourage the use of soil management (treatment) potions to minimize the potential release of VOCs; to facilitate the removal of petroleum contaminated soil from urban and industrialized setting which contain elevated lead levels; direct petroleum contaminated soils which are appropriate for recycling at all permitted soil recycling facilities; and, recognize and affirm that petroleum contaminated soils that exhibit lower levels of TPH and VOCs, with or without elevated metal concentrations, are appropriate and suitable for reuse as daily cover at lined landfills.

7.2.6 Section 401 Water Quality Certification

Section 401 of the CWA allows for states to regulate discharge of pollutants into surface water bodies. Typically, Section 404 CWA permits are not issued by the ACE until a water quality certificate is issued by DEP. Water quality certification is given if the proposed action will not significantly degrade water quality. Any disposal of dredged sediments on land that is in or near a surface water body would need water quality certification.

Massachusetts Water Quality Certification regulations at 310 CMR 9.00 require approval for activities affecting tidelands and certain non-tidal rivers or streams. Any disposal on land that could potentially affect these resources would likely require a permit from DEP under these regulations. Typically, disposal activities affecting fresh water wetland resources are issued Water Quality Certification through the local wetlands permitting process under the state Wetlands Protection Act, as a part of the Order of Conditions issued by the Conservation Commission.

7.2.7 Massachusetts Wetlands Protection Act, M.G.L. c.131, s.40 and Massachusetts Wetlands Protection Regulations 310 CMR 10.00

Under the Massachusetts Wetlands Protect Act and implementing regulations, any alteration of protected wetland resource areas within the Commonwealth must obtain an Order of Conditions from the local conservation commission, and upon appeal of a locally-issued Order, may undergo review by DEP. Permits are issued if the project poses no significant impact to wetlands. Siting of a new dredged material monofill or placement of dredged material at an existing landfill could occur within regulated wetland resource areas and, therefore, a permit would need to be obtained.

7.2.8 DEP Air Pollution Control Regulations, 310 CMR 7.00, for releases of off-gas from alternative treatment technologies

These regulations authorize DEP to issue permits for construciton, reconstruction or alteration of facilities that produce air emissions. Alternative treatment technologies that result in air pollution emissions (e.g. incineration, pyrolysis) would be subject to the requirements of these regulations. If the treatment process is expected to emit 100 tons per year, then Reasonably Available Control Technologies (RACT) must be used to minimize pollutant emissions.

7.2.9 DEP Policy #WSC-94-150 Off-Gas Treatment of Point Source Remedial Air Emissions

This policy is intended to articulate when off-gas treatment of point-source remedial air emissions may be necessary to eliminate significant risks to human health, safety, public welfare or the environment. Alternative treatment technologies that are designed to remove volatile or semi-volatile organic compounds from sediment often have "off-gas" as a product of the process. For example, incineration of PAH and PCB-laden sediments can produce volatile compounds that would be emitted to the air. If such a process were to be used, then the DEP review under policy #WSC-94-150 would apply.

7.2.10 Brownfields Act: Chapter 206 of the Acts of 1998

The “Brownfields Act”, signed into effect on August 5, 1998, establishes new incentives to cleanup and redevelop contaminated sites. The Act provides relief from liability and financial incentives to attract economic development to these “blighted” sites, while ensuring adherence with the State’s environmental standards and policies.

7.3 Compliance with Federal Regulations/Standards - Aquatic Sites

7.3.1 Clean Water Act Section 404(b)(1) Analysis

The Code of Federal Regulations at 40 CFR 230 specifies guidelines for implementing the policies of Section 404(b)(1) of the federal Clean Water Act. The guidelines apply to discharges of dredged or fill materials into navigable waters, and their purpose is to restore and maintain the chemical, physical, and biological integrity of waters of the United States. The guidelines are divided into Subparts A through I. Subpart A is a general discussion of the guidelines. Compliance with more specific requirements is discussed below.

7.3.2 Subpart B - Compliance with the Guidelines

(a) The discharge shall not be permitted is there is a practicable alternative which would have less adverse impact on the aquatic ecosystem, so long as the alternative does not have other significant adverse environmental consequences.

The Alternatives Analysis in Section 4 of this DEIR established that the Proposed Preferred Alternative aquatic site is the least environmentally damaging of the alternatives considered.

(b) No discharge shall be permitted if it contributes to the violation of a state water quality standard, violates any applicable toxic effluent standard or prohibition under Section 307 of the Act, jeopardizes the continued existence of endangered or threatened species, or violates any requirement to protect any federally-designated marine sanctuary. The proposed discharge shall not violate any of these requirements, as discussed in Section 6.1.2.3 (Water Quality) and Section 6.1.7 (Endangered or Threatened Species). The proposed discharge site is more than three miles from the closest point of the nearest marine sanctuary, Stellwagen Bank, and will have no effect on it.

(c) No discharge shall be permitted which will cause or contribute to significant degradation of the waters of the United States. This discharge will not cause such degradation, as explained in discussions of the Subparts C through F.

(d) No discharge shall be permitted unless appropriate and practicable steps have been taken to minimize adverse impacts. Steps which will be taken to minimize these impacts are listed in the discussion of Subpart H.

7.3.3 Subpart C - Potential Impacts on Physical/Chemical Characteristics of the Aquatic Ecosystem

The discharge will not have a significant impact on physical and chemical characteristics of the ecosystem, as discussed in Section 6.1.2. Within this section, impacts on sediments are discussed in 6.1.2.1; impacts on suspended particulates/turbidity and water column impacts are in 6.1.2.3; and current patterns and water circulation in 6.1.2.2. The discharge will have no impact on normal water fluctuations, because the proposed disposal locations are in an open area where they will not interfere with tidal circulation. Since the discharge will not affect circulation and is not near an area where fresh and salt water mix, it will therefore not affect salinity gradients.

7.3.4 Subpart D - Potential Impacts on Biological Characteristics of the Aquatic Ecosystem

The disposal will have no impact on threatened and endangered species, as discussed in Section 6.1.7. There are no benthic endangered species in the area which could be covered or otherwise directly killed, and no habitat for these species occurs in any area influenced by the disposal.

The disposal will not permanently affect fish, crustaceans, mollusks, or other organisms in the aquatic food web. Any benthic organisms affected by disposal will be replaced by recolonizing organisms with aquatic larvae brought in by currents. The dredged material will be capped by clean sediments and therefore the recolonizing organisms will not be affected by toxins or heavy metals. Further discussion of impacts on aquatic organisms is contained in Sections 6.1.3. and 6.1.4.

Other wildlife such as mammals, birds, reptiles, and amphibians will not be affected by the disposal. The subsurface open water disposal will not affect their habitat, and any turbidity during disposal will be temporary. Wildlife impacts are further discussed in Section 6.1.6.

7.3.5 Subpart E - Potential Impacts on Special Aquatic Sites

Sanctuaries and refuges. The proposed disposal sites are in urban harbors and are not in the vicinity of any designated sanctuaries or refuges.

Wetlands. The disposal sites, being in open water removed from shore in an urban harbor, will not affect any wetlands, as defined in these guidelines.

Mud flats. The proposed disposal site is all subtidal and will not affect any intertidal mud flats.

Vegetated shallows. Although eelgrass beds do exist in Salem Harbor, they are far enough removed from the proposed disposal sites so that they will not be affected.

The other two special aquatic sites, coral reefs and riffle and pool complexes, are found only in tropical and subtropical seas and in freshwater streams, respectively, and are not a factor in this project area.

7.3.6 Subpart F - Potential Effects on Human Use Characteristics

As a subaqueous disposal site, this project will have no effect on municipal and private water supplies. The proposed disposal site is not in an area of concentration or important migration or spawning areas for species important in recreational or commercial fisheries. Any impacts to the water column or substrate will be temporary and will have effect on fisheries. Fishery impacts are further discussed in Sections 6.1.3 and 6.1.4.

Water-related recreation activities will not be affected by disposal. Even if disposal is conducted in the limited period of the year when recreational activities take place, turbidity from disposal, the most probable impact, will be temporary and limited in scope.

The disposal of dredged material at the proposed disposal site will have no permanent aesthetic impacts because the subsurface disposal sites will not be visible. Temporary changes in appearance of the water will last no longer than the actual disposal operation.

There are no parks, national and historical monuments, national seashores, wilderness areas, research sites, and similar preserves which could be affected by disposal at the proposed site.

7.3.7 Subpart G - Evaluation and Testing

Thorough testing of sediments proposed for dredging from Salem Harbor has been initiated and will be completed in accordance with all regulatory requirements. This includes physical and bulk chemistry testing, bioaccumulation tests, and evaluation of sediment transport and circulation in the vicinity of disposal sites. These results of the chemical and physical testing performed to date are presented in Sections 3.3.2, 4.6.2, 5.1.2, and 6.1.2 of this DEIR.

7.3.8 Subpart H - Actions to Minimize Adverse Effects

The following actions, among those listed in Subpart H of the Guidelines, will be taken to minimize averse effects from disposal:

- Confining the discharge to minimize smothering of organisms;
- Designing the discharge to avoid a disruption of periodic water inundation patterns;
- Disposal of dredged material in such a manner that physicochemical conditions are maintained and the potency and availability of pollutants are reduced;
- Selecting discharge methods and disposal sites where the potential for erosion, slumping, or leaching of materials into the surrounding aquatic ecosystem will be reduced;
- Capping in-place contaminated material with clean material or selectively discharging the most contaminated material first to be capped with the remaining material;
- Avoiding changes in water current or circulation patterns which would interfere with the movement of animals;
- Avoiding sites having unique habitat or other value, including habitat of threatened or endangered species;
- Timing discharge to avoid spawning or migration seasons and other biologically critical time periods;

7.3.9 Endangered Species Act - Section 7

The project is being coordinated with the National Marine Fisheries Service and the U.S. Fish and Wildlife

Service to determine whether any endangered or threatened species under their jurisdiction may be affected by use of the Proposed Preferred Alternative disposal site in Salem Harbor. To date, staff of NMFS and USFWS have participated in the review of the preliminary aquatic, upland and dewatering site screening processes and have indicated their concurrence with the results of the screening. As the final Preferred Alternative disposal site is selected, CZM will continue to coordinate with both NMFS and USFWS staff in the Section 7 consultation process.

7.3.10 Magnuson-Stevens Fishery Convservation and Management Act (MSFCMA)

The MSFCMA authorizes the NMFS to establish Essential Fish Habitat (EFH) areas. The general purpose of the act is to conserve productive fisheries that provide recreational and commercial benefit. EFH is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" and all of Salem Harbor is classified as EFH.

Under section 305(b) of the Act, coordination between federal agencies is required for any work proposed within an EFH. The intent and procedures of the Act are very similar to the Endangered Species Act (ESA). CZM has been coordinating with NMFS and USFWS in accordance with Section 7 of the ESAs Act as well as the MSFCMA. Correspondence is included in Appendix A.

7.4 Compliance with Federal Regulations/Standards - Upland Sites

7.4.1 CERCLA (42 USC 9601) & SARA (P.L. 49-499)

CERCLA and SARA are two acts that deal with hazardous waste sites that pose risks to human health and the environment. USEPA establishes a national Priorities List (NPL) annually to prioritize those sites that pose the greatest risk. These NPL sites are eligible for federal funding for environmental cleanup. Typically, these sites are the most contaminated sites in the nation and are also listed as "State Superfund" sites. In the case of Massachusetts, they would be termed "21E" sites under the Massachusetts Contingency Plan (MCP).

NPL and 21E sites were excluded from consideration as potential upland disposal sites because of conflicts with the MCP and potential future liability under CERCLA. Salem Harbor UDM would not likely meet the best management practice standards for federal remediation and/or cleanup.

7.4.2 RCRA (42 USC 6901)

RCRA (42 U.S. 6901) is a federal statute enacted in 1976 to ensure that solid and hazardous wastes are managed in an environmentally sound manner. RCRA regulations promulgated by USEPA establish licensing or notification requirements for facilities that treat, store, or dispose of waster, or those who generate or transport waste. RCRA provides the primary federal definition of "hazardous waste" through step-by-step identification.

Dredged sediment would be regulated under RCRA if it were to be disposed of at a new or existing landfill. The testing requirements under RCRA have not been met for the sediments to be dredged from Salem Harbor. Toxicity characteristic leaching procedure (TCLP) tests would need to be conducted to determine if the sediments are classified as "hazardous waste".

7.4.3 TSCA

Toxic Substances Control Act, 40 CFR Chapter I Subchapter R, regulating the disposal of marine dredged sediments with PCB concentrations exceeding 50 parts per billion (ppb).

The Toxic Substance Control Act (TSCA) § 6 requires EPA to regulate PCBs including storage and disposal requirements. The regulations define "disposal" so that virtually any release of PCBs to the environment in concentrations of 50 ppb is prohibited from disposal. The dredged sediment in Salem Harbor does not exceed this 50 ppb threshold and therefore the provisions of TSCA do not apply.

7.5 Secondary Impact Analysis

In order to consider the full range of environmental impacts from the Salem Harbor DMMP, an assessment of potential wetlands impacts from anticipated dredging projects in Salem Harbor has been prepared. Dredging footprints for the eighteen identified potential dredging projects in Salem Harbor were located from reference to Chapter 91 License or USACOE permit records. Facilities which could not be identified from permit records were estimated based on aerial photography of Salem Harbor and professional judgement as to the likely area to require maintenance dredging.

Estimated dredging footprints were overlaid on mapped natural resource and wetlands information to derive the estimated wetland area impacts. As all of the eighteen potential dredging projects are primarily subtidal projects (only four projects had potential interitdal impacts), the principal state wetland resource areas impacted are Land Containing Shellfish and Land Under the Ocean. No salt marsh will be impacted by the eighteen dredging projects.

Federal wetlands impacted are divided into subtidal and intertidal areas. No special aquatic sites, including mud flats or submerged aquatic vegetation, are impacted by the eighteen potential dredging projects.

Total state wetland resource area impacts are presented in Table 7-1, federal wetland impacts are presented in Table 7-2. The location, dredging footprints and resource area impacts are illustrated on Figures 7-1 through 7-5.

Total state wetland resource area impacts are estimated as 971,200 square feet, or 22.3 acres, to Land Containing Shellfish, and 2,252,830 square feet, or 51.7 acres to Land Under the Ocean.. Federal wetland resource area impacts are estimated as 2,252,830 square feet, or 51.7 acres to subtidal wetlands, and 39,000 square feet, or 0.9 acres, to subtidal wetlands.

Table 7-1: Estimated State Wetland Resource Area Impacts from Salem Harbor Dredging Projects

Facility Name	Dredge Volume (cu. yds.)	Land Containing Shellfish (sq. ft.)	Land Under the Ocean (sq. ft.)
Federal Channel - 32 Ft. Channel	110,000	0	1,084,100
Federal Channel - South Channel	53,000	84,600	159,000
South River Redevelopment Project	14,000	0	50,900
Pickering Wharf Marina	3,000	0	18,400
Salem Maritime National Historic Site	5,000	0	3,280
House of Seven Gables - Turners Wharf	5,000	29,000	13,400
Hawthorne Cove Marina	5,000	22,500	17,350
Salem Port Development Plan	540,000	318,150	304,000
PG&E Generating Company	25,300	126,350	126,300
Winter Island Yacht Yard	1,000	70,000	66,300
Winter Island Municipal Boat Ramp	8,000	78,100	67,500
Winter Island Municipal Pier	8,000	60,800	50,400
Kerry Playground	5,000	50,700	32,400
Village Street Landing	5,000	30,600	39,500
Palmer's Cove Yacht Club	8,144	80,000	110,000
State Channel into Palmers Cove	20,000	20,400	110,000
TOTAL	—	**971,200 (22.3 acres)**	**2,252,830 (51.7 acres)**

Table 7-2: Estimated Federal Wetland Impacts from Salem Harbor Dredging Projects

Facility Name	Dredge Volume (cu. yds.)	Subtidal Wetlands	Intertidal Wetlands
Federal Channel - 32 Ft. Channel	110,000	1,084,100	
Federal Channel - South Channel	53,000	159,000	
South River Redevelopment Project	14,000	50,900	
Pickering Wharf Marina	3,000	18,400	
Salem Maritime National Historic Site	5,000	3,280	
House of Seven Gables - Turners Wharf	5,000	13,400	
Hawthorne Cove Marina	5,000	17,350	14,200
Salem Port Development Plan	540,000	304,000	
PG&E Generating Company	25,300	126,300	
Winter Island Yacht Yard	1,000	66,300	
Winter Island Municipal Boat Ramp	8,000	67,500	
Winter Island Municipal Pier	8,000	50,400	
Kerry Playground	5,000	32,400	
Village Street Landing	5,000	39,500	27,500
Palmer's Cove Yacht Club	8,144	110,000	11,500
State Channel into Palmers Cove	20,000	110,000	0
TOTAL	—	**2,252,830 (51.7 acres)**	**39,000 (0.9 acres)**

Figure 7-1: Secondary Impacts

Figure 7-2: Secondary Impacts

Figure 7-3: Secondary Impacts

Graphics to be Provided Under Separate Cover

SECTION 8.0 - DRAFT MITIGATION MEASURES

8.0 DRAFT MITIGATION MEASURES

This section describes the basis for conceptual engineering and a description of construction sequencing associated with the implementation of the aquatic and upland proposed preferred alternatives. Included in the discussion of the construction measures are the steps that need be taken to minimize negative environmental impacts associated with the disposal of unsuitable dredge material in either the marine or upland environment.

8.1 Aquatic Disposal Sites

8.1.1 Conceptual Engineering

To calculate the disposal capacity based upon engineering principles, the Consulting Team developed conceptual engineering drawings based upon the disposing of unsuitable dredged material identified in the Salem Harbor DMMP in a phased manner, corresponding with the Plan's five year planning horizons. The footprints of the Proposed Alternative identified through the site screening process for Salem was used to determine the extent of the disposal area sub-cells by evaluating the depth to bedrock and other operational constraints, the volume was calculated.

