U.S. Army Corps of Engineers

New England District

Malden River Ecosystem Restoration Detailed Project Report & Environmental Assessment

JUNE 2008

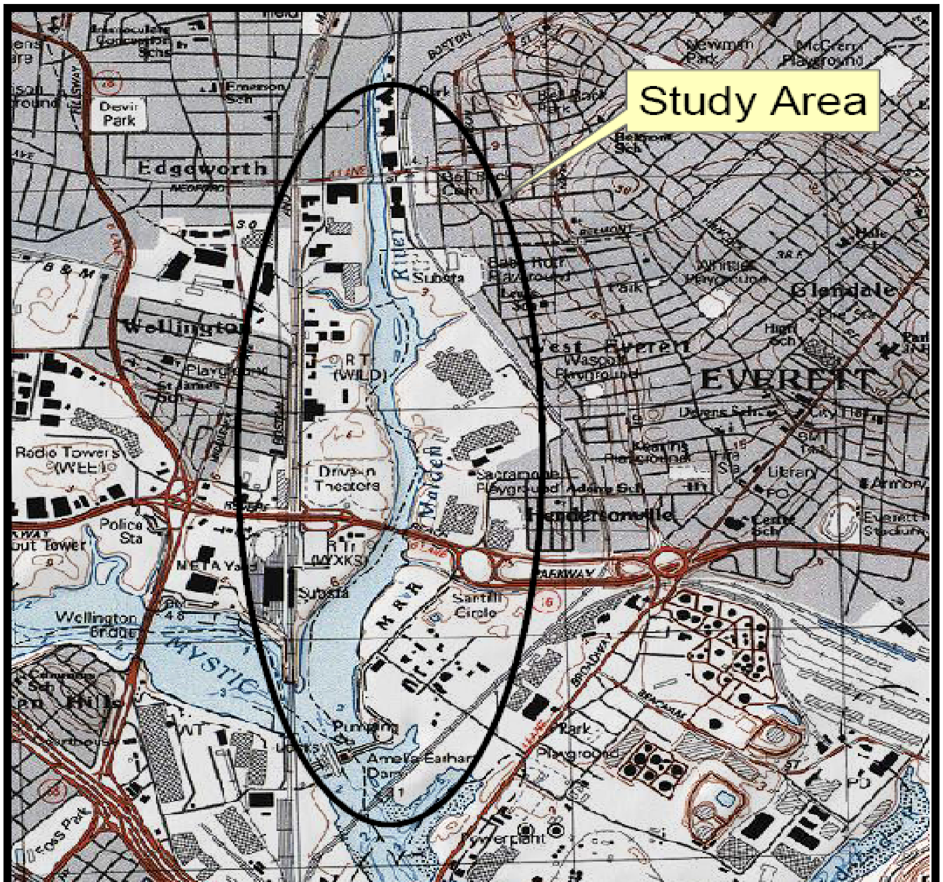
EXECUTIVE SUMMARY

The U.S. Army Corps of Engineers (USACE) in partnership with the Mystic Valley Development Commission (MVDC) developed this “Malden River Ecosystem Restoration Detailed Project Report and Environmental Assessment.” Restoration of the Malden River ecosystem to the “highest quality that it can reasonably support and sustain” is the overriding project goal for MVDC and USACE. Numerous ecosystem restoration components were developed and evaluated as the building blocks for a comprehensive strategy designed to restore the environmental quality of the Malden River ecosystem. These measures are directed towards the three primary restoration objectives: wetlands restoration, aquatic habitat restoration and riverine migratory restoration. This Detailed Project Report presents, through a plan formulation process, a recommended National Ecosystem Restoration (NER) plan that reasonably maximizes environmental restoration benefits compared to costs and meets the project goals.

The Malden River is a degraded riverine ecosystem, where the surface water quality and underlying toxic sediments depress local fisheries and benthic communities. The bordering lands of the Malden River consist predominately of former tidelands bound by rail lines along each bank that were previously filled with razed building materials, industrial wastes and dredged material to support early industrial development. In their current condition, riverbank frontage has little ecological resource value. Riparian wetlands along the riverbanks are dominated by the exotic invasive wetland plant species, *Phragmites australis*, and the abundance and diversity of resident wildlife is limited.

The Malden River watershed, a Mystic River sub-basin, is approximately 11 square miles and is located in the towns of Wakefield, Stoneham, Melrose, Malden, Medford and Everett, Massachusetts. The Malden River originates from the outflow from Spot Pond in the Fells Reservation and passes beneath the cities of Melrose and Malden in channelized conveyances through much of the upper watershed. The river daylights from two sets of stormwater culverts south of Malden Center and flows for approximately 2 miles as open surface water through the densely populated cities of Malden, Everett and Medford prior to its confluence with the Mystic River, just upstream of the Amelia Earhart Dam. The Study Area is defined where the river daylights from underground culverts in Malden to the confluence with the Mystic River with a lower downstream boundary at the Amelia Earhart Dam (see Figure ES-1).

Habitat degradation along the Malden River has concerned public agencies since the 1970’s. Numerous investigations by local, state, and federal agencies demonstrate a longstanding interest in the area and concerns about habitat degradation and deterioration of the river and its surrounding wetlands.

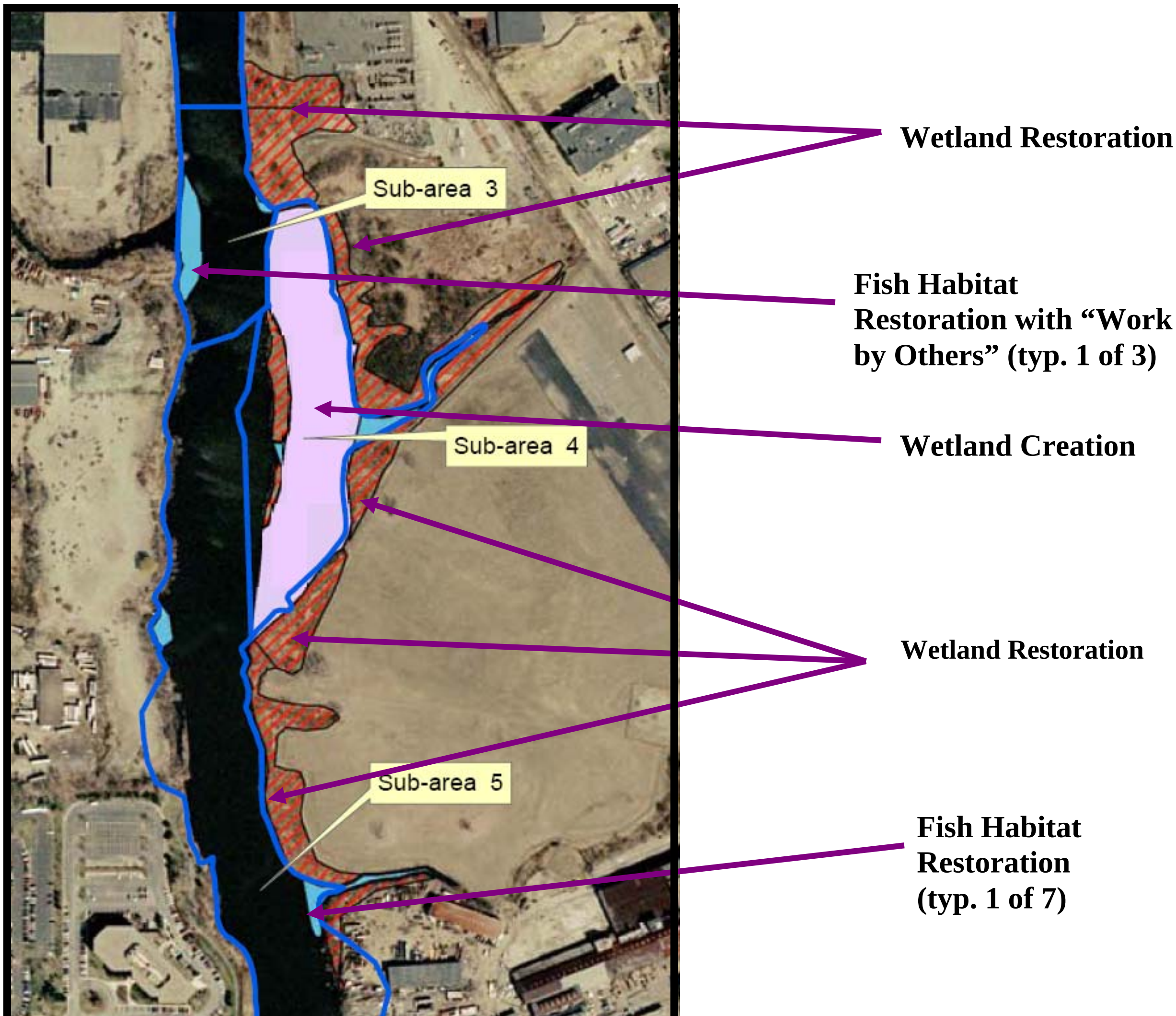


Malden River Ecosystem Restoration Project
Malden, Medford & Everett, Massachusetts