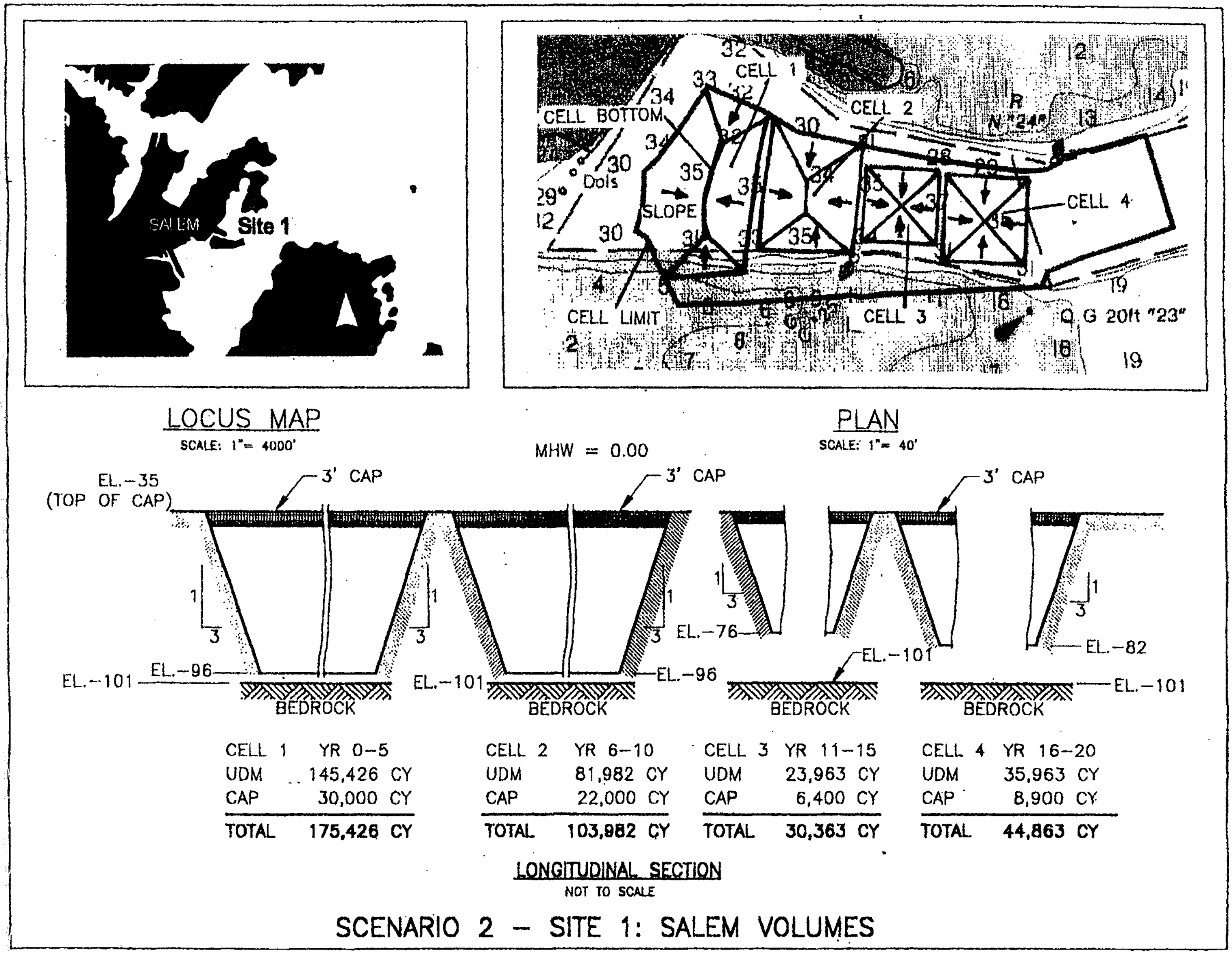
The site capacity calculation was an exercise to determine the extent the predicted disposal volumes would occupy within the preferred alternative sites for various disposal scenarios. The predicted disposal volumes for each of the planning horizons (Years 0 - 5, 6-10, 11-15 and 16-20) would occupy a cell for each planning horizon (4 cells total) within a Preferred alternative site. The geometry of the cell could differ widely, therefore some parameters were used to standardize a disposal cell for comparison purposes. It was also evident that particular shapes were inefficient. The following parameters and guidelines were used to layout the geometry of the cells:

- Each site will remain open for five years at the end of which a 3 foot deep cover of clean fill material will cap the cell.
- The cells shall have side slopes of 3:1 based on federal channel requirements. This may be modified with better geotechnical information on the existing material.
- The maximum depth of a cell will be 5 feet above the average bedrock depth for the site.
- The standard shape of a cell shall be a inverted four sided pyramid where possible.

Sub-cells were sized by a trial and error basis using an average end area calculation method. A polar planimeter was used to determine the area of the top and bottom of slope. The areas were averaged and multiplied by the available depth. Cells were located within the designated preferred alternate area as close to the main channel as possible. Cell sizes varied with the predicted disposal volume for the corresponding planning horizon.

The locations, configurations, and capacities of the disposal area sub-cells for the Proposed Alternative are shown on Figure 8-1.

Figure 8-1: Salem Harbor Conceptual Engineering Graphic for the Proposed Alternative



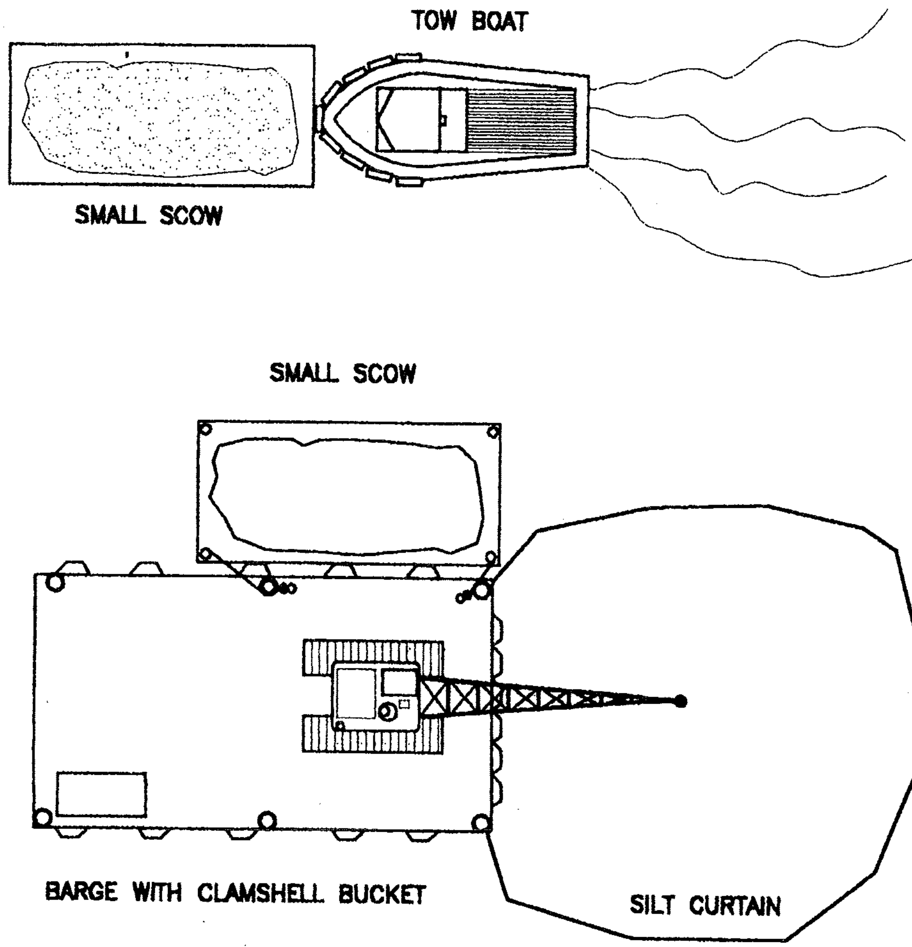
8.1.2 Construction Measures

Prior to the commencement of dredging projects, the construction of the disposal cell needs to be completed. Dredging of the disposal cells will be completed during an environmentally favorable window to reduce the disturbance to marine life. Dredge limits and locations will be located by GPS Geodetic Positioning System, which is a satellite positioning system, accurate to within a foot of the intended horizontal design limits. The dredge machinery will most likely be a large barge mounted crane with a clamshell bucket. Bucket size will likely be in excess of 10 cubic yards. The material will be removed to the intended depth and side slopes. The Dredging contractor will also be compensated for an allowable over-dredge limit to ensure that the intended depths are achieved. The material is removed by a bucket and deposited within a transport barge called a scow. The scow will deliver the material to the Massachusetts Bay Disposal Site where it is positioned prior to dumping using GPS. A bottom dumping or split hull scow will most likely be used. These barges open from the bottom allowing the material to drop out through the water column to the sea floor below. This material is clean and will therefore not need to be capped.

Following the completion of the disposal cell, the dredging of unsuitable material from the harbors will completed by mechanical means, using siltation curtains to minimize turbidity impacts. After being dredged, the unsuitable material will be placed on a dump scow and transported to the disposal cell, where the material will be deposited.

Table 8-1: Key Aquatic Mitigation Measures

Figure 8-2: Aquatic Disposal Site - Typical Mitigation Measures



8.2 Upland Disposal Sites

8.2.1 Conceptual Engineering

Upland Sites

Upland disposal sites used for dredged material will be engineered in accordance with DEP Solid Waste Management Regulations (310 CMR 16.00 and 19.00). Specific minimization measures aimed at protecting groundwater as well as nearby residents are the most critical means of ensuring impact to the natural and human environment. This would be achieved by adherence to minimum setback requirements from residences as per the aforementioned regulations and and from wetlands as per DEP Wetland Regulations.

Low permeability layers (liners) would be installed as base for the disposal "piles" to keep contaminants from entering groundwater. Debris, angular rocks and other materials that could potentially puncture the liner would be removed. Leachate collection systems would be installed, where necessary, to capture leachable contaminants. Other, more specific requirements a per 301 CMR 16.00 and 19.000 would be adhered to as per DEP request.

8.2.2 Construction Measures

Upland Sites

Measures to minimize potential environmental impact caused by construction would be employed if disposal at the Bardon-Trimont Quarry or the Fitchburg-Leominster Landfill were to occur. In Section 6.2, several potential impacts were identified under the various human and natural environment elements. In each case, measures would be taken to avoid or minimize these potential impacts.

Impacts associated with truck traffic (air emissions, noise, traffic congestion) would be minimized by limiting disposal to normal working days and hours. Dust would be controlled by a water truck if sediments become dry.

Potential impacts to sensitive receptors such as recreation areas, tourist areas, cemeteries, etc would be minimized, if possible, be establishing designated truck routes from the dewatering site to the disposal site.

Stormwater and in-situ runoff and leachate control methods will be employed as directed by DEP. These may include the installation of sedimentation basins, erosion control matting and vegetation, silt fences, and hay bales during the disposal operations.

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SECTION 9.0 - DISPOSAL SITE MANAGEMENT PLAN

9.0 DRAFT DISPOSAL SITE MANAGEMENT PLAN

9.1 Monitoring Objectives

The quantification of the perceived or actual short- and long-term impacts of dredged material disposal in Salem Harbor is best addressed through the design and implementation of a tiered monitoring strategy. With the exception of a few aquatic dredged material disposal monitoring programs including New England (DAMOS), Washington (PSDDA), and New York, most have suffered from a lack of clearly defined objectives, testable hypotheses, careful sampling design, statistical rigor, and conclusive results. The tiered approach is based upon monitoring and statistical testing at a series of predetermined levels to ensure compliance with objectives and permitting requirements. The decision criteria are used to create a framework for defensible management decisions and eliminate the tendency for a "shotgun" approach to data collection.

The tiered monitoring approach to dredged material disposal is dependent on rapid data return and analysis in order to most effectively identify and respond to changes in physical, chemical, or biological condition within the disposal site. Although the monitoring program will incorporate data at multiple temporal and spatial scales and of various media (i.e., video, photographs, continuous raster data, point information), it is critical that these data be quickly integrated into digital and written products. Utilization of state-of-the-art decision-making tools such as Geographic Information Systems (GIS) will facilitate the rapid dissemination of spatially-explicit information for decision-making by resource managers.

The monitoring objectives of DMMP address both the engineering aspects of the disposal and capping operations and the environmental impacts of the project. The monitoring program was designed to address the following major objectives:

- Establish an environmental baseline prior to dredging and disposal of the dredged material,
- Establish acceptance guidelines for Water Quality Standards during dredging and disposal operations,
- Evaluate the short-term effects of disposal on benthic habitat quality and marine resources,
- Assess the engineering effectiveness and integrity of the CAD approach cap, and
- Evaluate the effectiveness of the confined disposal method and cap for preventing long-term impacts on biological resources.

Federal testing requirements require that the point of comparison for evaluating proposed discharges of dredged material include a comparison to reference sediment. The use of reference sediment that is unimpacted by previous discharges of dredged material will result in more scientifically sound evaluation of potential individual and cumulative contaminant-related impacts. Reference sediment is generally located outside the influence of previous disposal operations at the dredged material disposal site, but near enough to the disposal site that the reference sediment is subjected to the same water quality and hydrodynamic influences.

There is an important distinction between control and reference sediments when testing for impacts of dredged material disposal. Control sediment is that within which the organisms resided prior to collection in the field or is that within which they were cultured in the laboratory, and serves to confirm the health of the test animals and the acceptability of the test conditions. Reference sediment provides a point of comparison to which benthic effects of dredged material are compared. Results of tests using reference sediment is the key to the evaluation of dredged material.

9.2 Baseline Studies

Although the dredged material disposal siting process in Salem Harbor incorporated vast amounts of information about the physical and chemical properties at the proposed disposal sites, much of this information was either dated, spatially insufficient to provide site-specific details, or lacking temporal resolution. Collection of additional information prior to usage of the designated site is necessary before proceeding to dredging or disposal activities. The baseline study should include the measurement of additional data baseline conditions within each of the harbors, including current velocity, background suspended sediment concentration, and water quality. The measurement of several of the parameters will continue during dredging and disposal activities, but it is critical to quantify ambient conditions prior to the disturbance to provide a comparison with later measurements.

9.2.1 Wave, Current, and Tidal Measurement

Circulation patterns and sediment transport in Salem Harbor have not been well characterized due to limited number of oceanographic studies. In order to develop an understanding of the physical processes influencing the stability of sediments at disposal sites, sufficient monitoring of seasonal and episodic changes in current flow dynamics using long- and short-term instrument deployments are required. The major objective of monitoring activities will be to acquire site-specific data on waves, near-bottom currents and sediment resuspension at various locations within and near the disposal site. For instance, vertical current profile measurements are necessary as input variables into computer models (i.e., STFATE and LTFATE) to predict the fate of dredged material during disposal operations. The collected data will be used to evaluate and predict the potential dredged material resuspension and transport under typical conditions, as well as during storm events. Measurement of critical site-specific data will help determine the potential for propeller wash, the impacts of surface waves at shallow water sites, the frequency and magnitude of storm events, the relationship between wave-height and near-bottom currents, and thereby provide for better estimates of bottom stress as it relates to sediment resuspension.

A suggested approach would be to deploy a bottom-mounted instrument array from a surface vessel and left in place on the seafloor at several locations within the disposal site. The use of an acoustic Doppler current profilers (ADCP) for several days during a maximum tidal phase (spring tides) will provide needed information characterizing local hydrodynamic conditions at the disposal site. It is suggested that one of the ADCPs be upward-looking to provide a profile of current speed and direction in the overlying water column. A second ADCP could be used to measure tidal current speed and direction within one meter of the bottom. The equipment can be deployed with no surface buoy and an acoustically released retrieval mechanism to reduce potential fouling with lobster trawls or anchor lines, although there is a low probability of disturbance to the instruments since fishing activity within Salem Harbor is minimal. The instruments can be recovered after a several day deployment.

The measurement of accurate tidal height measurement is also necessary since it can be used as input to nearshore circulation and tidal current amplitude predictions. Presently all tidal measurements in Salem Harbor are based on predicted estimates from the Boston Harbor tidal gauge, the nearest permanent NOS/NOAA measurement station. More accurate tidal height measurements in Salem Harbor are possible by deploying high resolution pressure sensors at one or more locations to provide vertical control and record tidal height measurements over a 28-day cycle. This information could then be used to predict the tidal component of currents and be correlated to long-term current data gathered from vertical profiles or bottom-mounted current measurements.

9.2.2 Water Quality Monitoring

Historically, waters of Salem Harbor were utilized for the disposal of millions of gallons of raw industrial and domestic sewage, as is typical of many tidal bays and estuaries in Massachusetts, although significant improvements in the marine environment have been evident since the addition of primary treatment (1978) and cessation of sludge discharge (1984) (CDM 1992). Pollution and the subsequent reduction in water quality have been a contributing factor to the disappearance of important commercial and recreational finfish species, as well as the closure or restriction of harvesting from shellfish beds (Jerome et al. 1967). Permitting requirements associated with the operation and expansion of the South Essex Sewage Treatment Center and the Salem Harbor Electric Generating Station and a year-long study conducted by the Massachusetts Division of Marine Fisheries (Chase 1998) have provided the primary characterization of present and past water quality conditions.

However, these programs merely provided a general characterization of conditions within Salem Sound or focused on specific events such as the impacts of thermal discharge or nutrient loading. In order to provide a statistically significant and accurate assessment of water quality impacts as a result of dredged material disposal, a more detailed characterization of baseline conditions at the disposal site is necessary and implementing a monitoring plan that conducts sampling at multiple time scales. The greatest potential change to background water column conditions is likely to occur during periods of high suspended sediment loads immediately following barge disposal. Thus intensive, real-time analysis of water quality conditions needs to be conducted at the time of disposal using both shipboard and stationary sampling instruments.

The data collected at the disposal site will also need to be compared with data collected at a nearby reference site to determine if changes are a result of localized or regional patterns. Water quality measurements should include vertical profiling of total suspended solids, dissolved oxygen, salinity, and temperature. These variables provide sufficient information to gauge the presence of hypoxic or anoxic conditions, the development of a thermocline, and localized hydrodynamic conditions, which in turn may influence water quality conditions.