Figure ES-1 U.S.G.S. Topographic

The primary elements of the recommended NER plan, depicted in Figure ES-2, were developed through the detailed evaluation of the Mystic/Malden River ecosystem characteristics. The elements are as follows:

- Removal of 36,000 cubic yards of invasive species along 14.9 acres of the riverbank corridor and replanting with native wetland plant species;
- Creation of 5.4 acres of emergent wetland within the existing oxbow;
- Placement of 4,400 cubic yards of gravel/sand substrate to create 2.8 acres of fish spawning habitat;
- Miscellaneous debris removal and disposal; and
- Operational changes at the Amelia Earhart Dam to improve fish passage for anadromous species.



Malden River Ecosystem Restoration Project
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Figure ES-2 Recommended NER Plan

Wetland restoration involves the removal of 14.9 acres of invasive species and replanting of native wetland species to create freshwater emergent/shrub wetland habitats. This recommendation consists of cutting, grubbing and removing existing *Phragmites* stands, excavating a minimum depth of 18 inches, placing a layer of clean soil and the planting of native wetland seedlings. The generated excavation volume is estimated at 36,000 cubic yards. This excavated material will be used as a sub-base for the wetland creation component of the NER plan. Once Project Approval is obtained and the Project Cooperation Agreement is executed, a condition survey and chemical testing program will be conducted over the project area. The survey and chemical analysis results may require the PDT to adjust the restoration limits. The chemical testing analysis will determine what percentage of the proposed excavated material will be designated for upland disposal.

Wetland creation involves the establishment of a vegetated wetland within the river's oxbow to create 5.4 acres of emergent wetland habitats. This wetland creation component restores the historic area of marsh within the Malden River limits. Most of the excavated material from the wetland restoration component would be used as a substrate. A screening/separation process will remove the *Phragmites* root matter from the useable excavated material. A minimum one foot layer of new wetland soil would be placed prior to the planting of native wetland seedlings. The required volume of wetland soil is estimated at 9,000 cubic yards. A flow control device such as a weir or flashboard riser would be installed within the existing tributary to control flow. The flow control device would divert the flow and provide improved stormwater treatment.

Ten individual areas comprise the fish habitat restoration measure. Fish habitat restoration involves the placement of 4,400 cubic yards of clean gravel/sand substrate to create 2.8 acres of fish spawning habitat. Three of the ten proposed areas require work by "others" before placement of the gravel substrate. Another party must remove/dispose a minimum of 3-foot depth of existing river bottom in order to provide a suitable and stable base prior to the placement of the proposed gravel substrate. Negotiations with the responsible parties are ongoing. If responsible party negotiations are unsuccessful, these 3 sites will be eliminated from the NER recommended plan.

Miscellaneous debris removal and disposal is proposed within the construction work limits. This recommendation involves the removal of existing debris (e.g. shopping carts, tires, appliances…) and transporting to an upland disposal site. The generated volume is estimated at 450 tons. Cost for this proposed action will be non-Federal responsibility.

Fish Passage improvement involves operational changes to the Amelia Earhart Dam locking system. This recommendation consists of expanding the periods of operation of one or more of the locks to provide a more effective passage of fish. In particular, the operation would be modified to attain greater transfer of Atlantic rainbow smelt. This would require operating the locks not only during the daytime periods (which has proved reasonably effective for alewives), but also during evening and early morning hours during the smelt migration period.

The recommended NER Plan will result in a significant reduction in the current impacts to water and sediment quality, improve the riverine migratory corridor/spawning habitat and benthic community, restore the freshwater wetlands, and potentially increase public access and recreational use of the river. The NER plan will complement the enhancement of both ongoing and proposed work by MVDC/responsible parties to achieve a long-term sustainable restoration program for the Malden River.

Ecosystem restoration is one of the primary missions of the Corps of Engineers Civil Work program (ER 1165-2-501 – Civil Works Ecosystem Restoration Policy). The primary objective of Corps ecosystem restoration efforts is to partially or fully restore naturalistic, functioning, and self-regulating ecosystems. Restoration of wetlands, other aquatic systems, and riparian areas are most appropriate for Corps involvement. Corps restoration initiatives may also include measures to protect ecosystems from further degradation. Ecosystem restoration and protection initiatives should be conceived in the context of broader watershed management objectives, which may include collaboration with other federal and non-federal agencies, local communities, and other stakeholders, as in the case of the Malden River.

The aquatic habitat outputs from the separable elements of the NER plan represent resources of federal significance and institutionally recognized in the Clean Water Act (vegetated wetlands). The additional benefits of forage and passage to spawning grounds for anadromous fish make restoration a critical Federal interest in this highly urbanized watershed. Federal interest in establishment and protection of anadromous fish is recognized in the Anadromous Fish Conservation Act and the Fish and Wildlife Conservation Act. Federal interest in invasive species control (*Phragmites*) is institutionally recognized by Executive Order 13112 of February 3, 1999 -- Invasive Species.

Corps planning guidance recommends description of technical significance in terms of one or more of the following ecological concepts: scarcity, status and trends, connectivity, critical habitat, and biodiversity.

- Scarcity: The coast of Massachusetts historically provided exceptionally productive fish and wildlife habitat through its numerous salt marshes and rivers. Over the last 300 years, these natural salt marshes and embayments have been degraded or lost through the development of transportation facilities and other coastal development. Restrict tidal flow, disposal of dredged sediment on the surface of the marshes, filling for business and residential development, and stormwater related sedimentation resulted in the loss of estuarine habitat and its associated values to fish and wildlife resources. In addition, the construction of dams and other structures along rivers and river channelization have prevented anadromous fish from accessing historic spawning and nursery habitat areas and have resulted in the loss of fish populations.

  The Malden River currently provides about 140 acres of degraded aquatic and wetland habitat in an otherwise heavily developed city landscape. The river is the only remaining resource in Malden that may provide significant aquatic and riparian habitat, including spawning habitat for anadromous fish. Other streams that once flowed freely in the area were culverted long ago and cannot be restored due to dense urbanization.

- Status and Trends: The Malden River system is a remnant of an extensive tidal wetland system, much of which was filled in during the 19th century. Past dredging and filling activities have created small disconnected aquatic and wildlife habitats. These remaining habitats are currently highly degraded, and in decline due to proliferation of *Phragmites*, sedimentation, and continued contaminant loading. These areas do not function as a self-sustaining interconnected ecosystem. Without action, some conditions are expected to improve through the ongoing restoration efforts by others. The construction and current operations at the Amelia Earhart Dam has eliminated the historic fish runs throughout the Malden and Mystic River systems.

  MVDC has promoted an ecosystem restoration approach to the Malden River corridor. Their goal is to restore and sustain the health, biological diversity and productivity of the river corridor. MVDC has begun integrating social and economic goals with ecosystem restoration efforts along the western riverbanks. MVDC's economic and ecosystem restoration initiatives consider interrelationships of aquatic and wetland habitats associated with disturbed and degraded ecosystem resources. MVDC is continuing their restoration efforts along the western side of the river corridor, which provides self-sustaining and functioning aquatic and wetland systems among a revitalized residential and employment community.

USEPA Brownfields Showcase Community designation of the Malden River corridor has involved numerous public and private entities, including the Malden Redevelopment Authority, Massachusetts Electric/National Grid, KeySpan, Tufts University, Exelon, ENSR, and Preotle Lane and Associates have joined MVDC and USEPA in addressing the systematic problems of the river system. These entities, as well as other riverfront property owners, watershed associations, and citizens of the three host communities, which number in excess of 140,000, share a common goal of restoring this long neglected Malden River corridor. Restoration efforts include remedial activities for Little Creek, high voltage cable relocation with sediment cleanup, Phase IV Remedy Implementation Plan (Mass Electric) and future site development for the General Electric property.

- Connectivity: The value of natural areas is enhanced by existence of habitat corridors that allow for movement and dispersal of native species between resource areas. Restoration alternatives that improve connectivity are considered technically significant. Restoration of in-stream, wetland and riparian habitat along the Malden River will be significant in providing a resting area (habitat island) for migratory songbirds passing through the highly urbanized Malden-Medford-Everett area. Restoration of the Malden River provides and essential link between freshwater and estuarine and marine habitats. Restoration of fish passage capacity will link anadromous fish to their historic spawning grounds.

- Critical Habitat: This is habitat that is essential for the conservation, survival, or recovery of one species listed as rare or endangered under the Federal Endangered Species Act or other significant federally interest species. The Malden and Mystic Rivers provide potential spawning habitat for the Blue-black Herring and possible spawning habitat for other anadromous species. Given the scarcity of anadromous fish spawning and rearing habitat in the greater Boston area, restoration of the Malden River is considered technically significant.

- Biodiversity: Restoration alternatives that improve biodiversity (either species richness or evenness) are considered technically significant. The NER plan would eradicate the monospecific stands of *Phragmites*, increasing the biodiversity (species richness) of emergent wetland and riparian communities. Removal of contaminated sediments would likely increase diversity of the benthic community, by increasing both the number of species and reducing the dominance of tubificid worms and oligiochaetes. Based on these criteria, restoration of the Malden River is considered technically significant.

The District Engineer recommends that the NER plan be authorized for implementation as a Federal project at an estimated total project cost of $7,344,000. As costs for environmental restoration projects are shared 65 percent Federal/ 35 percent non-Federal and implementing the maximum Federal limit, costs would be apportioned $4,773,600 Federal and $2,570,400 non-Federal. The recommendation is also subject to the non-Federal sponsor assuming full responsibility for the project including all lands, easements, rights-of-ways, relocation and disposal areas (LERRDs). The non-Federal sponsor, Mystic Valley Development Commission, understands and agrees with these requirements, and is anxious to move forward with the recommended NER plan. Based on the scope and cost of the selected plan, the District Engineer recommends that implementation be pursued under the authority of ***Section 206 of the Water Resources Development Act of 1996 (PL 104-303).***

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1.0 INTRODUCTION

This report describes the process used to develop an ecosystem restoration plan for the Malden River corridor in Malden, Medford and Everett, Massachusetts. The U.S. Army Corps of Engineers (USACE) and Mystic Valley Development Commission (MVDC) considered various options to restore the degrade resources of the river, which once was a tidal estuary of Massachusetts Bay. This report recommends a Federal restoration plan that complements MVDC's proposed Master Plan for the Malden River corridor.

The reconnaissance study identified Malden River as an ecosystem warranting a full feasibility study. The USACE New England District is the Federal lead for the project. The MVDC is the local sponsor for the study and representatives of the MVDC serve on the study team. MVDC is a tri-city legislative body established by the Commonwealth of Massachusetts that works to address commonly shared issues involving Brownfields redevelopment and river restoration within a 200-acre project area designated as the River's Edge (formerly known as TeleCom City). This tri-City initiative includes the cities of Everett, Malden and Medford, with the Malden River situated at the core of the project area. A key focus of River's Edge is the restoration of those benefits that have been lost through early dependence upon the Malden River as a transportation vehicle for early industrial expansion from the port of Boston. U.S. Environmental Protection Agency (USEPA) supports the Brownfields Program. Utilizing the USEPA Brownfields Showcase Community designation, MVDC was provided with a full-time Showcase Community Coordinator (i.e., USEPA staff member on three year assignment) to act on its behalf. Numerous public and private entities have also contributed to this study, including the Malden Redevelopment Authority, Massachusetts Electric/National Grid, KeySpan, Tufts University, Everett Police Department – Marine Division, Exelon, ENSR, and Preotle Lane and Associates and the cities of Malden, Medford and Everett. These entities, as well as other riverfront property owners, watershed associations, and citizens of the three host communities, which number in excess of 140,000, share a common goal of restoring this long neglected Malden River corridor through the construction of public parkland, employment and residential opportunities.

During the completion of the formulation process, the Project Development Team (PDT) determined that all contaminated sediment removal measures would be eliminated from further study. A pre-established goal for the PDT was to complete this feasibility study under the current General Investigation Program and then transition to the Section 206 Ecosystem Restoration Program Authority. The removal/reduction of contaminated sediments in the Malden River is outside of the scope of the USACE Aquatic Ecosystem Restoration Authority.

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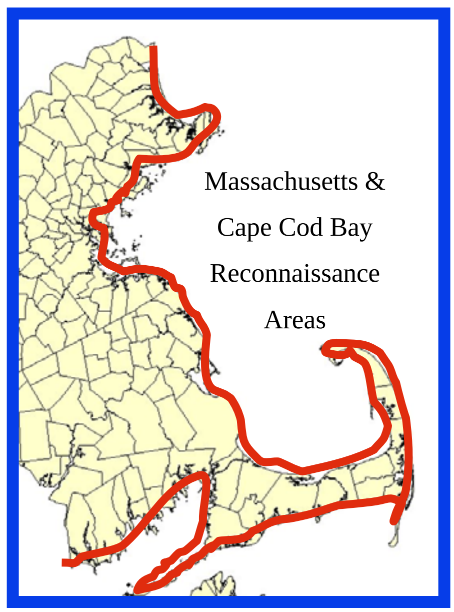
2.0 STUDY AUTHORITY

On 23 July 1997, the Coastal Massachusetts Ecosystem Reconnaissance Study, the initial authority for the investigation of the Malden River, was authorized by a resolution adopted by the Committee on Transportation and Infrastructure of the United States House of Representatives. The resolution states:

> "Resolved by the Committee on Transportation and Infrastructure of the United States House of Representatives, that the Secretary of the Army is requested to review the report of the Chief of Engineers on the Massachusetts and Cape Cod Bays, Massachusetts, published as Senate Document 14, 85th Congress, and other pertinent reports, to determine whether modifications of the recommendations therein are advisable in the interest of environmental restoration and other allied purposes along the Massachusetts and Cape Cod Bays' coastal shoreline and associated waters."

The USACE conducted a reconnaissance study encompassing the watersheds of Massachusetts and Cape Cod Bays. The reconnaissance study examined existing information to identify potential restoration areas and methods to restore degraded habitats. The four targeted restoration types for further USACE investigations were: (1) tidal and freshwater wetlands, (2) riverine migratory corridors, (3) benthic habitats containing contaminated sediments, and (4) degraded shellfish beds.



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3.0 STUDY PURPOSE AND SCOPE

This Malden River Ecosystem Restoration Detailed Project Report is an interim response to the resolution authorizing USACE to conduct ecosystem restoration feasibility studies along Massachusetts Bay and Cape Cod Bay watersheds.