9.3 Water Quality Standards

The development of water quality standards prior to dredging and disposal actives will provide target baseline conditions, which are not to be exceeded during operations. Failure to meet these standards will trigger mitigation response mechanism to ensure that water quality conditions and marine resources within

Salem Harbor are not compromised. The following criteria are recommended:

- The mixing zone for dredging and disposal or project sediments should be located 300 ft downcurrent from the operations. Both acute and chronic water quality criteria shall be met at this point within the mixing zone with the acute criteria to be met at all times. Acute criteria are defined as the one hour average concentration, which should not be exceeded, more than one every three years on average. Chronic criteria are defined as the four day average concentration which should not be exceeded more than once every three years, except for the PCB chronic criterion which is a 24 hour limit of exposure.
- Exceedence of the water quality criteria shall be attributed to operations when sample concentration down-current from the project operations exceeds the particular standard and the sample concentration is 30% higher than the reference sample. Real-time measurements of DO should be used to measure compliance and failure to meet the standards when there is a statistical difference at a 95% confidence interval between the mean of the reference sample and the mean of the down-current sample. If the samples exceed the water quality standard and this effect is attributed to project operations than repeat samples should be analyzed for TSS and the parameter(s) of concern within 24 hours.
- If two consecutive water samples fail to meet acute water quality criteria the project operants can take the following actions to limit such exceedences: implement pre-approved contingency plan or cease all activities till a suitable alternative is provided.
- If two consecutive water samples fail to meet acute water quality criteria than the following actions shall be implement: work may continue if chronic bioassay tests are conducted within 24 hours or implement and approved mitigation effort.

In the event that compliance with the water quality standards is not maintained, the following bioassay and bioaccumulation tests are recommended:

- Conduct bioassays to monitor disposal of dredged material. Collect water samples during first two days of monitoring, four to six hours after disposal 300 yards downcurrrent from the cell. Conduct two bioassay tests: sea urchin (*Arbacia punctulata*) fertilization and 7 day shrimp (*Mysidopsis bahia*) chronic endpoint studies to assess the biological effects of pollutants that may be present.

- Conduct a bioaccumulation study to assess the long-term impacts of contaminants on blue mussels (*Mytilus edulis*). Deploy caged mussels for at least 60 days at mid water column depth 300 yards from the disposal cell. Analyze mussel tissues for the metals arsenic, cadmium, lead, mercury, and organics (PCBs and PAHs).

9.4 Short-term Water Quality Impacts

9.4.1 Tier One: Acute and Chronic Water Quality Standards

Box 1.1: "Assess Water Quality in Mixing Zone"

The assessment of short-term (hours to days) water quality impacts from disposal activities will require standardized and frequent monitoring during disposal events. The tiered approach also allows for ensurance monitoring to verify compliance to the water quality standards. As shown in the intensive data collection effort for the dredging project in Boston Harbor, exceedances of water quality criteria were rare and are not expected to be a problem for Salem Harbor. The monitoring plan, however, allows for compliance monitoring without additional expense of unnecessary data collection. The following standards are recommended:

- The mixing zone for disposal of project sediments should be located 300 ft downcurrent from the activity.

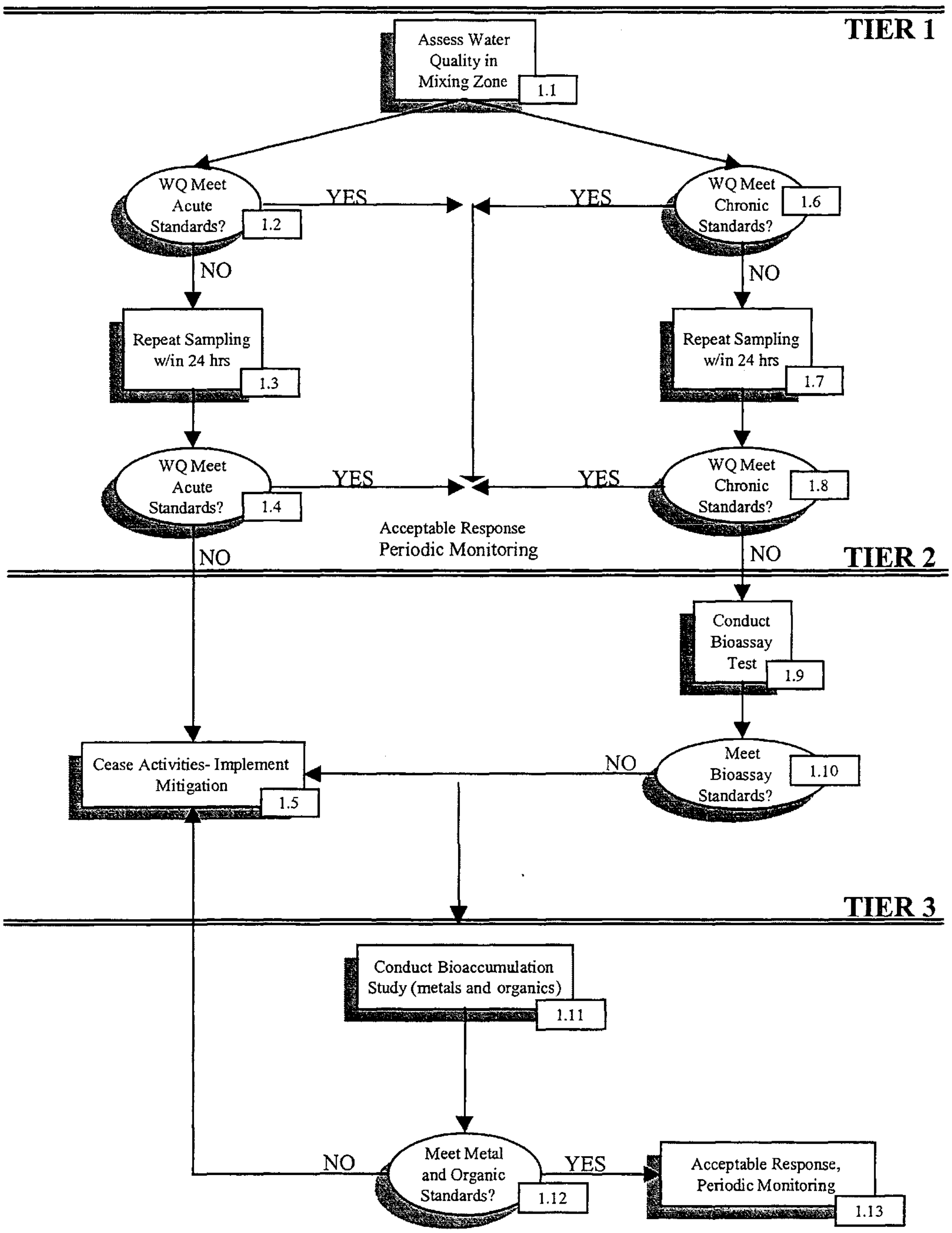

Figure 1: H_o1: Dredging or Disposal Activities have no Short-Term Impact on Water Quality.

- To ensure that water quality standards are maintained, samples should be taken within the downcurrent turbidity maximum; use of instrumentation capable of real-time display of the plume extent is recommended. Use of a transmissometer can provide a depth profile of light transmittance or turbidity values. This instrument provides the capability to generate turbidity contour plots showing the areal extent and concentration.

- Suspended solids should not exceed 25mg/l over background levels at 25 m from the operation when ambient levels are lower than 100 mg/l.

- Turbidity should not exceed ambient levels by more than 30% at 25m from the operation.

- Plume samples should be taken at 0.5 and 1.0 hours, and four and six hours after the disposal at a location 300 feet downcurrent from the cell. Samples should be obtained from within 3 feet of the harbor bottom and from the mid-water column. These samples can either be combined or depth integrated. The first set of samples will be used to determine if acute criteria are met and the second set to determine whether chronic criteria are met.

- Acceptable locations for reference samples include a point 1000 ft upcurrent of the disposal cell, a point 300 ft downcurrent from the disposal cell prior to disposal, or some other pre-approved location.

- Water quality monitoring and analysis should be conducted during the first five days of disposal.

Box 1.2 and Box 1.6 "Water Quality Conditions meet Acute and Chronic Standards"

Acute criteria are defined as the one hour average concentration which should not be exceeded more than once every three years on average. Acute criteria should be met within the mixing zone at all times. Chronic criteria are defined as the 4 day average concentration which should not be exceeded more than once every three years, except that the PCB chronic criterion is a 24 hr limit of exposure.

Box 1.3 and Box 1.7 "Repeat sampling within 24 hrs."

If samples fail to meet water quality standards, than repeat samples should be obtained within 24 hrs under similar conditions. The repeat samples should be analyzed for the parameter(s) of concern and TSS.

Box 1.4: "Water Quality Conditions meet Acute Standards"

If two consecutive water samples fail to meet the acute water quality criteria than either a pre-approved mitigation measure must be implemented or all disposal activities should cease within the effective area till further notice.

Box 1.8 : "Water Quality Conditions meet Chronic Standards"

If two consecutive water samples fail to meet chronic water quality criteria the following action should be implemented: work may continue if chronic biossay tests are conducted within 24 hours or mitigation controls are implemented.

9.4.2 Tier Two: Bioassay Testing

Box 1.9 "Conduct Bioassay Test"

Conduct sea urchin fertilization test and seven-day *Mysidopsis bathia* (shrimp) test according to EPA protocols for chronic endpoints. The results of the biological test should be considered as more significant than the water quality criteria in determining any operational mitigation measures to be required.

Box 1.10 "Meet Bioassay Standards"

Failure to meet Chronic bioassay standards will require all disposal activities to cease or implementing pre-approved mitigation controls.

9.4.3 Tier Three: Bioaccumulation Testing

Box 1.11 "Conduct Bioaccumulation Study"

Should continued concern over water quality impacts result from the first two tiers, conduct a bioaccumulation study for the contaminants of concern by deploying caged blue mussels (*Mytilus edulis*) at mid-water column depth within approximately 1000 ft of the disposal area for at least 60 days.

Box 1.12 "Meet Metal and Organic Standards"

Failure to meet bioaccumulation standards will require all disposal activities to cease or implementing pre-approved mitigation controls.

Box 1.13 "Acceptable Response, Periodic Monitoring"

Meeting the bioaccumulation standards will be considered an acceptable response. Disposal can continue with periodic water quality monitoring during events.

9.5 Verify Isolation of Sediment Contaminants

9.5.1 Tier I: Biological Processes

Box 2.1 "Verify Dredged Material Successfully Placed"

Physical monitoring of the disposal site plays an important function of ensuring that contaminated dredged material is correctly placed in the disposal cell or on a mound. The combination of a navigational dredged material disposal monitoring system, precision bathymetry, and acoustic imaging must be performed at the completion of the disposal activities to verify that the dredged material has been contained in the CAD cell. For example, periodic bathymetric surveys were effective in determining the presence of dredged materia

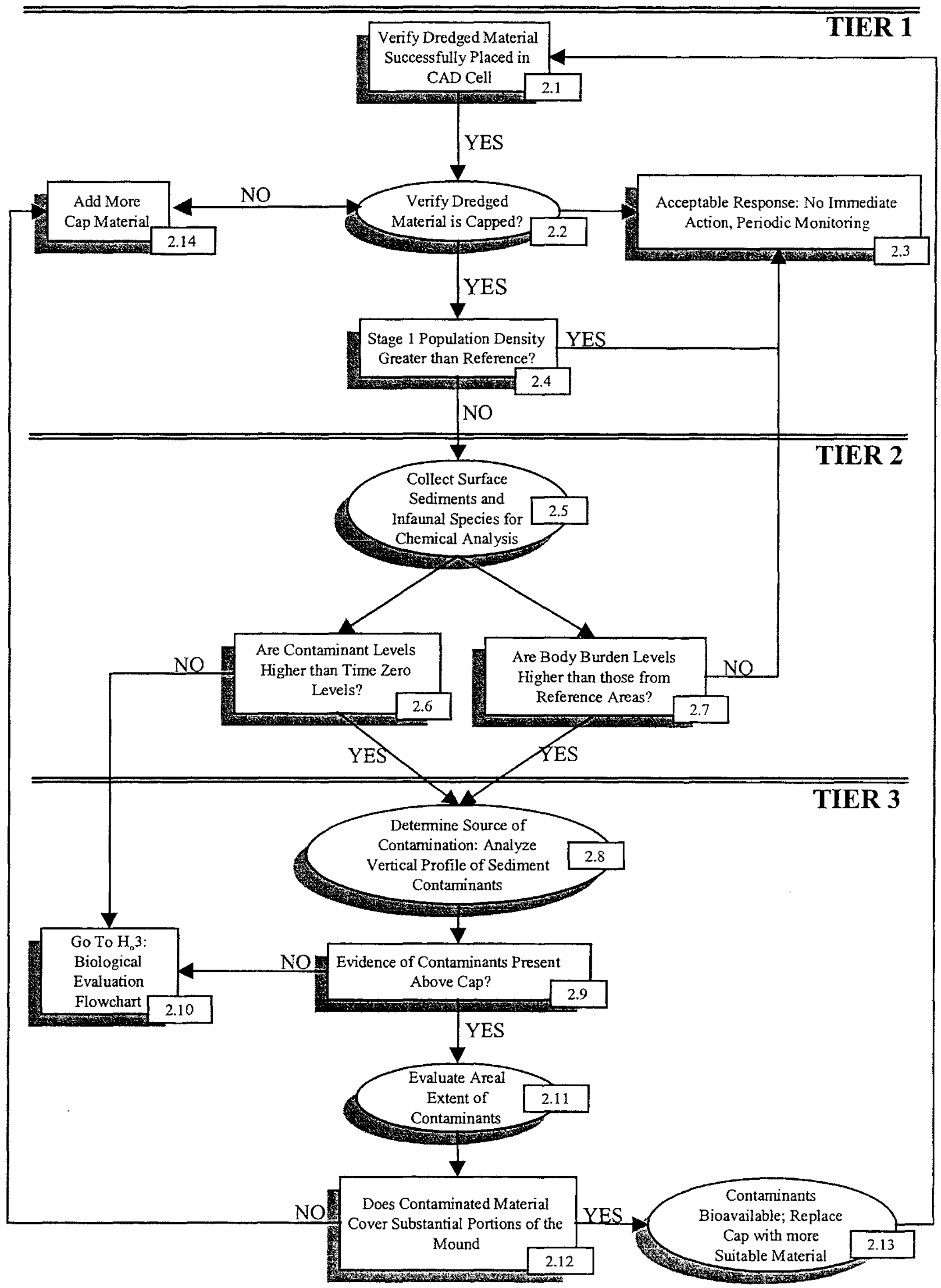

Figure 2: H_o2: Capping has Isolated Sediment Contaminants Effectively.

1 outside of the CAD cell in the Boston Harbor project; the material was re-dredged and placed in the cell. The occurrence was useful in determining what height the dredged material could reach in the cell before sediment could potentially end up on the seafloor outside of the cell.

Box 2.2 "Verify Placement of the Cap"

During cap placement, vessel monitoring (position, draft) data should be used to help establish where the cap material is placed during capping operations. Following cap placement, physical monitoring is conducted to verify complete coverage of the dredged material. This evaluation typically involves the combination of a precision bathymetric survey and sub-bottom profiling to verify depth of the cap material, along with sediment cores to measure cap thickness at individual points. Experience from the Boston Harbor project showed that the cap will have a layer of ambient fine-grained sediment that settles after the cap is placed. A minimum thickness of this material should be anticipated, but the majority of the dredged material (90%) should be contained under the cap layer.

Box 2.3 "Add More Cap Material"

If the dredged material is insufficiently covered with capping material, further capping operations are necessary until satisfactory containment is reached. Once the recapping has been completed, the disposal site is revisited to assess whether the dredged material is sufficiently covered. If recapping is successful, trend monitoring begins (Box 2.4)

Box 2.4 " Stage 1 Population Density Greater than Reference?"

The introduction of disposal material represent the introduction of organically-rich sediment material free from competition is typically recolonized to ambient species composition and densities within a short duration. The exceptions to this trend would include physical disturbance from erosion and scouring or the presence of contaminated material. Assessment of Stage 1 organisms at the disposal site should be conducted with a sediment profile imaging camera. The null hypothesis being tested is: H_o- The population density of opportunistic polychaetes at the disposal site as detected by the sediment profile imaging camera is not significantly less than that on the ambient seafloor outside the disposal site boundary. A reference site outside the disposal area should be selected with a similar species composition, within comparable water depth, and similar sediment type to compare with disposal site data. A significantly lower null hypothesis would lead to Tier II testing (Box 2.6). Acceptance of the null hypothesis would lead to Box 2.5

Box 2.5 "Acceptable Response: No Immediate Action, Periodic Monitoring"

Results indicate that the integrity of the cap has not been compromised indicating an acceptable response. Periodic annual monitoring would continue during mid to late summer, but with no other action required.

9.5.2 Tier II: Surface Sediment Chemical Profiling

Box 2.5 " Collect Surface Sediments and Infaunal Species for Chemical Analysis"

In the absence of physical disturbances, failure to recolonize represents the strong possibility of bioavailable contaminants present at the surface of the CAD cell. Samples of the sediment and representative species are collected from the disposal site and reference area. The dominant fauna are determined by collecting and sieving the sediment. Contaminant analysis is conducted on the tissue of the collected organisms, typically either a polychaete, large bivalve, or common amphipod. Once sufficient biomass of the target species are collected, it is frozen and shipped the laboratory for analysis. The null hypothesis regarding the tissue concentration is: H_0- Infaunal tissue contaminant levels are not higher at the disposal site than those on the ambient seafloor.

Box 2.6 " Are Body Contaminant Levels Higher than Time Zero Levels?"

Box 2.7 " Are Body Burden Levels Higher than those from Reference Areas?"

Both Box 2.6 and 2.7 are conducted simultaneously, though the numerical sequence of the collection is unimportant. Sufficient biomass of the target species are frozen immediately after the collection and shipped to the laboratory for analyses. Because of the expense associated with bioaccumulation studies, the number of samples analyzed is typically small (three replicates from the disposal site compared with three replicates from the ambient seafloor). Rejection of the null hypothesis would trigger testing at Tier 3 Box 2.8.

9.5.3 Tier III: Vertical Sediment Chemical Profiling

Box 2.8 "Determine Source of Contamination: Analyze Vertical Profile of Sediment Contaminants"

If there are contaminants present in the surface sediments at high enough concentration to cause bioaccumulation, it is likely that material has not been from sufficiently contained below the cap. Collection of coring samples can be used to measure the vertical contaminant gradient from the ambient surface sediments, through the cap material, to the underlying dredged material.

Box 2.9 "Evidence of Contaminants Present Above the Cap?"

Should the cores indicate that there is contaminated material at the surface of the cell that originated from below the cap, this suggests significant cap failure.

Box 2.10 "Go to H_o3: Biological Evaluation Flowchart"

If core analysis shows no evidence of contaminant migration through the cap, then a further estimation of the marine resources should be conducted to determine the conclusive impacts that can be identified.

Box 2.11 "Evaluate Areal Extent of Contamination"

Using the methods to establish cap presence (Box 2.2) along with the coring data from above, the areal extent of the contaminated sediments should be measured to establish the areas most in need of additional cap material. Results from this study may indicate whether new material has been deposited on the site, an errant disposal event occurred, or large-scale failure of the cap occurred.