3.1 PURPOSE AND SCOPE

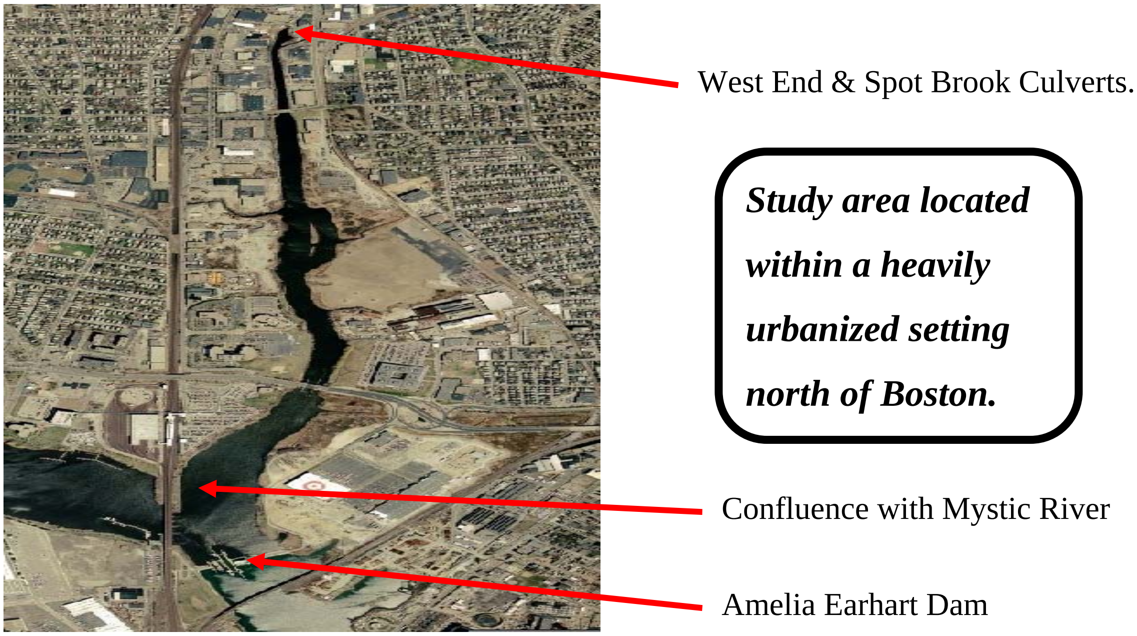
The Malden River Ecosystem Restoration Feasibility Study's overall goal is to identify feasible restoration activities that will restore the Malden River ecosystem to the highest habitat and resource quality that it can reasonably support and sustain. A comprehensive database pertaining to Malden River's ecosystem function provided a foundation for the development and screening of potential restoration measures. Using the information from this database, this Detailed Project Report focuses on development of alternative plans for the restoration of freshwater wetlands, riverine migratory corridor, and benthic habitats containing contaminated sediments, each of which was equally weighted during the evaluation process.

Currently, the Malden River is a degraded river ecosystem, where the surface water quality and underlying toxic sediments pose significant challenges to local fisheries and benthic communities. The bordering lands of the Malden River consist predominately of former tidelands bound by rail lines along each bank. These river banks are filled with razed building materials, industrial wastes and dredged material, which supported early industrial development. In their current condition, riverbank frontage has little ecological resource value. Riparian wetlands along the riverbanks are dominated by the exotic, invasive wetland plant, *Phragmites australis*, and the abundance and diversity of resident wildlife is limited.

The study area for this ecosystem restoration initiative is the upper reaches of the Malden River, where it daylights through the West End and Spot Pond Brook culverts after passing beneath the center of Malden to its major flow control structure the Amelia Earhart Dam, which is located immediately downstream from the confluence with the Mystic River.

3.2 STUDY PROCESS AND CHRONOLOGY

This report builds on the initial observations and recommendations of the Coastal Massachusetts Ecosystem Reconnaissance Study to fully evaluate the potential for ecosystem restoration opportunities within the Malden River corridor. The elements of this Detailed Project Report are outlined in a Project



Study Plan (PSP), which detailed the scope, schedule, and budget of the Detailed Project Report, in accordance with Corps of Engineers regulations. The project was initiated in October 2002 upon the execution of the Feasibility Study Cost Sharing Agreement (FCSA) between the Government and MVDC.

The Detailed Project Report was developed in two phases. Phase I dealt with initial data compilation and review, screening of feasible restoration strategies and the development of ecosystem restoration measures that could reasonably support and sustain the highest habitat and ecosystem quality. The selected components or “building blocks” for these restoration alternatives were then developed in sufficient detail for further evaluation and comparison by USACE personnel. This Detailed Project Report incorporates the results of Phase I and presents the results of this evaluation comparison of the selected ecosystem restoration alternative plan components and identifies the recommended National Ecosystem Restoration (NER) plan.

It is necessary to emphasize that the “building blocks” concept can be stand alone restoration activities that can be completed in whole or in part to achieve the maximum environmental benefits. They are intended to complement the ongoing as well as proposed restoration work by others as a part of the overall comprehensive NER plan. To this end, those alternatives that would incur significant environmental benefit and yet were eliminated from further consideration were primarily due to cost and/or outside the scope of this investigation such as ongoing response actions. The response actions are designed to address the historic sediment contamination and were given consideration during the selection of the recommended NER plan.

4.0 PRIOR STUDIES, REPORTS AND EXISTING WATER PROJECTS

The Malden River and its contributing watershed has been the subject of extensive studies and investigations as part of state and federal initiatives, actions by citizen advisory groups, educational projects and regulatory compliance programs.

During the mid-1800s to early 1900s, changes to the Malden River corridor reflected one of the most ambitious periods of industrial expansion in American history. Numerous chemical and manufacturing operations relied on the Malden River for transportation and commerce north from the port of Boston. The Federal and state governments in cooperation with the cities of Malden, Everett, and Medford, deepened and straightened a mile-long section of the Malden River to create a new Federal river channel for emerging chemical production, coal gasification and manufacturing firms. Following World War II, a retooling of American industry led to the progressive relocation of a majority of the operations conducted along the Malden River. Figure 4-1 depicts several chemical and manufacturing operations that existed within the study limits.

4.1 EXISTING PRIOR STUDIES AND REPORTS

Many reports have characterized hazardous materials left as a legacy sites to this early history. A comprehensive list of available environmental documents entitled "Historic Documentation Summary for Environmental Studies Malden River Corridor," (NCA, 2003; Appendix B Historical Background & Documentation).

4.2 ONGOING STUDIES AND INVESTIGATIONS

In addition to this Detailed Project Report, several comprehensive remedial and/or redevelopment initiatives are underway within the Malden River Corridor. This report integrates complementary goals and objectives to the extent feasible. These activities are briefly described below.

4.2.1 BROWNFIELDS ACTIVITIES

The Malden River corridor is home to a diverse set of current and historic industrial and commercial activities. Some of these activities have resulted in historic releases of oil and hazardous materials (OHM) in a number of abutting parcels to the river or in parcels that are connected hydraulically via groundwater leachate or stormwater conveyance. In 1998, USEPA selected the Malden River corridor to implement a Brownfields Demonstration Pilot Program.

Insert Figure 4-1 – Historic Land Uses

4.2.1.1 River's Edge Project

In 2000, the River's Edge project received a Brownfields Showcase Community designation. Through the development of the River's Edge project, numerous individual locations involving releases of OHM were integrated into one comprehensive remedial action program. The Malden River bisects the River's Edge project where comprehensive restoration of bordering banks is presently underway. As designed, the River's Edge project and the corresponding portion identified as the Malden River Park will involve "the restoration of approximately 8,000 linear feet of bordering banks and tributary wetland areas" including the construction of approximately 1.8 million square feet of office space, 200± residential units and extensive parkland along the Malden River (see Figure 4-2).

4.2.1.2 MCP and Other Hazardous Materials Sites in the Malden River Corridor

The Malden River corridor contains numerous Massachusetts Contingency Plans (MCP) sites involving various spills, leaks, or releases of OHM, including petroleum and fuel by-products, volatile organics compounds, polyaromatic hydrocarbons (PAHs), and metals. While extensive industrial activity within the Malden River Corridor has led to the identification of numerous releases of OHM, comprehensive response measures have been performed over the last two decades, which have led to an improvement in overall environmental quality. Of particular importance to the objectives of this study is that source control measures have been implemented to effectively mitigate the continued discharge of any significant releases to the river system.