Box 2.12 "Does Contaminated Material Cover Substantial Portions of the Cap"

If the survey data collected above indicates that contaminated material has migrated through the cap in substantial portions of the disposal site, than mitigation efforts will be necessary to prevent further bioavailability of contaminants.

Box 2.13 "Contaminants Bioavailable; Replace Cap with more Suitable Material"

The existing cap will need to be enhanced, based upon the results of the origin of the cap failure. For example, the cap may need to be enhanced with a coarser grain size sediment, which is less prone to erosion. It may also be necessary to increase the depth of the cap material to provide a buffer and greater insurance against future cap failures.

9.6 Long-term Impact on Biological Resources

9.6.1 Tier I: Physical Containment of Dredged Material

Box 3.1 : Assess Population Density of Stage 1Organism"

Typically, disposal sites are well populated by pioneering polychaetes within 1-2 weeks following completion of disposal operations. Disposal activities are usually scheduled during winter and early-spring to avoid impacts to reproduction and recruitment dynamics of marine and invertebrate species.

Box 3.2 "Stage 1 Population Density Greater then Reference Site"

The population of pioneering polychaetes should converge with the ambient bottom after a period of two years or more, depending on the sedimentation rate within the CAD cells. The densities of tube worms can be compared with mean densities from an appropriate reference stations located outside the designated boundaries of the disposal sites. The selection of a reference area should include the following factors: a similar sediment type as the disposal site cap, comparable water depths and water quality conditions, and a similar community structure as that of the disposal site prior to activities.

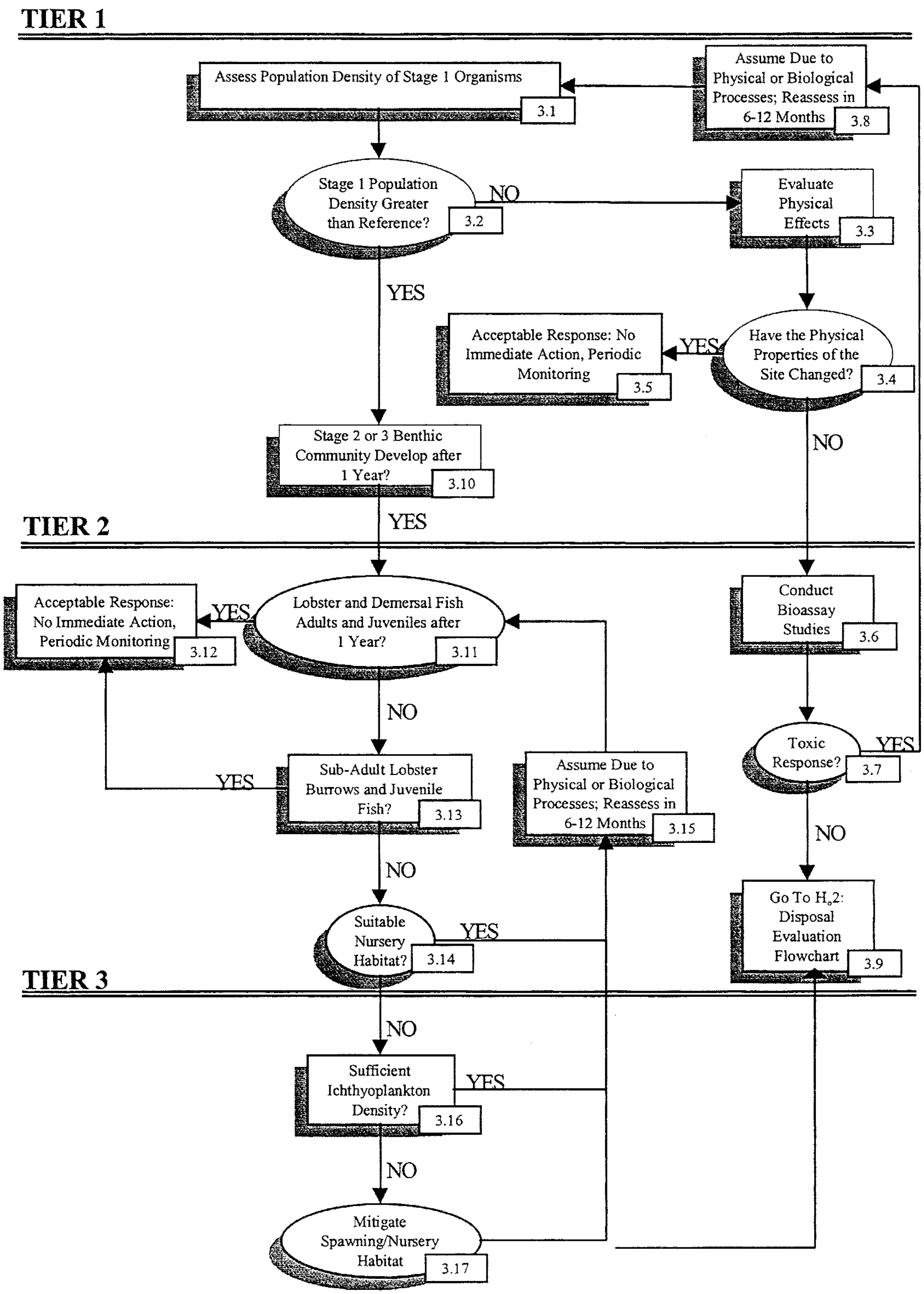

Figure 3: H$_o$3: Dredging or Disposal Activities have no Long-Term Impacts on Biological Resources.

Box 3.3 "Evaluate Physical Effects"

The detection of anomalous rates of colonization at the disposal site are typically attributed to physical or chemical properties of the dredged material.

Box 3.4 "Have the Physical Properties of the Site Changed"

Sediment erosion and scour or differences in sediment material may cause anomalous recruitment patterns at the disposal site that may disrupt larval colonization.

9.6.2 Tier II: Recovered Adult and Juvenile Marine Resources

Box 3.5 "Acceptable Response: No Immediate Action Necessary, Periodic Monitoring"

If the anomalous recolonization is due to a physical event, no immediate mitigation is warranted.

Box 3.6 "Conduct Bioassay Studies"

If the anomalous recolonization is not due to a physical event, additional bioassay analysis as discussed above (Box 1.9).

Box 3.7 "Toxic Response"

If the bioassay results in a toxic response, the data indicate a potential problem with the containment of the material.

Box 3.8 "Assume Due to Physical or Biological Processes"

If the bioassay results show no toxic response, the anomalous benthic results are most likely due to natural environmental conditions.

Box 3.9 " Go to $H_0 2$ Disposal Evaluation Flowchart"

If the bioassay results in a toxic response, the data indicate a potential problem with the containment of the material. The H_o2 (Effective Sediment Isolation) Flow Chart must be re-visited.

Box 3.10 "Stage 2 or 3 Benthic Community Develop after 1 Year"

Experience from prior monitoring events have shown that dredged material recolonizes to a more mature benthic habitat within 1-2 years. Using the REMOTS® camera, the benthic community can be compared to the reference station and evaluated for long-term benthic habitat.

Box 3.11 "Lobster and Demersal Fish Adults and Juveniles after 1 Year"

Although a healthy benthic community has traditionally been acceptable information to suggest a healthy environment, direct sampling of the fisheries at the disposal site can be used to evaluate potential long-term impact. These data need to be collected over several seasons and analyzed with caution due to the temporally and spatially variable nature of fisheries data.

Box 3.12 "Acceptable Response: No Immediate Action, Periodic Monitoring"

The presence of benthic fisheries would suggest no unacceptable impact from the disposal cell.

Box 3.13 "Sub-adult Lobster Burrows and Juvenile Fish"

If the lobster and demersal fisheries data show a paucity of numbers, additional information on different life stages of these species should be collected.

Box 3.14 "Suitable Nursery Habitat"

The lack of juvenile fish might indicate that the habitat at the CAD site is no longer productive as a fisheries resource. This information would trigger more evaluation in Tier 3.

Box 3.14 "Assume Due to Physical or Biological Processes"

If the juvenile fish data indicate acceptable nursery habitat, the lack of both adult and juvenile fisheries at the site may be due to natural environmental processes, and additional data should be collected within a year, potentially during a different sampling season.

9.6.3 Tier III: Recovered Spawning and Nursery Habitat for Marine Resources

Box 3.16 "Sufficient Icthyoplankton Density"

An icthyoplankton survey should be collected to further assess the use of the CAD site as acceptable spawning and nursery habitat for benthic fisheries.

Box 3.17 "Mitigate Spawning/Nursery Habitat"

If all of the data collected indicate that the CAD site, as compared to reference, has been negatively impacted by the dredging and disposal operations, a mitigation plan must be implemented. These data would indicate that the material has not been contained effectively, and that the site would have to be reassessed relative to the contaminant isolation flowchart (Figure 2).

9.7 Description of Monitoring Techniques

This section provides a brief descriptions of various oceanographic techniques suggested to achieve the monitoring objectives and explains how could be utilized to address specific questions associated with the disposal of dredged material in coastal embayments.

Disposal Tracking

Verification of the location and timing of dredged material disposal is a critical component of monitoring efforts. A suggested approach to disposal tracking are capabilities provided by the Automated Disposal

Surveillance System (ADISS). For instance, ADISS provides fully automated tracking of disposal scow positions and draft level information using highly accurate differential GPS and pressure sensors during the loading, transit, and disposal phases of dredging operations. The disposal tracking equipment consists of an electronic box, battery, and antennas can be easily installed onto one or more disposal scows. The instrumentation records the trackline of the scow navigation path, position of the released dredged material based on changes in vertical measurement of the scows position, and uplinks the data via ARGOS satellite for easy retrieval. These data can then be automatically updated and displayed via the internet using a Geographic Information System. By recording the precise locations and timing of disposal positions when placing dredged and cap material, ADISS data will increase the accuracy of cap material placement.

Sediment-Profile Imaging

REMOTS® technology is a combination of sediment-profile imaging and computer image analysis. It is a means of rapidly obtaining low cost reconnaissance mapping information about physical and biological seafloor processes (Rhoads and Germano 1982; 1986). The REMOTS® hardware consists of a wedge-shaped optical prism having a camera (sensor) mounted horizontally above in a watertight housing. The prism is shaped like an inverted periscope, with a clear Plexiglas window and an internal mirror mounted at a 45° angle to reflect the image in the window up to the camera. The entire assembly is lowered to the bottom using a standard winch mounted aboard the survey vessel. Upon contact with the bottom, the prism descends slowly into the seabed, cuts a vertical cross-section profile of the upper 15 to 20 cm of the seabed, and a photo is taken. The camera normally is raised and lowered multiple times at each sampling station to obtain replicate images. Because the photographed sediment is directly in contact with the prism window and light is provided by an internal strobe, turbidity of the ambient seawater is never a limiting factor. Typically, 100 to 200 images can be obtained in a single survey day (i.e., three replicate images obtained at roughly 30 to 70 stations).

In the laboratory, a suite of physical and biological parameters are measured directly from the film negatives using a video digitizer and computer image analysis system. Proprietary SAIC software allows measurement and computer storage of data on 21 different variables for each REMOTS® image. The measured parameters include sediment grain-size major mode and range, prism penetration depth (a relative measure of sediment shear strength), boundary roughness as measured from small-scale topographic relief (e.g., ripples, faecal mounds), depth of the apparent redox potential discontinuity (RPD), surface mud clast number and diameter, thickness of dredged material or other depositional layers, linear density of tubicolous fauna at the sediment-water interface, depth and number of subsurface feeding void structures, and designation of infaunal successional stage. Complete image analysis, interpretation, mapping and reporting can be accomplished within 1 to 4 weeks, depending on the size of the survey.

REMOTS® has proven to be an effective tool for addressing the monitoring objectives of several dredged material disposal projects (SAIC 1998). The REMOTS® information on physical sediment characteristics and biological activity has been useful for assessing benthic habitat quality both prior to and following the disposal and capping operations . REMOTS® has also facilitated monitoring of the recolonization of the capped mound by benthic organisms following placement of the sand cap. In addition, REMOTS® can be used to detect and map depositional layers of disposed project material occurring on the mound apron in layers too thin to be detected using high-resolution bathymetric techniques. For instance, this information on the disposal mound "footprint" was used to ensure that all of the dioxin-contaminated dredged material was covered with clean capping material and thus isolated from the overlying water column at the New York Mud Dump Site (SAIC 1998).

Subbottom Profiling

Subbottom seismic profiling is a standard technique for determining changes in acoustic impedance below the sediment/water interface. In a seismic profiling survey, the vessel is driven over the seafloor along consecutive lanes in a manner similar to that used for bathymetric surveys. Penetration of sound in sediment is both a function of system frequency and the impedance contrast between the water column and sediment. In general, sound penetrates further into fine-grained sediment because the impedance of silt and clay with a high water content is closer to that of the water column. Sediments having different geotechnical characteristics (i.e. bulk density) will have distinct acoustic impedance, and therefore sound will reflect from the boundary between layers of sediment having different densities. This digital information collected via subbottom sampling can be used to identify depth to bedrock, and therefore potential containment capacity of the site, and for verifying the thickness and distribution of the cap material.

The presence of subbottom reflectors depends on changes of acoustic impedance between the water column and the sediment (first bottom reflector), and between subbottom layers of different lithologies. In general, the basement reflector is a dark (high amplitude) subbottom reflector because of the acoustic contrast between the basement rock and overlying sediments. The chirp was used because the higher frequency signal has a shorter wavelength that allows information to be collected at a greater resolution, although this system is usually more limited in depth of penetration. The lower frequency bubble pulser is emits a longer wavelength signal which penetrates deeper into the sediment. These two sediment profiling instruments are commonly used in tandem to provide a greater range of depth penetration, and therefore an extra level of confidence in selecting and digitizing the basement reflector.

Following the survey, the acoustic reflectors are digitized and the thickness of each layer calculated. Gridded data of layer thickness are used to produce isopach maps of cap and dredged material thickness. The thicknesses obtained from the subbottom survey can then be compared with those calculated from sequential bathymetric surveys to determine depth and distribution of the cap material.

Geotechnical and Chemical Analysis of Sediment Cores

Geotechnical surveys are generally performed as part of a dredged material monitoring program to obtain sediment core samples at stations located on and around the disposal site. Vibracorer systems (which employ a motor to "vibrate" the core into the sediment) are used for sediment core analysis because they are capable of obtaining long, relatively undisturbed cores from the coarse-grained sand cap, while conventional gravity corers (which rely on weight alone to push into the sediment) are incapable of penetrating to the desired depths. The cores provided a vertical section of both the sand cap and the underlying, fine-grained dredged material at a single location. Visual observations and geotechnical analyses of these vertical sections enable assessments to be made of sand cap thickness and stability through time, while chemical analyses enable a determination of cap effectiveness in isolating underlying contaminants.

It is proposed that for each coring survey, a vibracorer will be used to obtain cores up to 3 m in length at stations within the project capping area. In general, a three-point anchor system is used to prevent the vessel from drifting during coring operations. All cores should be stored horizontally and refrigerated in an enclosed storage container throughout the core collection, transport, geotechnical and chemical sampling phases. In the laboratory, each core will be split longitudinally. One half-section is to be used for detailed core description and chemical sampling, and the other half is to be photographed and processed for geotechnical testing.

The chemical analyses should include contaminants of concern in the project material. Samples for geotechnical analyses will also be collected from both the sand cap and underlying dredged material. The geotechnical analyses will include measurements of sediment grain size, water content, bulk density, specific gravity (grain density), Atterberg limits and shear strength.

Macrobenthic Analysis

Although the overall response of benthic infaunal populations to disposal activities can be assessed using REMOTS® imaging, ground-truthing of REMOTS® results and more detailed information about benthic community structure including dominant species, diversity, and population density and abundance is primarily obtained through traditional benthic sampling and processing of invertebrate populations. Grab samples are typically collected and analysed when assessing soft bottom infaunal communities, as is present at the dredged material disposal and reference site within Salem Harbor. Benthic stations are commonly sampled using a 0.1 m^2 Smith McIntyre grab sampler. Three grab samples are collected per station, sieved through 0.5 and 1.0

mm screens, and preserved in 10% buffered formalin.

Laboratory analysis consists of sample transfer to alcohol, Rose Bengal staining, and sorting to major taxonomic groups (e.g,. crustaceans, polychaetes, mollusks, nemerteans). Following initial sorting procedures, each organism is counted and identified to the lowest practical taxon (typically to the species level) by taxonomic specialists. Taxonomic identification is then loaded into a database and evaluated using a variety of statistical procedures (e.g., Analysis of Variance and multivariate techniques such as principal component analysis and clustering) to quantify the relative similarity of benthic infaunal populations among those stations sampled and species density variations. Summary information derived for each station from the macrobenthic analysis typically includes estimates of: 1) mean number of individuals; 2) total number of individuals; 3) total number of taxa; 4) Shannon's Diversity Index; 5) Simpson's Dominance Index; 6) Species Richness; and 7) Evenness.

Fisheries Assessment

A number of organizations have conducted assessments of seasonal fisheries distribution, abundance, and species composition within Salem Sound/Harbor using a variety of techniques and gear types. For instance, the Massachusetts Division of Marine Fisheries recently concluded a yearlong study of finfish populations within Salem Harbor and Sound during 1998 with sampling conducted monthly at 6 boat trawl and 6 beach seine stations (Salem Sound 2000). The presence of early benthic phase (EBP) lobster habitat at the disposal site was estimated by conducting diver video transects and suction sampling survey at several potential disposal sites. Shellfish resources were mapped by delineating information provided by Commonwealth resource managers, digitizing data shown in the Massachusetts Monograph series, and interpreting video transect data.

Despite these efforts, continued monitoring is necessary to further define the present pre-disposal abundance of marine resources, estimate the magnitude and rate of reuse by non-benthic species, and to assess the success of mitigation efforts. Although fisheries sampling efforts to date have been useful in providing a general characterization of biological resources within Salem Harbor, greater concentrated effort at the disposal site will be necessary to fully quantify species distribution and composition. Further effort is necessary to elucidate the relationship between physical conditions (i.e. sediment type, flow conditions, water quality) and marine resources at the disposal site to estimate the potential long-term consequences of permanent disturbance to the habitat from dredged material placement. This objective is best met by more intense but continued use of methods which have been successful to-date such as diver transects and lobster EBP suction sampling. Sampling techniques such as visual observations, benthic grabs, patent tonging, or raking can also be used to better estimate the presence and density of ecologically important bivalve species at the disposal site. This information should then be transcribed to cartographic products to provide a spatially-explicit record of shellfish and their abundance in the vicinity of the disposal area.

Post-capping sampling efforts are best addressed using a mixture of collection techniques for targeting demersal and pelagic species. These include use of otter trawls for capturing lobster and demersal species and experimental gill nets to sample pelagic fish species of various sizes. In waters less then 20 m, *in situ* observation using video or 35 mm photographic images from a drop camera may also be utilized to estimate lobster size-class distributions or burrow densities. Shellfish recolonization plates can be deployed at strategic positions in the water column to assess recruitment and attachment of pediveliger larvae such as the blue mussel, eastern oyster, or european oyster. Further information about impacts (positive and negative) to commercial and recreational activities can be obtained from on-site interviews with local fishermen, bait shops, and resource managers as well as conducting visual assessment of commercial fishing activity and lobster pot distributions. Continuous contact with lobstermen and local fishing clubs or organizations can aide in identifying timeframes and locations of greatest activity, as well as provide a review of the proposed dredging "windows" (i.e. months in which dredging and disposal should be limited due to the presence of spawning or nursery activity).

9.8 Management Options for Aquatic Disposal Site

MADEM

Massachusetts Department of Environmental Management would manage the operation of the aquatic disposal site in Salem Harbor. This agency has a long history of managing state owned waterfront properties, such as state fish/cargo piers, and maintenance of waterways, including dredging state channels, harbors and berthing areas.

As the disposal site manager, MADEM would officially obtain site designation by securing permits from MADEP and USACE; announce the availability of the disposal site to public and private users; levy any fees for use; have legal authority to manage liability; oversee disposal activities; and monitor short and long term impacts and environmental conditions of the disposal site environs.

USACE

The USACE has a long history of managing aquatic dredge material disposal sites throughout New England. Under this option, the USACE would obtain site designation and manage the site as it does the other New England disposal sites. The Salem Harbor disposal site would be added to DAMOS providing for long term monitoring of the site.

Local Agency

Under this option, an agency of the City of Salem or an existing or created semi-public authority would manage the disposal site. The agency would levy fees for use and manage liability much like that of a municipal landfill.

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SECTION 10.0 - DRAFT SECTION 61 FINDINGS

10.0 DRAFT SECTION 61 FINDINGS

THIS SECTION TO BE PROVIDED UNDER SEPARATE COVER

SECTION 11.0 - RESPONSE TO COMMENTS

11.0 RESPONSE TO COMMENTS

This section of the DEIR provides individual responses to the public and agency comments received on the Environmental Notification Form (ENF) for the Salem Harbor DMMP. In this section, each comment letter is addressed in a specific subsection, with individual comments listed, followed by a response to the comment. Letters are addressed in the order in which they are listed in the MEPA ENF Certificate of April 24, 1998.

Comments are presented in italicized text for ease in distinguishing between comments and responses. Where appropriate, the response may direct the commentator to the specific sections of the DEIR where the comments are answered. The Certificate of the Secretary of Environmental Affairs is included in the front matter of this report, the remaining comment letters are included in Appendix A.

11.1 Certificate of the Secretary of Environmental Affairs on the Environmental Notification Form

Comment: *Project Description, Purpose and Need*

The EIR should contain a full description of the project that includes a description of the purpose and need for the DMMP in Salem Harbor.

Response: A full description of the Salem DMMP is included in Section 1, Executive Summary. Purpose and Need for the project is addressed in Section 3.1.

Comment: *Sediment Quality and Quantity*

The EIR should contain an analysis of the quality and quantity of dredged material for DMMP dredging projects. It should summarize dredge sampling and testing programs (I understand that the sampling plan has been pre-approved by the regulatory agencies) and discuss conformance with the Department of Environmental Protection (DEP) and Army Corps/EPA requirements, including physical, bulk chemistry and any required biological testing. It should identify low, medium and high volume dredge volume estimates in consultation with Salem Working Group and Harbor Plan Committee. For overdredge and adjacent to channel aquatic disposal alternatives, it should provide a summary of results of subsurface investigations.

Response: Section 3.3 includes a complete discussion of the quality and quantity of the dredged material for the Salem DMMP. However, biological testing has not been completed to date and is scheduled to be completed this year. We anticipate that the Final Environmental Impact Report will include the results of the biological testing in Salem Harbor.

Note that the Draft EIR analysis assumes conservative unsuitable dredged material volume estimates, roughly corresponding to the "high volume" dredging estimates included in the ENF. We have taken this approach to ensure that disposal site planning considers the maximum volume of unsuitable dredged material that may need to be disposed. Future chemical and biological, if required, analyses of individual dredging projects will pinpoint the capacity required for the final disposal site or alternative treatment method.

Comment: *Identification of Disposal Alternatives*

The EIR should identify the full range of practicable disposal alternatives considered under DMMP Phases, including:

a. Alternative Technologies and Methodologies

Identify potential alternative technologies, and discuss operational requirements, regulatory feasibility, and characteristics of output and sidestream flows and associated environmental impacts. Based on these factors, identify potentially practicable technologies.

b. Upland Reuse/Disposal

Identify potential upland alternatives within the Zone of Siting Feasibility Suitability relating to Salem, consistent with existing DEP regulations and policy. The EIR should also consider the use of brownfield sites consistent with DEP policy and the Massachusetts Contingency Plan.

c. Aquatic Disposal

Identify all potential aquatic disposal alternatives as defined under DMMP Phase I within the Salem Zone of Siting Feasibility, consistent with Army Corps operational policies and Clean Water Act, Section 404 provisions.

Response:

a. Alternative Technologies and Methodologies: Section 4.3.2 summarizes the Alternative Technologies and Methodologies analyzed for the DMMP.

b. Upland Reuse/Disposal: Section 4.3.4 summarizes the Upland Reuse and Disposal Alternatives analyzed for the Salem DMMP.

c. Aquatic Disposal: Section 4.3.1 summarizes the Aquatic Disposal Alternatives analyzed for the Salem

DMMP.

Comment: *Screening of Disposal Alternatives*

1. Perform a first order screen of disposal alternatives for impacts to natural resources, permitting feasibility, engineering characteristics, capacity, cost, logistics, and users conflicts, based on existing information. Screening criteria used in the analysis should be developed in consultation with local interests and state and federal resource agencies. Identify potentially practicable alternatives resulting from the screening.

Response: Section 4.5 of the DEIR provides a summary of the first order screen of disposal alternatives and alternative technologies and methodologies identified for the Salem DMMP.

Comment: *2. Fisheries Investigation and Monitoring*

The proposed fisheries studies are intended to fill information voids relative to the present status of marine resources in specific areas so that the potential impacts from dredging and in-water disposal can be determined.

These studies will complement other resource investigations either currently underway or recently completed by the Division of Marine Fisheries (DMF).

The important marine fisheries resources in Salem Sound are shellfish (soft shell clams), lobster, and finfish. Detailed assessments of the resources are underway in Salem Sound in connection with the Salem 2000 study.

DMF will direct the Contractor to the sites to be sampled for finfish and lobster sea sampling, the data from *which shall be transferrable within the DMMP survey area. Juvenile lobster and shellfish surveys shall be site specific, and shall be conducted at the areas identified within each study site, subject to final direction from DMF and MCZM.*

With one exception, no studies or assessments are proposed in Salem Harbor. DMF is currently conducting a one year estuarine study in the Beverly - Salem Harbor complex in connection with the Salem Sound 2000 Program. Finfish monitoring and shellfish stock assessment are under way and field work will be completed by December 1997. Lobster sea sampling was conducted from May through November in 1997 in Salem Sound and may have occurred within the proposed dredge and potential spoil areas. This material should be included in the EIR.

Juvenile lobster surveys will be conducted at the aquatic sites identified on DMMP project maps as federal maintenance and improvement dredging areas, the proposed Salem pier project areas, and ATC CAD sites in Salem Sound. Information obtained will be analyzed in relation to other juvenile surveys. Juvenile lobsters (carapace length <40mm) will be surveyed in August in both the proposed dredge area and the aquatic sites identified on DMMP project maps as ATC, CAD and the Fish Pier CDF. A diver- operated suction device will be utilized to obtain quantitative information on juvenile lobsters. Twelve randomly placed 0.5 M2 quadrats will be sampled in each site. Samples will be enumerated and compared to other similar investigations in state waters. It is noted that while this method of EBP lobster assessment is experimental, it is rapidly becoming the standard for evaluating juvenile lobster habitat.

Response: Section 4.6 of the DEIR provides a detailed screening of aquatic disposal alternatives which include an assessment of benthic impacts in Section 4.6.3 and finfish impacts in Section 4.6.4. Section 6.1.3 provides a detailed assessment of impacts to benthic species, while Section 6.1.4 provides a detailed assessment of impacts to finfish for aquatic disposal alternatives.

Comment: *3. Analyze the effects of disposal activities on shore birds and the impacts of these activities* *on shore bird habitat.*

Response: Sections 4.6.6. and 4.6..7 provide a general assessment of wildlife and endangered species habitats including shorebirds, while sections 6.1.6 and 6.1.7 provide a more specific assessment of these resources for the Proposed Preferred Aquatic Alternatives.

Comment: *Additionally, provide the results of a cultural investigation to identify any resources that might be affected by disposal options. I suggest consultation with the Board of Underwater Archaeology in preparing this information.*

Response: Section 5.1.11 of this DEIR presents the results of a initial (Phase I) underwater archaeological investigation for Salem Harbor and nearby waters. As noted in Section 6.1.11, prehistoric sites may be present, but almost impossible to detect. Historical research indicates, because of centuries of intense maritime activity in the bay and harbor, there were at least 298 historically significant small and large vessels lost in the general area that includes the proposed disposal sites. Any dredged material activities in the area might disturb one or more of the shipwreck sites.

Aquatic disposal activities will be preceded by an archaeological remote sensing survey, to locate and identify by type, any significant sites within the proposed disturbance areas. Once any detectable cultural resources have been located and identified by type, decisions can be made to avoid or mitigate them. CZM will coordinate further underwater archaeological investigations with MHC and the Board of Underwater Archaeological Resources.

Comment: *Characterize identified potentially practicable sites in terms of: engineering, physical, chemical, and meteorological characteristics; quantify natural resource impacts; identify permitting requirements; cost; capacity; and operational requirements, based on site specific conditions.*

Response: The full text of this DEIR provides the requested analyses.

Comment: *Identify, in consultation with Salem officials and other interested organizations and individuals, a preferred alternative(s)and/or methodology(s). Identify mitigation requirements and identify the parties responsible for implementation of mitigation measures.*

Response: The disposal site screening process has been closely coordinated with City of Salem and representatives from surrounding communities, as described in this DEIR. The Draft Section 61 Finding identifies mitigation requirements specific to the upland and aquatic Proposed Preferred Alterntatives.

Comment: *Disposal Site Management Plan*

The EIR should contain a draft disposal site management plan detailing measures to be taken to ensure protection of the public. health and welfare and to properly manage the construction and operation of the preferred disposal alternative. It should also identify parties responsible for implementation of the plan.

Response: The Disposal Site Management plan is included in Section 9 of this DEIR.

Comment: *Draft Section 61 Findings*

The EIR should contain a draft Section 61 Finding for the preferred alternative. This finding should set out what mitigation is available to minimize or eliminate environmental impacts.

Response: Section 10 of this DEIR includes the Draft Section 61 Finding.

Comment: *Federal permitting requirements*

The EIR should contain, as appropriate, the draft federal Endangered Species Act Section 7 consultation and draft Clean Water Act Section 404(b)(1) analysis.

Response: Section 7.2.5 includes a draft Clean Water Act Section 404(b)(1) analysis for the Proposed Preferred Aquatic Disposal site in Salem Harbor. As the Proposed Preferred Aquatic and Upland Disposal Sites are located outside of any federally-listed Endangered Species habitat areas, a draft ESA Section 7 consultation is not included in this DEIR. Consultation and coordination with the National Marine Fisheries Service and the US Fish and Wildlife Service is continuing to determine the need for a formal Section 7 consultation process.

11.2 Department of Environmental Protection

Comment: *DEP experiences with CA/T materials (both excavate and dredged sediments) have demonstrated that even though there initially appeared to be a fairly large demand for these materials at public (or private) landfills, the reality was that very few landfills actually decided to use the materials. In addition, by 1999 most unlined landfills in Massachusetts will be capped, the exception being a category of historic landfill disposal sites, most of which have been unused for over 30 years, and the potential for placement of significant volumes of dredged sediments at any of these sites is questionable and severely limited at best. Nevertheless, the DMMP should fully assess any and all historic landfills and DEP will work with the consultant in this activity.*

The ENF specifically refer[s} to [the] existing municipal solid waste landfill in ... Salem (1-acre site)... As the ENF for Salem correctly states, the facility is only 1 acre and has been inactive since 1975; in fact the site has been closed and capped and could not be used for sediment disposal. ...

Response: CZM and the DMMP Consulting Team have worked in consultation with the DEP on the inclusion and assessment of historic landfills in the identification and screening of upland disposal sites.

Comment: *The DMMP estimates a total volume of... 452,000 cubic yards of dredged material unsuitable for unconfined ocean disposal for the port... of Salem ... DEP fully supports the conclusion in the Phase I DMMP that this large volume and physical/chemical quality of dredged material drives an informed alternatives analysis; one that must carefully review all possible mechanisms for both in-water and upland disposal/reuse.*

Response: The comment is acknowledged.

Comment: *Upland Disposal/Reuse at Locations Subject to Jurisdiction of M.G.L. c. 21 and the Massachusetts Contingency Plan, 310 CMR 40.0000 et. sec.*

"Despoiled Areas," "Brownfields", and 21E Sites

The ENF states that, should an upland disposal/reuse alternative be selected, ... use of already despoiled areas, such as a "brownfield" site are preferable to pristine areas. Potentially contaminated areas of an otherwise suitable brownfield site will be identified via the Environmental Site Assessment Process under M.G.L. c. 21E and the Massachusetts Contingency Plan (310 CMR 40.0000) (Page 7, Section III. E. 3.).

Response: CZM acknowledges that Chapter 21E and the MCP may apply to areas of the Salem/Swampscott upland disposal site identified as a Potential Preferred Alternative in this DEIR.

Comment: *DEP wishes to point out that it is inaccurate to conclude that "brownfields" are synonymous with "despoiled areas." Areas that could be considered brownfields include much of downtown Boston, the commercial/retail/industrial hubs of many Massachusetts cities, and many suburban and rural locations that have hosted and continue to support a variety of land uses and activities; e.g. manufacturing, research, medical facilities, retail establishments, etc.; and would likely not be appropriate for the disposal of dredged sediments.*

Response: The comment is acknowledged.

Comment: *In addition, the phrase "... potentially contaminated areas of an otherwise suitable brownfield site ..." suggests the type of brownfields site that, in fact, ends up proving to be "clean." Such areas would not be appropriate for the disposal of dredged sediments.*

Response: The comment is acknowledged and the Salem Harbor DMMP DEIR does not include such a site as a Potential Preferred Alternative.

Comment: *Neither c. 21E nor the MCP define the word "brownfields." C. 21E sites are those areas that become subject to the jurisdiction of c. 21E and the MCP because they are where releases[1] of oil or hazardous material have come to be located. DEP only allows contaminated media generated at a 21E site to go to locations or facilities that are permitted or otherwise approved by DEP.*

Response: The comment is acknowledged.

Comment: *DEP* understands *that, if upland disposal outside of site assigned facilities is necessary, it is preferable to consider locations that have already been subject to contamination over areas that may be described as "pristine." However, DEP currently has no statutory/regulatory authority over "despoiled areas" or "brownfields" as described in the ENF statement.*

Accordingly, DEP suggests that the discussion concerning the use of non-pristine locations be restyled to consider the locations over which DEP has such authority, specifically 21E sites.

[1] While 21E jurisdiction also encompasses threats of release of oil or hazardous material, these comments are limited to actual releases.

Response: The comment is acknowledged. The intent of the ENF statement regarding "pristine" areas was to express a preference for a beneficial reuse approach to a contaminated (despoiled) site over a disposal approach on a pristine, undeveloped site. CZM understands that "despoiled areas" and "brownfields" are not regulatory definitions.

Comment: *Scope and Complexity of 21E Site Remediation*

DEP, while concurring with limiting any upland alternatives analysis for the disposal/reuse of dredged sediments to non-pristine areas, has several concerns about focusing on 21E sites:

- *21E sites must be remediated to a condition of No Significant Risk*[2]*. This is, in many instances, a complicated process and, in some cases, a process that requires years of careful oversight and treatment to achieve; and*

Response: CZM understands that a human health risk assessment will be required if an upland disposal site subject to Chapter 21E and the MCP is selected as the Preferred Alternative disposal site for the Salem Harbor DMMP.

Comment:

(b) the awareness of the complexity of this process has precipitated DEP's ongoing development of guidelines for the use and management of dredged sediments and DEP is hopeful that it will have at least draft guidelines by November of this year [1998].

[2] A "Significant Risk" exists when a release of oil or hazardous material presents a hazard to health, safety, public welfare, or the environment if it were present even for a short time.

Response: CZM concurs with the comment and is actively working with DEP to develop the draft guidelines.

Comment: *Project Permitting*

The ENFs correctly indicate the various potential major DEP Permits that might be necessary to implement the construction and operation of dredged sediment reuse/disposal facilities. Depending on the alternative(s) finally chosen additional DEP permits (or technical reviews) may be required under the jurisdiction of c.111 s.150A and 310 CMR 16.000 and 19.000 (Solid Waste Review); c.21E/MCP at 310 CMR 40.000; 310 CMR 7.00 (Air Plans Review); and c.131, s.40 (Wetlands Protection Act) if a Superseding order or Variance is deemed to be necessary.

Response: CZM acknowledges the comment.

Comment: *Waterways Permitting*

The projects will require a Chapter 91 dredge permit. If the Confined Disposal Facility (CDF)or the Tidal Habitat Creation option is chosen, a Chapter 91 license will be necessary. Chapter 91 licenses require the payment of Commonwealth tidelands occupation fees at $30/sq.yd. and tidewater displacement fees at $2.00/cu.yd. These costs may become quite prohibitive for large amounts of fill. Public agencies however are exempt from these licensing fees. So if one of these options is chosen, a public agency should be the permittee. A further requirement of the Waterways regulations at 310 CMR 9.32 (1)(b), is that within DPAs, a project shall be eligible for a license only if it is restricted to fill or structures for water-dependent-industrial use, provided that, in the case of proposed fill, neither pile-supported nor floating structures are a reasonable alternative. The EIR should address how this requirement will be met.