A comprehensive review of all historic releases of OHM that have occurred within this formerly industrialized river corridor is beyond the scope of this evaluation. However, a brief evaluation of disposal site characteristics, in terms of location, areal extent, and/or scope of associated remedial activities is in appended (see Appendix B – Historical Background & Documentation).

4.2.2 Other Watershed Studies

Other organizations are actively monitoring or studying the Malden River. Some of these activities are in conjunction with studies of the larger Mystic River watershed. The organizations that are actively monitoring or studying the Malden River include the Mystic River Watershed Association (MyRWA), Tufts University partnering with MyRWA to form the Mystic Watershed Collaborative, United States Geological Survey (USGS), and ENSR performing a watershed-based Flood Insurance Study for FEMA Region I in the Mystic River Basin.

Insert Figure 4-2 River's Edge Phase I

4.3 AUTHORIZED FEDERAL NAVIGATION PROJECT

An authorized Federal navigation project exists within the study area. Adopted in 1912 and modified in 1915, the Rivers and Harbors Act authorized a channel 6 feet deep and 100 to 150 feet wide extending northerly approximately 1.5 miles from the Malden River confluence with the Mystic River to the Medford Street Bridge (see Figure 4-3). The intent of this navigation project was to build upon earlier dredging activities and provide adequate depths for commercial traffic to the cities of Medford and Malden. Channel improvements to aid in navigation were performed through dredging activities in the late 1930s[1] and the mid 1970s[2] by the Commonwealth of Massachusetts. Dredged materials were presumably cast to banks along both side of the Malden River destroying riparian and wetland habitats that historically enhanced its value to fish and wildlife. This loss of wetland habitat along with the straightening of the river to aid navigation severely degraded aquatic habitats of the former estuary.

[1] Proposed Dredging, Malden River, Everett, Malden and Medford, Department of Public Works of Massachusetts, June 1937, Contract No. 499.

[2] Proposed Malden River Channel Improvements, Department of Environmental Quality Engineering, Malden River, Malden, Massachusetts

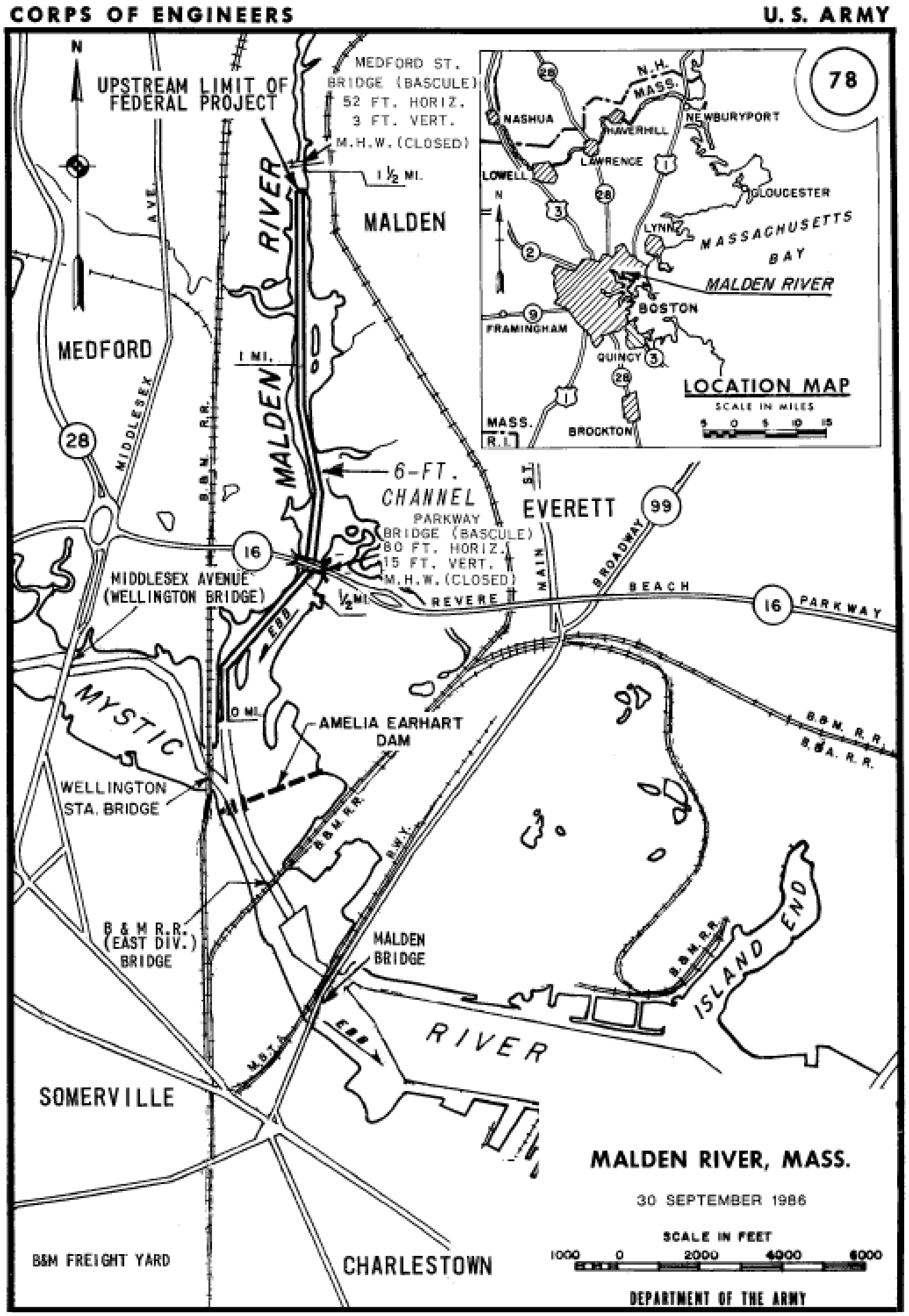


Figure 4-3 Authorized Federal Navigation Channel

5.0 PLAN FORMULATION

This section provides the background on the current conditions and concerns with the Malden River with a brief assessment of existing opportunities and constraints.

5.1 WITHOUT PROJECT CONDITIONS

The Without Project Conditions or No Action Alternative assumes that no restoration efforts of the Malden River would occur. The No Action Alternative would involve no changes to the present situation, except for regulatory-mandated progress in clean-up of Massachusetts Contingency Plan (MCP) and other hazardous materials sites in the watershed that are potential sources of contamination to the river.

Due to limited public access and environmental quality concerns particularly as they pertain to sediments, extensive recreational usage of the River is not provided nor promoted by the three neighboring communities.

5.1.1 ENVIRONMENTAL ANALYSIS

The draft Environmental Assessment (EA) included at the end of this report thoroughly discusses the environmental conditions of the affected area. Findings are briefly summarized in the following sections.

5.1.1.1 Water Quality

Without the project, regulatory-mandated actions by others (stormwater Best Management Practices - BMPs) and remediation of hazardous materials sites will continue to go forward. These actions will contribute to improved water quality, particularly if source areas for contaminated groundwater or sediments at the hazardous materials sites are effectively remediated. Stormwater BMPs, including regulatory programs (USEPA Phase II Stormwater Management) and public education, will aid in the improvement of water quality. However, significant improvements to stormwater quality in such a highly urbanized area as the Malden River watershed are difficult to achieve due to the lack of land for adequate treatment areas and significant costs. Without the implementation of the project, water quality could be expected to exhibit slight improvements but is likely to remain on the Massachusetts 303(d) list for organic enrichment/low dissolved oxygen, pathogens, oil and grease, taste, odor, color, suspended solids, and “objectionable deposits.”

The Malden River will not fully attain its designated use criteria for aquatic life use support in the future without a restoration project. The poor water quality and limited flushing, inefficient fish passage operations, and poor fishery and wetland habitats in the Malden River do not support a healthy aquatic ecosystem.

Without significant improvement in the water quality and reduction in the concentrations of toxic chemicals in the sediments, potential human health risk concerns will persist regarding exposure to Malden River fish or sediments.