Response: The Salem Harbor DMMP has not identified a CDF or Tidal Habitat Creation option as a

Potential Preferred Alternative site. Therefore, the analysis requested to address the requirements of 310 CMR 9.32(1)(b) is not included in the DEIR.

Comment: *Wetlands Permitting*

There is not yet enough information on the Wetland Resource Areas likely to be impacted by these projects to determine what the requirements under the Wetlands regulations will be. For each of the alternatives under consideration, the EIR should address the following: which Wetlands Resource Areas will be impacted, the square footage of impact, whether the impact is temporary or permanent, whether the project will require a variance, or whether it can be considered a Limited Project under the Wetlands Regulations.

Response: Sections 6.1.5 (Aquatic sites) and 6.2.3 (Upland Sites) quantify the amount and type of wetland resource areas, and the duration of the impact, for all wetland resources which are potentially impacted.

11.3 Massachusetts Historical Commission

***Comment**: The City of Salem contains a high density of known archaeological sites which are recorded in MHC's Inventory of Historic and Archaeological Resources of the Commonwealth. The majority of land in the City of Salem has never been systematically surveyed for archaeological resources. Additional as yet unidentified sites may also be present both on land and under water.*

MHC requests the opportunity to review preliminary plans as early as possible in the planning of this project in order to determine the need for an archaeological survey. Further consultation with the MHC will provide a forum to explore ways to avoid, minimize, or mitigate effects to significant historic or archaeological resources that are identified in project impact areas.

Response: There are no shoreline or near-shore disposal sites proposed in Salem, thus no impacts to land based archaeological sites within the city are expected. The two Proposed Preferred Upland Disposal sites proposed are both actively used and heavily disturbed industrial sites with a very low likelihood of undisturbed archaeological resources.

Section 5.1.11 of this DEIR presents the results of a initial (Phase I) underwater archaeological investigation for Salem Harbor and nearby waters. As noted in Section 6.1.11, prehistoric sites may be present, but almost impossible to detect. Historical research indicates, because of centuries of intense maritime activity in the bay and harbor, there were at least 298 historically significant small and large vessels lost in the general area that includes the proposed disposal sites. Any dredged material activities in the area might disturb one or more of the shipwreck sites.

Aquatic disposal activities will be preceded by an archaeological remote sensing survey, to locate and identify by type, any significant sites within the proposed disturbance areas. Once any detectable cultural resources have been located and identified by type, decisions can be made to avoid or mitigate them. CZM will coordinate further underwater archaeological investigations with MHC and the Board of Underwater Archaeological Resources.

11.4 Board of Underwater Archaeological Resources

Comment: *The BUAR conducted a review of its files and secondary literature sources to identify known and potential submerged cultural resources. Research strongly suggests there exists the possibility for both prehistoric and historic cultural resources, now submerged, to be located within the vicinity of Salem Harbor and Salem Sound. This preliminary review revealed potential submerged cultural resource (e.g., shipwrecks) in the vicinity of the study area.*

Given the geomorphological evolution of the Salem Harbor and Salem Sound as a possible inundation feature (limited seaward exposure reducing erosional effects), there exists the strong possibility for the *preservation of now submerged prehistoric cultural resources. A regional model for the southern Gulf of Maine suggests the expected site frequency for the study area would be low for all site types dating prior to 6000 BP, but would increase from low (habitation) to high (shell middens) for the period 6000 to 3000 BP. In the period from 3000 BP to Present, the expected site frequency increases to high for habitation, camp, and shell midden sites. During both periods, the size of these sites would be small. While this model does not provide sufficient resolution to specifically identify potential site locations at the scale of the study area, it points to the need to consider the occurrence of prehistoric sites.*

A preliminary review of historic literature strongly suggests there exists some reasonable concern for possible site occurrence within the proposed dredging and disposal areas. In general, we must recognize Salem was a major early colonial port in the region and maintained commercial and fishing importance throughout the historic period, and thus maintained a high volume of vessel traffic. Additionally, the numerous coves and islands along the shore provided small safe harbors and quays to support both fisheries and vessel outfitting activities. At the same time, we must recognize that Salem Sound with its proximity to Cape Ann, like Cape Cod, was a major natural landscape feature that contained numerous hazards to navigation, and thus became the site of several hundred shipwrecks. A variety of maritime related cultural resources, such as wharves/piers/quays, anchorages, careening sites, derelict and shipwreck vessels, might be anticipated to be located in the project area, either submerged or along the shore.

While the vast majority of known shipwrecks occurred along the eastern of Salem Neck, Marblehead, Marblehead Neck, and the islands of Salem Sound, a number of shipwrecks are known to have occurred in the vicinity of the project area. At least 12 historic shipwrecks occurred in the immediate vicinity of the project area. Further, secondary sources indicate that as many as 300 shipwrecks might be located in the vicinity of Salem Sound. The loss of earlier and smaller coastal vessels and the purposeful abandonment of derelict vessels are generally not found in the documentary record. The level and diversity of maritime commercial, fishing, and recreational activities throughout the Salem Sound region may have resulted in the creation of a number of undocumented and anonymous underwater archaeological sites such as small *craft, derelict vessels, or dump sites. These possible site types represent classes of vessels where our knowledge is severely limited and, thus, are potentially historically and archaeologically important.*

Therefore, the BUAR takes this opportunity to express its concern that heretofore unknown cultural resources might be encountered during the course of work and hopes the project's sponsor will take steps to limit adverse affects and notify the BUAR, as well as other appropriate agencies, if historical or archaeological
resources are encountered.

Response: As noted in the response to the MHC comment above, Section 5.1.11 of this DEIR presents the results of a initial (Phase I) underwater archaeological investigation for Salem Harbor and nearby waters. We concur the waters of Salem Harbor, near the location of the Proposed Preferred Aquatic Disposal Alternatives, are likely to contain several potentially significant archaeological sites. As noted above, CZM will coordinate with both the BUAR and MHC to define the appropriate further investigations and identification of mitigation and avoidance measures as the DMMP site selection and disposal site design process proceeds.

11.5 Salem Planning Department

Comment: <u>Sediment Quality and Quantity</u>*: As you are aware, the Salem Harbor Master Planning process is underway. Through that effort, additional priority areas for dredging are being considered, for example, to accommodate additional recreational moorings, and to improve navigation between the harbor's Federal and State Channels. The DMMP process should remain flexible enough to allow for additional sediment analysis to support Harbor Planning priorities which have not yet been finalized.*

Response: CZM is committed to continuing cooperation with the City of Salem through its completion of the Salem Harbor Plan. The DMMP will remain flexible and responsive to the needs identified by the City through the Harbor Plan process.

Comment: *<u>Identification of Disposal Alternatives</u>: The plan should fully analyze and give high priority to beneficial reuse alternatives, including use of material for marine construction, brownfield projects and landfill capping. Specific use of appropriate material for parkland construction along the North River, in conjunction with construction of the Bridge St. By-Pass Road, should be given full consideration.*

We request that the planning process explore the feasibility of locating and designing CAD sites in such a way as to serve the dual purposes of providing disposal sites and creating additional mooring areas through over-dredging. Specific areas to consider are noted on the attached map, as follows: A) the area NW of a line drawn between the end of Derby Wharf and Day Marker 23; B) Cat Cove; and C) the area at the mouth of Collins Cove.

Response: Alternative disposal sites and reuse alternatives, including the specific uses and sites identified by the City of Salem, were thoroughly examined by the DMMP Consulting Team throughout the development of this DEIR. However, the specific uses of marine construction, brownfield projects and landfill capping were not identified as components of the Proposed Preferred Alternatives identified in this report. Similarly, the specific CAD sites identified in the comment sis not survive the aquatic disposal site screening process described in this report.

Comment: *<u>Screening of Disposal Alternatives</u>: Attention and analytical effort should be focused on proposed reuse options and disposal sites 1) with the greatest likelihood of being acceptable to the community; 2) which are feasible in the regulatory context; and 3) where the benefits of dredging and any potential impacts from disposal are in close proximity. Therefore, waterside study should be concentrated within Salem's waters. We do not support introducing contaminated dredged material to pristine sites such as Eagle Island, Halfway Rock, Deep Bay and Misery Island, where fisheries resources, habitat values and recreational uses may be severely impacted. In addition, Misery Island is located adjacent to a Federal*

Channel, and issues of potential shoaling are of concern. The Collins Cove CDF site, as proposed, would have direct impacts on a residential neighborhood. This area is also believed to be a significant seaworm spawning area and feeding habitat for shorebirds.

Response: The disposal site screening criteria used in the analysis described in this DEIR did include the three factors listed in the comment, although potential aquatic disposal sites were also identified and analyzed which were located outside of Salem's waters, as required under the procedures proscribed under Section 404(b)(1) of the federal Clean Water Act. The aquatic sites at Eagle Island, Halfway Rock, Deep Bay and Misery Island and Collins Cove did not survive the disposal site screening process and are not included as Proposed Preferred Sites in this DEIR.

Comment: *Regional Coordination of DMMP Efforts: This study is focused on providing environmentally sound and cost effective options for addressing dredged material generated by Salem Harbor projects. We recognize, however, the potential for neighboring communities to have concerns regarding the siting of a disposal site within Salem Sound, as well as the opportunity such a facility may represent to neighboring harbors. The City of Beverly and Town of Marblehead are represented on this Working Group for these reasons.*

In addition, the City of Gloucester is currently engaged in a-parallel DMMP effort. We are aware that the Zones of Siting Feasibility (ZSF) for these two studies overlap significantly. We request that these processes be well coordinated and do not duplicate effort, particularly with regard to potential upland reuse/disposal sites.

Response: CZM has strongly supported the inclusion of adjacent communities in the deliberations of the Salem Disposal Options Working Group. The DMMPs for both Salem and Gloucester have significantly overlap, with largely similar sets of aquatic disposal and upland disposal/reuse sites, and an identical set of alternative treatments and methodologies. Analysis of these disposal options, with the exception of detailed analyses of inner harbor aquatic alternatives in either harbor, have been strongly coordinated.

11.6 Letter of Frank Michel, Invicta Consulting Group

Comment: *My basic comment on the DMMP for Gloucester and Salem Harbors is that options have not been adequately evaluated. The plan is short in these ways:*

1. A complete assessment of alternative processes has nor been considered. An array of processes are available or are quickly becoming available. These were not identified and compared.

Response: The ENF was not intended to provide a "complete assessment of alternative processes". The assessment requested has been summarized in Section 4.3.2 of this document.

Comment:

2. Cost comparisons need to go beyond the cost of disposal of dredged material to include profits obtained by manufacturing and using products from sediments. Seaport Bond Bill Moneys should be particularly tuned to the possibilities of environmental impact and development via dredged material management and use.

Response: While CZM does not disagree with the statement that any profits obtained through manufacture and use of products derived from sediments are part of a full cost analysis of alternative treatment technologies, this analysis is beyond the scope of the DMMP analyses. As to the use of Seaport Bond bill moneys, the bond bill specifically lists many line items for specific projects, for which bond funds are authorized.

Comment:

3. Contained Disposal Facilities (CDFs) should be planned so that sediment that goes into them is used. This will extend the life of the CDF and allow time for structural and market assessments to determine which processes and products are going to be best for each port.

Response: CZM concurs with the comment. Note, however, no CDF disposal site has been selected as a Proposed Preferred Alternative site for the Salem Harbor DMMP.

Comment:

4. Statements that there are no opportunities or sites available for processing suggests that such alternatives have nor been duely [sic] considered.

Response: This DEIR has more completely summarized the opportunities for processing of sediments. It should be noted, however, that the DEIR does not identify a suitable dredged material disposal site within Salem that would allow the processing of unsuitable sediments.

Comment: *With inadequate information and a very short public-response time, some responsible citizens feel that the agenda is set, contrary to the spirit of the law.*

This plan reflects a state inclination to do a quick and expedient job which neither solves problems adequately nor does it allow for responsible decision making. Poor solutions will negatively impact the environment, communities and people during and beyond the 20 years of the plan.

Response: The ENF public comment period is specified under the MEPA regulations. It is clearly the intent of CZM to provide for multiple opportunities for public comment on the specifics of the DMMP. Public review of this DEIR is yet another opportunity for that public comment.

CZM disagrees that the DMMP constitutes "a quick and expedient job which neither solves problems adequately nor does it allow for responsible decision making". The DMMP process has been ongoing for over two years and has produced a thorough analysis of feasible disposal options for unsuitable dredged material from Salem and other ports.

11.7 Letters of Doris Bergen, Jack Pitman, Jack Osgood, Harvey Freedman, and Marcie Stevenson

Bergen, Pitman, Osgood, Freedman and Stevenson submitted identical letters to the MEPA Unit. A single set of responses is provided.

Comment: *The Dredge Material Management Plan for Salem Harbor, which supports aquatic and upland containment of dredged material, is based on incomplete data. Some major issues are:*

Aquatic disposal of contaminated material will harm fish and other sea life, which is recognized in the report.

Response: There are minimal impacts to existing benthic and finfish resources from use of the Proposed Preferred Alternative Aquatic Disposal sites identified in this report. As noted in screening analysis, the aquatic sites have been selected largely as a consequence of thier minimal value as finfish or benthic habitat. Disposal impacts are temporary and the use of clean material as a cap over the unsuitable dredge material will result in improved habitat over the existing, degraded conditions.

Comment: *This dumping contaminated dredged material in the ocean and covering it over leaves the problem, and money and plans do not exist for later correction.*

Comment:

- *There has been some indication that a Confined Aquatic Disposal option may be selected. It would be useful to have the most up-to-date information from the Boston Harbor dredging project, including the problems they have encountered and how those have been remedied.*

Response: Although Confined Aquatic Disposal options are two of the Proposed Preferred Alternatives included in this DEIR, the "problems" encountered during the Boston Harbor project are still being studied and no remedies have been selected to date. CZM, the DEP and the Army Corps of Engineers are all aware of the Boston Harbor CAD situation and are closely working to arrive at the optimum solution. Any lessons learned in Boston Harbor will be applied, as appropriate, to the ultimate disposal of dredged sediment in Salem Harbor, if a CAD site is the final Preferred Alternative.

Response: The use of an aquatic disposal site, over a twenty year period, will require long term monitoring and maintenance for evidence of potential problems, such as leakage of contaminated material from the confined disposal site. A portion of "tipping" fees paid for use of the site by individual dredging projects may be earmarked for an escrow-type fund dedicated for any future required remediation efforts.

Comment: *Clean sediments should be used, when possible, as a valuable natural resource, and we understand that methods have come available to make useful products.*

Response: Clean, or "suitable", dredged sediments have traditionally been disposed at the Massachusetts Bay Disposal Site. As the purpose of the DMMP is to identify suitable disposal sites or alternative treatment methodologies for "unsuitable" sediments, CZM makes no commitment as to the method of disposal to be chosen by individual dredging project proponents for suitable sediments. CZM has committed in this DEIR to a periodic five year review of the efficacy of alternative treatment technologies and will publicize the results of this periodic review for the benefit of all dredging proponents.

Comment: *Contaminated sediments should be made environmentally safe, with the lowest cost that meet proven standards.*

Response: CZM concurs with the comment and encourages further research into the development of cost effective and environmentally safe treatment methodologies.

Comment: *When possible, sediments made environmentally safe should be used, such as in especially constructed wetlands, walls to prevent erosion, or capping contaminated sites.*

Response: CZM concurs with the comment. Although the Salem Harbor DMMP DEIR has not identified such uses as feasible given current shortcomings of viable treatment methodologies, we are aware of similar uses in other states. In Massachusetts, current environmental regulatory programs governing alterations to wetlands and remediation of contaminated sites using treated sediments pose difficult hurdles to successful implementation of these types of projects. The DEP and CZM are working to revise the Massachusetts environmental regulatory program governing dredging and dredged material disposal, in part to simplify the regulatory burden for projects such as these.

Comment: *Public and professional education seems inadequate; newly proven methods and good uses of sediment seem to be overlooked.*

Response: CZM concurs that the public is not adequately informed, but we disagree that professional education is inadequate. For the DMMP, we have surveyed fourteen classes of treatment technologies from [xxx] individual vendors, and have built upon the knowledge base from other research performed in the Port of New York and New Jersey and elsewhere.

Comment: *We believe that costs for long-term solutions can be much less than the report indicates, and we suggest a study of this.*

Response: As noted, we have surveyed [xxx] individual treatment technology vendors for the most up-to-date information available on cost and efficacy. We believe that this information is the most accurate available.

Comment: *We believe that manufacturing useful products may create jobs, be applied in ways to help the environment, and help in port and other construction.*

Response: CZM concurs with the comment.

Comment: *The plan is for 20 years. It does not allow for applications of new methods for uses and remediation, although the U.S. and other nations are ardently seeking better ways, some of which are* *proving. After 20 years, when the ocean and up-land disposal sites are full and we start over, will we have gained as much as applying **new technologies now**?*

Response: As previously noted, the DMMP includes a periodic review, every five years, of the efficacy of alternative treatment technologies and methodologies. This information will be made available to individual dredging proponents.

Comment: *Scheduling allows little time for further assessment of alternatives.*

Response: See the response to the previous comment.

Comment: *State permitting procedures for alternatives may deter fuller solutions.*

Response: As noted above, current state permitting programs for use of treated sediments may impose procedural hurdles on a project applicant. As noted, he DEP and CZM are working to revise the Massachusetts environmental regulatory program governing dredging and dredged material disposal, in part to simplify the regulatory burden.

Comment: *Overall, we ask if the plan is good, since a) alternatives and consequences to all options seem incomplete and b) arbitrary schedules and permitting procedures limit adequate assessment.*

Response: This DEIR provides additional information on alternatives and environmental consequences to supplement the preliminary information provided in the ENF. As to "arbitrary schedules and permitting procedures", the DMMP schedule is driven by the necessity of identifying disposal sites for long delayed dredging projects in the individual ports, including Salem.

Comment: *We urge a fuller assessment of alternatives to ocean dumping of contaminated sediments and* *to on-land containment of various sediments. All options have shortcomings and costs; however, new options may lend significant information for short-and long-term plans.*

Response: This DEIR has provided the fuller assessment requested.

As citizens of Massachusetts, we are concerned that all harbors receiving moneys from the $350M Sea Port Bond Bill seek and receive up-dated information on alternatives. We understand that Boston Harbor is well underway with its plan and it may be too late for significant input; yet, Salem, Gloucester, Fall River, and New Bedford can benefit.

Safety for the earth and its inhabitants is imperative to strive for. Safer solutions that are also useful to man and the environment should be adequately considered, for genuine savings and informed choice.

All citizens and participants need to know more, to decide what is best to do.

Response: The comment is acknowledged.

11.8 Letter of Anne Montague, Montague Associates

Comment: *Please note that, overall, I feel the 20 year plan must be based o n more. Examples are:*

- *Innovative technologies and methods;*
- *Designing CDFs with beneficial uses in mind, with one benefit being that life of CDFs be extended far beyond 20 yrs;*
- *Cost analyses that depend on much fuller information;*
- *Better professional and public education, for better procedures of choice.*

Response: CZM concurs with the basic intent of the comment. It is the intent of the Massachusetts DMMP to research and provide such information, while recognizing the practical limits of the existing regulatory and financial environment.

Comment: *The science and technology of managing sediments is rapidly changing as technologies and methods emerge for processing a) clean and b) contaminated sediments. Decision makers and the public need to know what is possible, in order to know how to manage and use sediments.*

From review of the DMMP and public meeting I have attended, my comments center on the inadequate consideration of processing sediments and of beneficial uses of processed sediments, which, in my view, result from a lack good understanding of alternatives. The use of sediments requires integration of technology, sediments, products, uses, sites, storage, and other factors. Thus, the following comments stress looking at the whole, as well as details, by cooperating with various initiatives for better short-term to permanent solutions.

Response: CZM disagrees that inadequate consideration has been given in the DMMP to processing sediments. We have reviewed fourteen classes of treatment technologies for their efficacy and cost-effectiveness in treating dredged sediments. The review is summarized in Section 4.5.2 of this document.

Comment: *A Paradigm Shift Is Occurring, Based on Emerging Breakthroughs a) in Technologies/Methods and in b) Beneficial Uses of Sediment, which outdates conventional planning and public comment fur dredging, scheduling, cost, and port and other development. Thus, the procedures should be up-dated to accommodate progress with both clean sediments and contaminated sediments made environmentally safe. Some examples of new information that must be evaluated are (see throughout for others):*

A. *Beneficial Use Products (blocks, statues, flowable cementitious material [for fill, highway objects such as Jersey barriers. etc.), manufactured soils, artificial soils, capping materials,* *molded products (lampposts, flagstones), soil-crosion control blocks, roofing dies), and others.*

B. *Beneficial Use Sites. Wildlife habitat, wetlands (including for remediation), construction of shoreline land space (including for processing sediments), brownfields (including for processing sediments), anywhere that blocks, molded objects, soils, etc. can be used.*

C. *Cost comparisons are not meaningful without adequate studies of how sediment uses can a) saved [sic] money, b) help create unique, viable solutions to brownfields and industrial reuse sites, c) make products that can be sold, d) provide long-term planning of markets/uses and of remediation, c) create jobs, f) increase community pride and tourism from a beautiful communities that have been a first to reconstruct with sediments.*

D. *Matching sediments with products, site uses, and best technologies should be on-going. Extreme activity in finding processes and uses for sediment may help save money, resources, environment. Again, using sediments from CDFs to avoid their filling up, is one example.*

E. *It is usually necessary to know the specific use before finding the technology to meet a need. For example, stabilization and solidification for capping a brownfield may have different performance standards than SS technologies for landfill cover, building monoliths such as berms that might border CDFs or constructed wetlands.*

F. *Balancing/coordinating/integrating many factors emerges as a short-to-long term mission of dynamic problem-solving centered around people's fuller awareness and choices.*

G. *Open-Water Disposal of Uncontaminated Dredged Material Is A Waste of Valuable Natural Resources.*

Response: No response is necessary.

Comment: *III. Demonstrations of Processing Sediments into Safe Products, How Processes/Products Can Be Used Cost-effectively, and How To Do Good Cost Analyses Are Not Outlined.*

Slow but definitely emerging are:

A. Demonstrations of Contaminated Sediments Made Environmentally Safe. For many reasons beyond product safety and viability, moneys for demonstrations have been slow, although many demonstrations are under way now. Some barriers to demonstrations are:

1) Brookhaven National Laboratory and others first concentrated on high-tech decontamination technologies that are expensive. Many policy makers had a wait-and-see attitude about these and are only now beginning to realize that a) other decontamination technologies are emerging at lower cost and b) low-tech processes that do not decontaminate per se but make useful product that is environmentally safe and ready to be demonstrated.

2) Prevailing attitudes of some stakeholders is that vendors with technologies should find their own funding for demonstrations, despite the fact that these processes a) are proving in scientific and bench scale ways, and b) are proving to make useful product with clean sediment. This is unfortunate and not in the American spirit of allowing ways to solve problems for the common good.

3) The private-sector is slow to invest till markets are proven, which is happening, but slowed by the above bottle necks.

4) Research on public acceptance bas been too slow. Those who might fund objective research are afraid that their present plans will be stopped with public involvement and education.

However, based on my own and others' research (e.g., brownfields managers, sediment uses on the West coast) that the public should be involved early and the public wants to know: the alternatives, that contaminated raw material will require several classes of decisions for safety (e.g., monitoring), what environmental good can come of uses, what jobs can be created, what education can come from looking at the issues, what kinds of structures can be created, and what full costs are. By and large, the public wants to face the problem of contamination, not run from it or have it hidden. We have polluted, we need to decide how to take care of what we have created, as well as how to prevent it.

5) Products (e.g., soils, bricks, wetlands, capping) have not been made visible to the public. Talk is absolutely insufficient.

B. Demonstrations of Clean Sediment Products.

1) These are evolving, including commercialization of soils from sediment, bricks and blocks for homes, security walls, and various plans for statues and other beautification projects.

2) These are likely to be shorter in permitting and public acceptance.

C. Demonstrations of Cost Effectiveness.

Cost analyses are often case-by-case. Some issues are:

1) Profit from different processes will differ. For example, transportable manufacturing plants for bricks used for specific environmental projects such as soil/riparian erosion control will have different cost analyses than permanent plants for making aggregates and these will differ for other solutions.

2) Markets may have to be developed.

3) Waste products (e.g., ash, fish gurry, glass) will have different savings, and some may bring *a tipping fee to offset production cost.*

4) *The integration of many missions can offset costs. A few examples are:*

- *Creation of nature-friendly sites such as wildlife habitat, ecoeducation sites, wetlands, plant propagation walks).*
- *Job creation efforts such as with fishermen, HUD, youth.*
- *Port development with sediment-based products that will enhance port missions and reduce costs.*
- *Brownfields/Superfund redevelopment.*

These barriers to demonstration are not long-term. However, the DMMP is for 20 years, which means there is time to introduce processes, if plans are made now for their introduction

Response: Much of the comment is not directed at the Salem Harbor DMMP ENF and is acknowledged. As previously noted, the DMMP includes a periodic review, every five years, of the efficacy of alternative treatment technologies and methodologies. This information will be made available to individual dredging proponents.

Comment: *IV. Confined Disposal Facilities and Contained Aquatic Disposal design should be rethought.*

A) CDFs should not be filled and then rebuilt. Sediment can be used from these CDFs to make them last much longer than 20 years. CDFs should:

a) Contain all (uncontaminated and contaminated) material that is not used, to make it environmentally safe and useful later

b) Be coordinated with beneficial uses (blocks, statues, flowable fill, soils, brown field capping and other uses, wetlands, wildlife habitat, construction of shoreline landspace. so that CDFs are neither overbuilt nor do they fill up, which will produce product and save CDF *construction.*

c) *Be coordinated with remediation (minimize contaminant migration), so that contaminants are rendered environmentally safe, and., if possible used in appropriate ways.*

A) *CADs should be reconsidered. Alternatives are suggested based on:*

a) *Public distaste for putting contaminated sediment in an aquatic environment and not planning more than to cover it is accepted procedure; however, there have been few choices, and alternatives need to be openly considered to get to choices for determining accepted and preferred procedures.*

b) *Possibly creating wetlands with new know-how that has good scientific evidence of passively remediating organics.*

c) *Problems with monitoring CADs, which should be compared to evolving ways to monitor via constructed wetland and low-cost technologies to bind up contaminants.*

Response: A CDF alternative is not included as a Potential Preferred Alternative for the Salem Harbor DMMP. As to a Potential Preferred Alternative CAD site, and the listed reasons for reconsideration of a CAD alternative: 1) public distaste exists for many projects involving disposal or treatment or processing of contaminated media, including dredged sediments; 2) wetland creation often involves significant permitting hurdles, as viable sites are often considered as valuable wetland resources in themselves, and "creating" wetlands often means converting one type of resource to another; and 3) the issue of monitoring CADs is ongoing and regulatory agencies and project proponents are learning from experience. Section 9 of this DEIR outlines a comprehensive monitoring program that will be implemented if the CAD alternative is selected as the Preferred Alternative for the Salem Harbor DMMP.

Comment: *V. Inadequate Sequence: The sequence of schedules and selections is not in synchrony with full consideration of alternatives. For example:*

A) Sites: Finding the site where sediment can be used and assessing those needs are early steps in assessing if there are adequate technologies to deliver desired products and/or materials. Since little site assessment has been done, technologies and methods, by definition, have not been adequately considered.

It is usually necessary to know the specific use before finding the technology to fit. For example, stabilization and solidification for capping a brownfield may have different performance standards than SS technology for landfill cover, building monoliths such as berm that might border CDFs or constructed wetlands,

B) Therefore, sufficient search for technology and methods has not. been done.

C) Selection and summation of alternative technologies (i.e., soil washing) was typical of what might have been done a year ago, while high-tech processes were being stressed.

Response: The ENF was not intended to provide a comprehensive summary of all research conducted on alternative treatments and methodologies conducted for Phase I of the DMMP. This DEIR includes a more comprehensive summary of research conducted to date, including on the specific treatment technologies identified above.

Comment: *VII. Along with Emerging Technologies/Methods and Uses of Sediment, Emerging Procedures of Assessment of Alternatives are Necessary. Full professional and public awareness of alternatives and public education will take additional effort.*

Some (not all) Other Problems Include:

a) Since areas to be dredged are not fully decided, dredged material and users/uses are hard to put together, which stack the cards against a realistic look at beneficial uses.

b) *The type of dredging to be used is unclear and, likewise, impacts decisions about uses.*

c) *Cost sharing for uses is unduly difficult to plan or assess without these and other questions answered.*

d) *Innovative and proven technologies have not been fully assessed, and numbers are not accurate for comparisons.*

Response: This DEIR has attempted to determine, with reasonable certainty, the volume of dredged material from all identified potential public and private dredging projects in the port of Salem, in an attempt to answer these questions. It is simply not realistic to expect that these questions can be answered with certainty for a multitude of potential dredging proponents who may or may not undertake dredging projects anytime during a twenty-year planning horizon.

Comment: *VIII. Time for Introduction and Community Assessment of Alternative/Emerging Technologies and Methods is Too Short. In this period of advance where the education, testing, demonstration, cost/benefit analyses are emerging, means for up-to date, practical solutions should be fully allowed.*

Response: CZM concurs that a means for identifying up-to-date practical solutions needs to be identified. As such, the DMMP includes a periodic review of alternative treatments and methodologies every five years, when the efficacy of these technologies will be determined.

Comment: *IX. Can Sediment Uses Be Tied to Brownfields (Inside and Outside these Two Harbors) via Applications for Redevelopment and via Making Brownfields Processing Centers for Sediment? Interest is increasing in using sediments for brownfields, particularly along waterways, and moneys to do this should be planned.*

Response: As part of the review of alternative treatments and methodologies, this DEIR included an assessment of the use of "brownfields" sites as potential sites for disposal and/or reuse of unsuitable dredged sediments. No such sites were identified as Potential Preferred Alternative sites.

Comment: *X. Cost is a major factor; however, the DMMP does not adequately deal with cost, particularly over 20 years. Examples are inadequate cost analysis:*

- *of alternative, low-tech, low-cost technologies (short-term forward);*
- *of uses of clean and contaminated sediments (short-term forward);*
- *to fish breeding grounds (short-term);*
- *to make CDFs last longer by using sediment (long-term);*
- *of adequate public and professional education so that decisions, including from required public comment, is meaningful and industry can grow from sediment uses;*
- *of not just treatment but what the product will sell for or save (e.g., in brownfield development).*

Response: CZM disagrees that cost has not been adequately considered in the analysis of alternative treatment technologies and methodologies. The DMMP does include a 20-year planning horizon, however, it deals with only <u>unsuitable</u> dredged materials, and not clean material, for whcih there are available practicable disposal options. Impacts to fish breeding grounds are an important screening factor in the identification of potential aquatic disposal sites, as documented in this DEIR.

Comment: *XI. The public must be involved better and early (via research from many sources).*

Regarding contaminated sediments, the public often says it does not want to pass contamination on to the future. Though they do not yet trust beneficial uses of sediment made environmentally safe and know that choices will sometimes be difficult, they want to a) know that we are doing something more, b) know we are *doing something, c) want to know what those somethings are, and e) want to be able to monitor what is done so that problems will be detected and dealt with.*

Regarding clean sediments, the public is accepting products (e.g., manufactured soils in Toledo).

Again, the public and professionals want to a) see what can be done--to touch and smell and see product and b) understand and help plan uses.

Response: CZM concurs with the comment. The DMMP is an attempt to begin the public information process.

Comment: *XII. Public Meetings and the Draft Left Questions and Issues. Examples are:*

1. *Is there Time to introduce technologies/methods and uses?*

   Two messages seemed to be given, one by MEPA and the other by CZM.

   Message 1. *MEPA: There is time for assessment of alternatives to CADs and CDFs.*

   Message 2. *CZM: Technologies have been adequately assessed, there will be no time for feasibility studies of others, permitting of alternative technologies and beneficial uses will be next to impossible.*

2. *If sampling and analysis of the sediments has not been done, how can alternative methods be considered? That is, CADs and CDFs require less sampling, since there is less concern over what is in the sediment when they are contained and confined.*

The answer was unclear, and these issues emerge from lack of up-front sampling:

1) *Sampling helps determine best alternative uses, but little has been done.*

2) *Alternative uses must be introduced quickly in order to be considered as part of the state and local plans, which are slated for the fall of this year.*

3. *Is it possible to get funds for demonstration of technologies/methods and uses?*

One answer was to call the State after CZM talked to them (Salem meeting). Another was that, although the State would decide, there was little room for demonstrations and other proof of viability of beneficial uses and technologies.

4. *What portion of the Seaport Bond moneys goes to each harbor and are the Harbors in danger of losing moneys if schedules are not met (e.g., If time is taken to consider alternatives)?*

5. A. *Why is prevention via point and non-point-source prevention and cleanup (e.g., tributaries into Salem Harbor) not part of the short- or long-term action plan?*

   B. *Why is the Anasquam [sic] River part of the Gloucester effort, while the tributaries to Salem are not?*

6. A. *Why is WRDA not an issue (CZM stated in Salem meeting that it is not).*

   B. *Why does it apply or not apply to the five ports receiving Sea Port Bond Moneys?:*

It seems that WRDA's mandate to consider beneficial uses applies to both Harbors and the Anasquam.

7. *What per cent of Gloucester Harbor is federal channel?*

Though Corps responsibility is probably not a key issue since all permitting for dredging must go through the Corps, it was not answered, and, instead, the question was asked to why one would want to know).

8. *If sites are found that would use large volumes of sediment, is it too late to use Boston sediments, assuming that uses can be found?*

9. *What rules apply and don't apply to five different ports - are they similar and different?*

10. *What will happen to the debris and how is this a different topic than sediment (asked in the context of landfill disposition).*

11. A. *Is the purpose of dredging these harbor for commerce, only? If it is for environmental cleanup, issues such as the tributaries into the Salem Harbor seems relevant.*

    B. *How do these and other purposes/goals interact with funding via other agencies for cleanup.*

(Discussion on this question was poor in Gloucester, and such lack of discussion appears to be leading to frustration from fisherman and others that in my view, is great enough to lead to the "no dredging" option),

12. *Why are secondary effects of dredging not discussed?*

(Question from USACE, Boston District led to this answer Salem meeting, April 7.)

13. *Will attendees be provided with the attendee list? (Was provided in Salem; was not answered in Gloucester).*

14. *Since Gloucester's sewage went into the harbor for many years and is now taken into the outer harbor, several questions arise:*

    A. *What is the breakdown of the 94% pollution that was named in the public meeting in Gloucester on April 9th. What percentage is from pathogens left from sewage, from metals, from hydrocarbons, from copper paint, from pesticides, etc. ?*

    B. *Does this pose different problems than in other ports (e. g. Salem), in terms of suspension of contaminants into fishing waters?*

    C. *Do fishermen not oppose pathogens in the waterway? What impact does this have on any aspect of the DMMP plan?*

    D. *Has a common solution to the sewage and the sediment, as a common effort been considered?*

15. *CZM stated that all materials that could be blended into sediment were assessed.*

    A. *What is that list of blending materials that have been considered?*

    B. *What were the technologies/methods and uses assessed that led to the decision that the process of blending does not prove desirable?*

    C. *Were products assessed with tipping fees, to offset costs?*

16. *Manufacturing plants can be sea based (i.e., barge) or land based (i.e., stationary or transportable). Was the statement that manufacturing sediment-based product won't work based on a full assessment:*

    A. *Were more flexible (i.e. barge and transportable) systems considered, to offset the problem of factories needing large supplies of sediment on a regular, long-term basis?*

    B. *Did manufacturers give presentations based on the situation or was assessment made in the abstract?*

    C. *What is the list of alternative technologies that were assessed for beneficial use products?*

17. *Has there been effort to assess cost in light of local efforts that might offset expenses? A few examples are HUD (e.g., in Gloucester where HUD is an active issue), historic restoration, Brownfields, marinas?*

18. *Disposal and use are different actions. They should not be referred to as "disposal/use" but as Disposal and Use, as separate concepts. Representing disposal/use as one concept fails to recognize that sediments are becoming a valuable resource (i.e., raw material) and that products can be selected based on problem solution. Combining them shows the need to get rid of sediment, not the growing awareness that the emphasis should be on the needs of the user of sediment-based products and the sites where they are applied. An alternative to consider is to entirely change phrasing to "Placement and Use."*

19. *Scheduling of major events was unclear to most attendees. Hand outs should have been available to show steps and what must be done by given dates.*

20. *What will be done with the sediments in the CDFs to make them safe?*

21. *It has been assumed that sediments must be used by the cities where the harbors are (i.e., Salem and Gloucester). This may not be the case, if:*

    a) *Sites are made attractive, profit making, safe, especially from sediment that can be engineered to perform better than conventional materials.*

    b) *Product is deemed safe and useful, perhaps starting with clean sediment.*

22. *Can what is learned in Salem and Gloucester about alternatives to CDFs and CADS be transferred to Fall River and New Bedford?*

23. *Can practices in Boston be altered, based on advances in the other four ports? How is that introduced?*

24. *What mechanisms exist for integrating many efforts, so that a) repletion of red-tape can be avoided, b) needs of individual ports can be honored while still benefitting from common efforts, c) many missions can be met, short-term to permanently.*

Response:

1. As noted at the ENF "scoping" meeting, there is ample opportunity for examination of alternatives to CADs and CDFs. The analysis summarized in this DEIR is the first comprehensive attempt at examination of the alternatives.