5.1.1.2 Sediment Quality

The primary source of sediments to the river will continue to be urban runoff from the large watershed. Contamination will continue to come from runoff as well as from contaminated groundwater and sediment sources of oil and hazardous materials (OHM) from historic releases and existing MCP sites undergoing remediation activities. Elevated levels of semi-volatile organic compounds (SVOCs), most likely from past releases, are considered the primary sediment quality issue. Remediation and clean-up of known groundwater contamination sources that are hydrologically connected to the river system have been undertaken and are likely to have a positive impact on sediment quality. Remediation efforts to control ongoing sources, although helpful in the long run, will not significantly improve existing sediment quality without removal or remediation. The SVOCs in the sediments are very persistent and are not expected to attenuate naturally in the short term.

5.1.1.3 Wetland Habitat

The No Action alternative is unlikely to result in significant differences in wetland quality in the near future from a physical/structural and biogeochemical standpoint.

One component of the wetlands within the study area that may change is the extent of invasive species. The current areal extent of *Phragmites* growth could expand if the surrounding vegetative communities are in a transitional condition, high nutrient levels and partially restricted brackish waters. Conversely, without significant disturbance in the riparian zone, the existing vegetative zonation may differ little or not at all in the future.

Assuming no significant outside influences, the quality and quantity of biological resources (temporal and resident fauna, including benthic community) are unlikely to change over the project evaluation timeframe.

5.1.1.4 Fish & Wildlife Resources

The fish and wildlife resources in the Malden River, which include invertebrate, fish, amphibian, reptile, mammal, and avian populations, are typical for a highly urbanized open water/wetland area. These populations have been impacted by habitat loss, habitat alteration, and habitat degradation for an extensive period of time. Without the proposed project, the limited populations of these resources that are able to persist in degraded habitat will continue to exist.

5.1.1.5 Historic and Archeological Resources

It is likely that prehistoric sites were once present along the original course of the Malden River; however, any evidence of these sites has likely been destroyed by channelization and industrial development.

The Malden River was originally an estuarine coastal stream that flowed into the Mystic River, winding through a dendritic network of tidal flats and wetland marshes (see Figure 5-1). The Mystic River drainage and the coastal zone were utilized by prehistoric populations for at least 9,000 years. Most of the known prehistoric sites in the northern Boston Basin were located in close proximity to coastal estuarine environments, major rivers, and ponds. Other areas of concentrated prehistoric settlement were on the margins of large ponds like Spy Pond and Fresh Pond. Several of these areas contain evidence of recurrent occupation over thousands of years. The inventory of known prehistoric sites in the hilly, upland sections of the northern Boston Basin and Mystic River drainage is limited. However, there were several clusters of prehistoric quarry/lithic workshop sites near outcrops of fine-grained volcanic rocks (rhyolite) in the Melrose and Wakefield sections of the Middlesex Fells uplands. It is likely that prehistoric sites were once present along the original course of the Malden River; however, any evidence of these sites has likely been destroyed by channelization and industrial development.

5.2 ASSESSMENT OF PROBLEMS

5.2.1 EXISTING CONDITIONS

The initial step of the assessment of problems and opportunities is the description of the existing conditions and the impacts to the resources of interest (water quality, sediment quality, freshwater wetlands). This information also provides a context for understanding and evaluating the No Action Alternative, which is discussed in detail later.

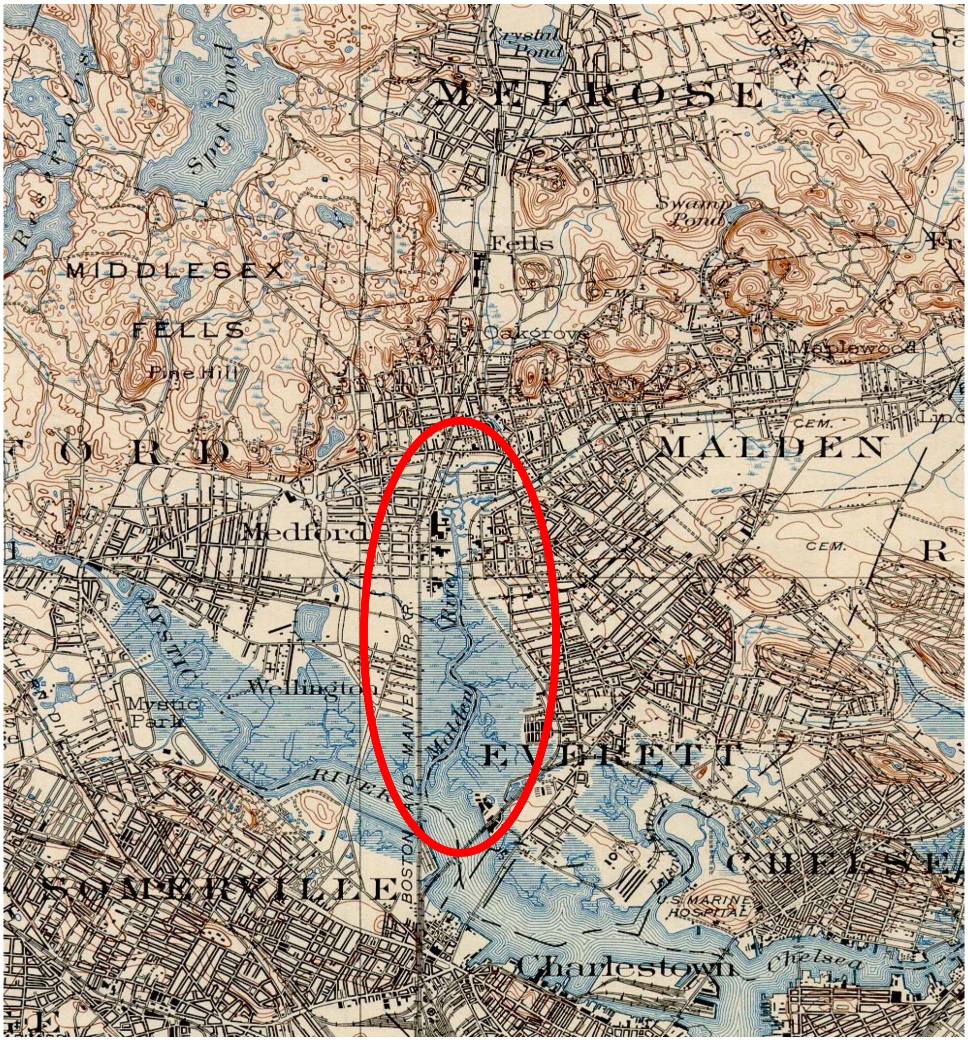


Figure 5-1 Historical Malden River System

(1903 USGS Boston 15 minute Quad Map)

5.2.1.1 Existing Water Quality and Use

The water quality in the Malden River system is a combination of historical filling of the riverine wetlands, and urban and industrial nonpoint/point pollutant sources entering the river. Water quality in the Malden River is generally considered degraded, owing to several sources of contamination (e.g., contaminated sediments, stormwater, historic releases of OHM) and, in particular, poor flushing and mixing. Several focused studies (e.g. NCA, 2000b) describe degraded water quality conditions in the river primarily due to poor mixing and stormwater run-off contributions. In addition, a detailed inspection of the river system, performed by Harris (2000) revealed extensive accumulations of solid waste and debris as remnants of its past industrial setting.

The Mystic Watershed Collaborative, a partnership between the Mystic River Watershed Associations and Tufts University, has been designated to perform weekly monitoring of the system. Monitoring includes fecal coliform bacteria, dissolved oxygen, conductivity, pH and water depth.

5.2.1.2 Existing Sediment Quality

A general description of site history and sources of sediment contamination is provided in the following subsections.

5.2.1.2.1 Sources of Sediment Contamination

The Malden River was originally an extensive tidal wetlands area bisected by a sinuous, meandering channel. Beginning in the 1800's, the wetland areas were filled, the path of the river straightened, and the main stem of the river dredged at various times (1840's, 1890's, 1930's and 1970's) with additional spot dredging to access specific shoreline properties. Eventually tidal influences were eliminated when Metropolitan District Commission constructed the Amelia Earhart Dam. Since the 1970's dredging and loss of tidal circulation, sediments have accumulated undisturbed in the river. Accumulated sediments are underlain by light yellow to blue clay (often referred to as Boston blue clay).

Potential sources of pollutants impacting the sediments include extensive industrial practices during early American history and lingering residuals associated with historic waste deposition. Beginning in the 1800's, intensive industrial land uses were established along the Malden River corridor. Towards the end of the 1900's, most of the industrial companies relocated out of the area. Industries that probably had the greatest impact on sediment quality include manufactured gas plant operations, several asphalt and tar companies, tanneries, metal working plants, and chemical companies (NCA, 1996; 1997; 2000a).

5.2.1.2.2 Location of Sediment Contamination

Sediment depths, together with physical and chemical characteristics have been assessed within major portions of the Malden River. The depth of water in the upper section of the river is five feet or less. Sediments include organic silt, sands, clayey organic silts and clay (Haley & Aldrich, 2001). The depth of sediments (defined as the depth to clay) varies from two feet to over ten feet in the upper section of the river. The thickness of sediment increases with distance from the West End and Spot Pond Brook culvert outfalls. The top layer of sediment is primarily sand at the culvert outfalls and immediately to the south. Further south, the top layer of sediment is primarily organic silt. A cross section depicting sediment in the upper section of the river (from Malden River Culvert Outfall to Medford Street Bridge) is provided in Appendix F (Haley & Aldrich, 2001).

The depth of water in the River's Edge section is five to ten feet and generally increases from north to south. The thickness of sediment in the River's Edge section ranges from approximately seven to eighteen feet. The sediment layer is thickest near the Medford Street Bridge and in the area of the confluence of Little Creek. The top layer of sediment is primarily organic silt. A layer of sand is present below the organic silts in some areas. A profile depicting sediment in the River's Edge section (from Medford Street to Revere Beach Parkway) is provided in Appendix F (NCA, 2003a).

5.2.1.2.3 Pollutant Concentrations in Sediment

Data on sediment quality is available from a variety of sources (TRC, 1985; Haley and Aldrich, 2001, NCA, 2003a; 2003b). A summary of the pollutants detected, range of concentrations average concentration and ecological benchmarks is provided in Appendix F (Tables F-1 to F-4). To provide some context for the discussion of pollutant concentrations in sediments, pollutant concentrations are compared to generic human health and ecological screening criteria. These comparisons are not intended to provide any indication of potential risks. The potential human health and ecological risks associated with sediments in the Malden River can only be assessed through the completion of detailed human health and ecological risk assessments. These assessments would include an evaluation of background conditions, site-specific receptors, and site-specific exposure scenarios.

The screening benchmarks (e.g. threshold effects levels) for ecological receptors are generally less than one part per million for semivolatile organic compounds (SVOCs). These benchmarks are exceeded throughout the river. In an urban setting, a local condition or background level of SVOCs can be expected and may exceed the ecological benchmarks. However, pollutant levels in some areas of the Malden River are significantly elevated and up to five orders of magnitude above the ecological screening benchmarks.

The average concentrations of arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc in sediments exceeded the ecological benchmarks. With the exception of lead, the average concentrations of metals were less than one order of magnitude above the ecological benchmarks. The average concentration of lead was 15 times the ecological benchmark.

5.2.1.3 Existing Wetland Habitat

Historically, the Malden (and Mystic) Rivers consisted of tidal systems with broad expanses of salt marsh and a much different saltwater-driven ecosystem. Since industrialization, filling of wetlands has been completed to allow riverside construction, including making space for portions of the Revere Beach Parkway and adjacent industrial developments. Historic Coast and Geodetic Survey maps from 1860-

1893 illustrate broad expanses of wetlands associated with the river's floodplain, and subsequent wetland loss from the development of railroads, industrial facilities, residential development, and parks. In 1966, the Amelia Earhart Dam construction alleviated upstream flooding and provided a long-term flood protection of infrastructure and residents. This action effectively converted the existing wetlands from a tidally driven saltwater environment into a freshwater system.

Functions performed by the in-stream and adjacent wetlands within the study area include:

- provision of nesting, breeding, and foraging habitat for wildlife;
- transformation of nutrients;
- filtering of toxic substances from stormwater;
- floodwater storage;
- shoreline erosion prevention.

Unvegetated aquatic resources, such as river bottom and unvegetated exposed banks, may provide habitat for wildlife and invertebrate species and provide a substrate for spawning or nesting. The historic losses of wetlands along with river channelization and urbanization of the watershed have reduced the overall effectiveness of the existing wetlands to perform many of these functions. As evidenced by the poor water and sediment quality in the river, and the lack of quality habitat for fish and wildlife, the existing wetlands are insufficient in area and distribution to prevent long-term habitat deterioration.

Currently, wetlands contiguous to the Malden River and its tributaries as well as wetlands isolated in its floodplain exist in limited quantities relative to the river's size. In addition, wetlands communities are predominantly composed of invasive species, primarily common reed (*P. australis*).

***Phragmites* Dominated Riverbanks**

Degraded Riparian Area

The bulk of existing wetlands are located on the east side of the river, both above and below the Amelia Earhart Dam. A plan dated October 5, 1999 and produced by Toomey-Munson & Associates (Wetlands and Wildlife, 1999) provides survey data on wetland boundaries at that time, and extends from the Medford Street Bridge to the north and to the Revere Beach parkway to the south. The following sections provide a description of the different types and characteristics of vegetated wetlands and other protected wetland resources present within the Malden River study area.

5.2.1.3.1 In-stream Habitat

Existing vegetated wetland habitat within the Malden River study area can be classified into several main types. The most predominant type of wetland is palustrine shrub, represented by non-continuous narrow (5 to 30 feet wide) bands of wetlands along the river banks. The shrub wetland is typically at elevations that allow annual or semi-annual flooding to permeate the wetlands. In addition, several other types of wetlands are present and include emergent wetlands, emergent wetland islands and submergent aquatic bed wetlands. Aquatic bed wetlands are typically located in areas along the shoreline with water depths less than 6 feet, and include such species as water shield (*Brasenia schreberi*) and coontail (*Ceratophyllum* spp.).

The great majority of in-stream wetlands in the Malden River are hydrologically sustained by root zone saturation because of their proximity and elevation relative to the Malden River, while a smaller area of wetlands are maintained via seasonal flooding. A minor contribution to the hydrology of in-stream wetlands is also present in the form of stormwater runoff.

5.2.1.3.2 Adjacent Habitat

In addition to those wetlands within or immediately adjacent to the main stem of the Malden River, limited resource areas are also present along or adjacent to the river's tributaries. Primarily, these include Little Creek, North and South Creeks, Mall Creek, and several smaller unnamed tributaries. The majority of these wetlands are dominated by palustrine shrub vegetative communities, although a significant percentage of them are dominated by the invasive species *Phragmites*. Hydrologic conditions in adjacent wetlands are sustained by shallow groundwater and stormwater runoff, with lesser contributions from seasonal flooding. Several of the tributaries to the river appear to be sustained almost entirely by stormwater runoff and overland flow from surrounding areas.

5.2.1.3.3 Non-Vegetated Aquatic Resources

In addition to vegetated wetlands, state and federally protected aquatic resources exist within the Malden River study area. The riverbed itself and its banks up to the mean annual high water elevation represent state and federally-protected aquatic resources. These areas, being primarily unvegetated soft sediment along the river bottom and the riverbanks in their various forms, provide habitat for fish, benthic organisms, mammals, reptiles, and amphibians. In addition, state regulatory “Riverfront Area” protection exists for all of the land located within 25 linear feet of the top of the Malden River’s banks, beginning at the river’s bankfull elevation.