2. This DEIR includes a summary of the chemical characterization of potential dredged sediments in Salem Harbor.

3. The DMMP does not include funds for demonstrations of technologies and uses.

4. Specific projects in ports and waterways throughout the Commonwealth are included in the Seaport Bond Bill, not just projects in the four ports of Salem, Gloucester, fall River and New Bedford. There are no strict schedules set in the bill, and bonding authorization for a project is no guarantee that moneys will be allocated in the future.

5. CZM has been very active in the development of coastal non-point pollution prevention programs throughout the Commonwealth. Prevention of non-point pollution is an important priority and is expected to make a significant contribution to a reduction in pollution ot Massachusetts waterways in the future. The Annisquam River is included in the Gloucester DMMP because of the presence of the federal navigation channel in the river, while tributaries to Salem Harbor do not include any federal navigation channels.

6. The federal Water Resources Development Act (WRDA) does not apply to the DMMP because it applies only to federally-funded projects. The DMMP does not include federal funding.

7. The question does not pertain to the Salem Harbor DMMP.

8. Sediments from Boston Harbor are being accommodated within the confines of Boston Harbor. There are no plans to bring Boston Harbor sediments to any other disposal sites, including any site that may be located in Salem Harbor.

9. Boston is not considered a part of the DMMP study efforts. The other four ports will be subject to the same "rules".

10. Debris (items such as large metal pieces, fishing tackle, and other material found in the harbors) will

be separated by the dredging contractor, and be separately disposed of. This is common to dredging projects in urban waterways.

11. Maintenance and improvement dredging projects identified in Salem Harbor over the next twenty years are considered to be for the purpose of maintaining or improving commerce in the ports. There are no environmental cleanup dredging projects identified in Salem. CZM is not aware of other agencies' funding for cleanup of Salem Harbor.

12. Secondary impacts resulting from identified dredging projects in Salem Harbor are included in Section 7.3, Secondary Impact Analysis.

13. The attendance list for the Salem Harbor ENF scoping meeting of April 7, 1998 is included in Appendix A, following the ENF.

14. The comment relates to the Gloucester portion of the DMMP and is not answered in this DEIR.

15. Blending materials identified by specific technology vendors, such as clean sands, cement and lime, were assessed. Contrary to the comment, blending (also considered as a form of solidification and stabilization) has been used in Massachusetts to treat unsuitable sediments prior to disposal. Tipping fees were not included unless specifically identified by technology vendors [check this]

16. The type of systems assessed were identified by specific technology vendors and included mobile, transportable systems. Assessment was based on information provided by vendors and on the personal experiences of the DMMP consulting team members with specific technologies. A complete list of the technologies assessed in included in Appendix D.

17. As previously noted, use of brownfields sites was included in the assessment of upland alternatives summarized in this DEIR. CZM is not aware of local efforts such as those identified in the comment that may "offset expenses" for treating unsuitable dredged material.

18. CZM does not consider disposal and use to be a single concept, but has rather assessed both disposal and reuse options in this DEIR.

19. CZM intends to fully publicize the progress of the DMMP in regards to Salem Harbor. The two public meetings held in Salem on July 28 and September 7 were well publicized and well attended.

20. The Salem Harbor DMMP does not include a CDF site as an potential Preferred Alternative.

21. While CZM does not disagree with the comment, the practical reality of gaining public acceptance for a regional site is a difficult process that has proven to be extremely difficult in the past for other major infrastructure projects in Massachusetts.

22. The Gloucester, Fall River and New Bedford DMMPs will all build upon the lessons learned in Salem.

23. The practices in Boston are beyond the scope of this DEIR.

24. The fact that the DMMP includes the four ports of Salem, Gloucester, Fall River and New Bedford ensures that integration of study efforts will occur.

Comment: XII. Professionals and the Public Showed Misperceptions in My Discussions with Them

1. Reasons professionals cited over last weeks for not using sediment in this region must be

reassessed. Some of these cited reasons and their answers are:

– Products can not be made from salt water sediments.

Ans: They can be.

– Supply is not consistent enough to warrant manufacturing,

Ans: This is overcomeable.

– There are no processing sites.

Ans: This is not convincing, since many a complete assessment of ways to Process (e.g. transportable. passively remediating wetlands, on brownfields), creation of processing locations via dredged material, and kinds of processing are not included in the DMMP, since they were likely not know at the time of the DMMP.

– Landfills are too far away or are already using Boston Harbor materials.

Ans: Landfills

a) are not likely a preferred alternative use,
b) were not informed well (public meeting in Gloucester) that debris is not sediment and problems of debris will be solved, and
c) might be generated for special uses (profit making) and know how in design will incorporate, the use of sediments.

– If technologies were good, investors would have invested.

Ans: Investors wait for markets to be clear, and this is happening. In addition, environmental technologies are not popular with investors.

– Markets are not developed.

Ans: True, but they can be, likely starting with clean sediment and going to contaminated sediments, but not necessarily. That the need to be is further evidence that more work is needed on the plan.

Sediment may be regulated as a waste in Massachusetts.

Ans: Clear evidence exists that Congress has deemed that sediment is not a waste and policy seems unformed in Massachusetts.

Response: As noted previously, the DMMP has comprehensively assessed the efficacy of alternative treatment technologies and methodologies for treating unsuitable sediments from Salem Harbor, considering the current market and regulatory environment. As previously noted, it is the intent of both CZM and the DEP to promulgate revised dredging regulations in Massachusetts in the near future.

Comment: 2. Issues that the public did not seem to understand (beyond those above) were:

Why can't dredging be postponed till a) it is clear why dredging must be done, and b) alternatives are better assessed?

Why should the public accept that the state has done a complete assessment?

Why were questions not fully answered (i.e., why dredge, does WRDA play a role, what happens to the debris, etc.) or glibly responded to which stifled discussion?

Is there political payoff/Incentive? Are contracts already let for dredging and disposal? Will Ports lose money if they do not dump at sea and follow the recommended plan?

Why was the public not better informed for better involvement in public comment?

Response: Dredging projects that include any volume of unsuitable sediments are effectively postponed at this time, due to the lack of cost-effective and environmentally suitable disposal options. CZM urges the public to consider the facts in the review of the technology assessment described in this DEIR in making a determination on its completeness. As was clearly stated at the meeting, it is not the intent of the MEPA scoping meeting to answer all questions, merely to identify those issues to be addressed in the EIR.

CZM categorically states that there are no "political payoffs or incentives" for the Salem Harbor DMMP. There are no contracts let at this time for dredging and disposal activities related to the DMMP. There are no financial penalties if ports such as Salem do not follow the recommended plan, other than the potential increase in costs if an alternative plan is not as cost effective.

Comment:

OUTSTANDING ISSUES, IN SUMMARY

Some leading issues (not to diminish those mentioned above).

Conventional assessment and implementation of "disposal/use" alternatives must respond to information which is so new that most professionals working with sediment need more comprehensive education.

Technologies and methods, mostly innovative, must be considered.

Integration of sediment technology/methods with uses calls for public involvement and cost assessments that is lacking in the current process. With sediment uses comes more public involvement in decision making, and old methods of public involvement are not adequate.

Sites that can use sediment products and products that can be sold must be found and involved very early.

Plans for ocean dumping are wasteful, plans for CADs and CDFs are not the safest alternative and should be rethought in order to balance them beneficial uses, full costs, environmental issues, with more public choice.

Time and money must be allowed to find out what is best to do, so all can do their best.

A change of mind-set is needed to allow for beat solutions,, to:

A. Prevent irreversible solutions that will be outdated quickly.

B. Select best alternatives, based on full public awareness.

C. Flexible planning that can include better ways as they emerge.

The science and technology of sediment management is quickly emerging. Some advances occurring in sediment use that should be incorporated into Harbor Plans are:

Lower cost, low-tech processes that yield useful practical products. Clean sediment products appear to be:

a) cost effective compared to conventional materials

b) yield products that can be engineered to do a better job than conventional materials, create *jobs, beautify, and help in port development cost and pride.*

Other advances emerging are:

a) *Decontamination technologies at lower cost (ports and states are putting out RFPs for no more than $35 c.y.)*

b) *Indications of job creation.*

c) *Indications of profit from manufacturing.*

Potential for interesting, aesthetic applications that are both structurally sound and environmentally safe.

Demonstrations are needed to expand the array of proven technologies and will continue to be necessary for specific sites, uses and sediments. These can be a plus for sponsoring organizations, because the public wants to know what will work and what will be safe.

Public understanding is not apparent. One-to-one interviews of citizens that offer questions that both give public education and get public opinion is needed in order to get dynamic public involvement that will lead to consensus and long-term cooperation.

Problems with CDFs as the end of the plans for the dredged material:

They put the problem off of what to do with contaminated materials off to the future;

They fill up, and new ones must be built, unless the sediments are extracted and used beneficially;

Response: See the responses to each of the summary comments, included previously in this subsection.

REFERENCES

REFERENCES

SECTION 4.0

Carey, D.A., R.M. Valente, and B.D. Andrews. 1999. Draft Disposal Options for Materials Dredged from Narragansett Bay. In: Quonset/Davisville Port Alternatives Report Baseline Economic and Environmental Data. Report prepared for Quonset/Davisville Port and Commerce Park Stakeholders Committee, January 15, 1999.

NAE (U.S. Army Corps of Engineers, New England Division [now District]) and Massport (Massachusetts Port Authority). 1995. "Boston Harbor, Massachusetts Navigation Improvement Project and Berth Dredging Project." Final Environmental Impact Report and Final Environmental Impact Statement. Massachusetts Executive Office of Environmental Affairs, File Number 8695.

DAMOS. 1994. Sediment Capping of Subaqueous Dredged Material Disposal Mounds: An Overview of the New England Experience 1979 - 1993. Disposal Area Monitoring System (DAMOS) Contribution No. 95. New England District, U.S. Army Corps of Engineers, Concord, MA.

DAMOS. 1999. Monitoring Results from the First Boston Harbor Navigation Improvement Project Confined Aquatic Disposal Cell. Disposal Area Monitoring System (DAMOS) Contribution No. 124. New England District, U.S. Army Corps of Engineers, Concord, MA.

SAIC. 1998. Synthesis of Monitoring Results for the 1993 Dioxin Capping Project at the New York Mud Dump Site. Report #79 of the New York Mud Dump Site Studies. Science Applications International Corporation (SAIC) Report No. 430. Submitted to the New York District of the U.S. Army Corps of Engineers, New York, NY.

Knebel, H.J. and R.C. Circé. 1995. Seafloor environments within the Boston Harbor- Massachusetts Bay sedimentary system: a regional synthesis. Journal of Coastal Research. 11:230-251.

Maguire Group Inc., 1997a. Dredged Material Management Plan Phase 1, Volume I, Gloucester, Salem, New Bedford and Fall River. Prepared for Massachusetts Coastal Zone Management, Boston, MA. September 30, 1997.

Maguire Group Inc., 1997b. Dredged Material Management Plan Phase 1, Volume II, Gloucester, Salem, New Bedford and Fall River. Prepared for Massachusetts Coastal Zone Management, Boston, MA. September 30, 1997.

Maguire Group. 1999. Capacity Analysis of CAD Sites within Salem, Gloucester, and New Bedford Harbors. Submitted to Massachusetts Coastal Zone Management, Boston, MA. Submitted by Science Applications International Corporation, Newport, RI. SAIC Report No. 467.

NAE (U.S. Army Corps of Engineers, New England Division [now District]) and Massport (Massachusetts Port Authority). 1995. "Boston Harbor, Massachusetts Navigation Improvement Project and Berth Dredging Project." Final Environmental Impact Report and Final Environmental Impact Statement. Massachusetts Executive Office of Environmental Affairs, File Number 8695.

Brown, B. and J. Neff. 1993. Bioavailability of sediment-bound contaminants to marine organisms. Report to NOAA, National Pollution Program Office, Rockville, MD.

Johnson, B.H. 1990. User's guide for models of dredged material disposal in open water. Technical Report D-90-5. Waterways Experiment Station, Corps of Engineers, Vicksburg, MS. February 1990.

Knebel, H. J. and R.C. Circe. 1995. Seafloor Environments within the Boston Harbor-Massachusetts Bay Sedimentary System. Journal of Coastal Research. 11:230-251.

Lee, H. 1996. Methods for assessing sediment bioaccumulation in marine/estuarine benthic organisms. In: Proceedings of the National Sediment Bioaccumulation Conference, September 11-13, 1996. Bethesda, MD. pp. 1:11-23.

Lee, H., B.L. Boese, J. Pelletier, M. Winsor, D.S. Specht, and R.C. Randall. 1989. Guidance manual: Bedded sediment bioaccumulation tests. US.EPA, Pacific Ecosystems Branch, Newport, OR. 163 p.

Murray, P., D. Carey, and T.J. Fredette. 1994. Chemical flux of pore water through sediment caps. In: Proceedings of the Second International Conference on Dredging and Dredged Material Placement. November 13-16, 1994. Lake Buena Vista, FL. pp. 1008-1016.

Rees, S.I. and P. Wilbur. 1994. Effects from thin-layer disposal of dredged material on water quality in Mississippi Sound. In: Proceedings of the Second International Conference on Dredging and Dredged Material Placement. November 13-16, 1994. Lake Buena Vista, FL. pp. 1481-1489.

Rhoads, D.C., P.L. McCall, and J.Y. Yingst. 1978. Disturbance and production on the estuarine seafloor. American Scientist, 66:577-586.

SAIC. 1988. Long-term sand cap stability: New York Dredged Material Disposal Site. Submitted to New York District U.S. Army Corps of Engineers, New York, NY. Submitted by Science Applications International Corporation, Newport, RI. SAIC Report No. 374.

SAIC. 1994. Analysis of the Contribution of Dredged Material to Sediment and Contaminant Fluxes in Long Island Sound. Submitted to U.S. Army Corps of Engineers, Waltham, MA. Submitted by Science Applications International Corporation, Newport, RI. SAIC Report No. SAIC-89/7571&C82.

SAIC. 1997. Capping dredged materials in the New York Bight: Evaluation of the effects of bioturbation. Submitted to New York District U.S. Army Corps of Engineers, New York, NY. Submitted by Science Applications International Corporation, Newport, RI. SAIC Report CERC-88-2. 85 p.

SAIC. 1999a. Habitat Characterization of the DMMP Candidate Aquatic Disposal Sites. Submitted to Massachusetts Coastal Zone Management, Boston, MA. Submitted by Science Applications International Corporation, Newport, RI. SAIC Report No. SAIC-99/463.

SAIC. 1999b. Observations of Physical Oceanographic Conditions at the New London Disposal Site, 1997-1998. Submitted to U.S. Army Corps of Engineers, Concord, MA. Submitted by Science Applications International Corporation, Newport, RI. SAIC Report No. SAIC-453.

Stern, E.M. and W.B. Stickle. 1978. Effects of turbidity and suspended material in aquatic environments. USEPA Dredged Material Research Program, Final report 1978. Vicksburg, MS. pp. 1-116.

Thibodeaux, L.J., K.T. Valsaraj, and D.D. Reible. 1994. Capping contaminated sediments - The theoretical basis and laboratory experimental evidence for chemical containment. In: Proceedings of the Second International Conference on Dredging and Dredged Material Placement. November 13-16, 1994. Lake Buena Vista, FL. pp. 1001-1007.

Truitt, C.L. 1986. Fate of Dredged material during open-water disposal. Environmental Effects of Dredging, Technical Notes, EEDP-01-2. US Waterways Experiment Station, Vicksburg, MS. 12 p.

USACE. 1986. The Duwamish Waterway Capping Demonstration Project: Engineering analysis and results of physical monitoring. Prepared by the US Army Engineers Waterways Experiment Station, Vicksburg, MS. Technical Report D-86-2. 54 p.

USACE/MPA. 1995. Modeling results to assess water quality impacts from dredged material disposal operation from the Boston Harbor Navigation Improvement Project. In: Final Environmental Impact Report/ Environmental Impact Statement: Boston Harbor Navigation Improvement Dredging and Berth Dredging Project. (Appendix F). USCOE Impact Analysis Division, Waltham, MA. June 1995.

USACE. 1998. Providence River and Harbor Maintenance Dredging Project Draft Environmental Impact Statement. U.S. Army Corps of Engineers New England District, Concord, MA.

USEPA/USACE. 1991. Evaluation of dredged material proposed for ocean disposal (testing manual). EPA-503/8-91/001. USEPA Office of Marine and Estuarine Protection, Washington, DC.

U.S. Environmental Protection Agency. 1998. *EPA's Contaminated Sediment Management Strategy*, EPA-823-R-98-001, Office of Water.

U.S. Environmental Protection Agency. 1996. *Vendor Information System for Innovative Treatment Technologies, Version 5*, Computer Database, Office of Solid Waste and Emergency Response.

U.S. Environmental Protection Agency Region 2. February 22, 1999. *(Press Release) New Sediment Decontamination Technology Shows Promise.*

SECTION 9.0

Camp Dresser & McKee Inc. (CDM). 1992. Draft Facilities Plan for Wastewater Treatment and Disposal: Phase II, Sections 10-16. Prepared for the South Essex Sewerage District, Salem, MA.

Chase, B. *In Prep*. Salem Sound Resource Assessment. Massachusetts Division of Marine Fisheries. Boston, MA.

Jerome, W.C., Jr., Chesmore, A.P., and C.O. Anderson, Jr. 1967. Study of the Marine Resources of Beverly-Salem Harbor. Monograph Series No. 4. Massachusetts Division of Marine Fisheries. 74 pp.

APPENDICES