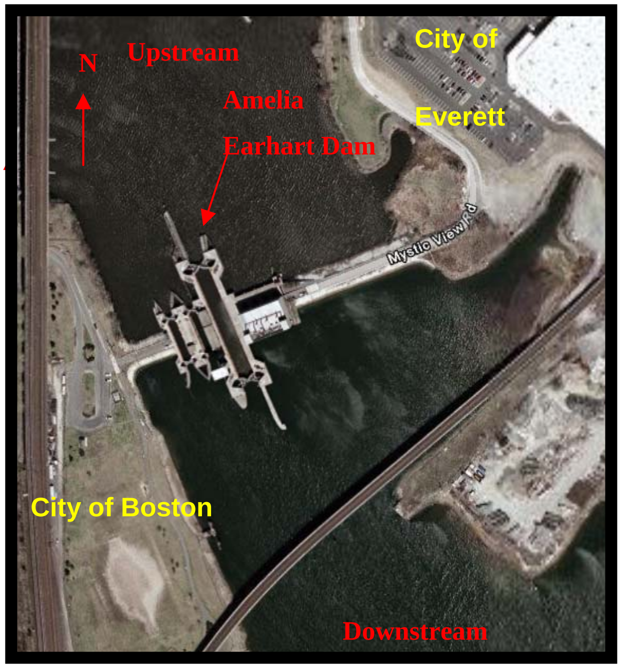
5.2.1.4 Existing Fish and Macroinvertebrates Resources

The following section describes the aquatic biological resources in the Malden River, including resident and migratory fish and benthic macroinvertebrates.

5.2.1.4.1 Fish

The Malden River currently supports a resident, pollution-tolerant warmwater fishery. A significant anadromous fishery was likely present prior to the industrial expansion. Fish species such as white perch (*Morone americana*), American shad (*Alosa sapidissima*), rainbow smelt (*Osmerus mordax*), Atlantic salmon (*Salmo salar*), and Atlantic Sturgeon (*Acipenser oxyrinchus*) historically used Atlantic coastal river systems. Construction of dams and other impacts to their habitat have significantly reduced their overall presence in New England (NMFS, 2004).

As a result from the severe flooding during Hurricane Diane (August 1955); the Amelia Earhart Dam was constructed during the late 1970’s. The flood control facility included a pumping station with a capacity of 4,200 cubic feet per second (cfs) to maintain the upstream basin level between elevation 104 and 106 feet MDC datum. Freshwater discharges from the basin by gravity on the outgoing tides via manually controlled gates. During storm events occurring at high tide, three pumps can each discharge 1,400 cfs to the downstream side of the dam.



While the Mystic River and Lower Mystic Lake system is known to support an anadromous fish run, including blueback herring (*Alosa aestivalis*) and alewife (*Alosa pseudoharengus*), state and federal regulatory agencies are unaware of any significant fishery in the Malden River at this time (MADMF/NMFS, 2003). However, anecdotal evidence of the presence of blueback herring has been presented by Mystic River Watershed Association (MyRWA) volunteers. Based upon the observations of MyRWA, herring and potentially other anadromous fish are present annually near outfalls and creek mouths along the Malden River in readily observable numbers. It is unknown whether these fish enter the Malden after passing through the Earhart Dam, or have emigrated from the Mystic River. Presently, however, the Massachusetts Division of Marine Fisheries (MADMF) consider the Malden to be a primarily warmwater system known to harbor selected freshwater fishes, such as carp (*Cyprinus carpio*), yellow perch (*Perca flavescens*), brown bullhead (*Ictalurus nebulosus*), and the catadromous species American eel (*Anguilla rostrata*) (MADMF, 2003). Correspondence with the Massachusetts Natural Heritage & Endangered Species Program (NHESP) included in the Natural Resource Inventory/Assessment (Wetlands and Wildlife, 1999) completed for the MVDC indicates the potential presence of several other warmwater gamefish, including largemouth bass (*Micropterus salmoides*) and chain pickerel (*Esox niger*). Based upon discussions with regulators and local individuals, some limited sport fishing does occur in the Malden River, though no population data is known to be available for the species believed present. Striped bass (*Morone saxatilis*) are passed through the lock in the spring, summer, and fall months when present.

Currently, the sole means of passing anadromous fish through the dam is via lock operation by the Department of Conservation and Recreation (former Metropolitan District Commission). While the frequency and duration of lock operations and the number of fish passed is not known, it is known that blueback herring numbering over one million migrate through the Mystic River to arrive at the Lower Mystic to spawn each year (MADMF, 2003). Amelia Earhart dam operations occur in the daytime hours only, inhibiting night-migrating anadromous fish such as smelt from moving upstream. Based upon discussions with the MADMF, numbers of smelt and shad that were known to migrate upstream prior to dam construction and became nonexistent within several years of installation. There is an existing sluice structure within the Amelia Earhart Dam which, based upon discussion with state and federal agencies (MADMF and National Marine Fisheries Service) (NMFS, 2004), is reportedly inoperative. While the efficacy of the sluice is not known, there may be concerns over allowing too much saltwater upstream as a result of its use. As described in Section 4.1.1.4, there have been historical difficulties resulting from saltwater intrusion into the Lower Mystic Lake. Consequently, fish passage through the dam is facilitated through lock operation only.

While fish passage impairment and the removal of tidal flushing through the dam are assumed a significant factor in the absence of a good quality anadromous fishery in the Malden River, lack of flow and suitable habitat (as exists in the Mystic River) may be of equal importance. Although the lower reach of the Malden River at its confluence with the Mystic may at some time temporarily contain transient anadromous species, there is consensus among agencies such as DMF and the NMFS that the Malden River is presently unlikely to attract and support significant populations of anadromous fishes due to four primary reasons: 1) lack of good quality spawning habitat, 2) lack of flow volume, 3) lack of deep pools, and 4) poor water quality,. While some of these issues may be addressed through restoration efforts, the Mystic River system may continue to be more attractive and hospitable to anadromous species than the Malden River even if improved fish passage is accomplished.

5.2.1.4.2 Macroinvertebrates

Benthic community richness and composition are commonly considered a primary means of assessing water quality. These primary means provide many details about a waterbody such as the salinity of the environment, the relative level of oxygen demand present and relative toxicity of sediment (Merritt, 1996, Thorp, 1991). While no additional in-field studies of the benthic community were completed during this study, the study team reviewed previous characterizations of the Malden River's benthic community completed in February 2003 (Pratt, 2003). In addition, available information on sediment and water quality as well as benthic habitat type and suitability were factored into consideration of the macroinvertebrate community.

Based upon the 2003 study, the dominant benthic species present in the Malden River are oligochaetes, a type of annelid worm capable of living in very low oxygen and polluted environments. In addition to the oligochaetes, midges (*Chironomidae*) and copepods (*Harpacticoida*) were also present in noticeable quantities. Overall, the 2003 study illustrated low diversity and low relative abundance, with significantly lower totals downstream. The average number of individuals per sample decreased from 1590 at the Medford Street sampling point to 2.3 at the Route 16 sampling point. Sediment substrate downstream of the confluence of Little Creek is described in the 2003 report as "a surface layer of liquid mud," observed to severely inhibit the benthic community. As discussed in Appendix F, this portion of the river system also contains the most concentrated area of historic sediment contamination due in part to the formerly tidal nature of the Malden River and related sediment deposition at its confluence with Little Creek.

It should be noted that a previous study completed in 2002 (Larsen, 2002) that is referenced in the 2003 study, showed a larger and more diverse group of macroinvertebrates in the Malden River than was observed in the 2003 study. This may be due to the method of sample collection in the 2002 study, which included the placement and retrieval of a substrate that attracts macroinvertebrates. However, no species known to be intolerant of poor water quality, such as mayfly, caddisfly, or stonefly (*EPT taxa*) was observed in either the 2002 or 2003 studies.

5.2.1.5 Other Wildlife

Minimal existing information was available regarding the present use of the Malden River by mammals, reptiles and amphibians, or avian species. It has been directly observed that a significant variety of common species tolerant of anthropogenic habitat changes use the Malden River corridor, as well as a variety of waterfowl and water-dependant species (kingfisher (*Ceryle alcyon*), black-crowned night heron (*Nycticorax nycticorax*)); small mammals, including muskrats (*Ondatra zibethica*); and reptiles (Northern water snake (*Nerodia sipedon*) and snapping turtle (*Chelydra serpentina*)). Disturbance-intolerant species and wetland/riparian habitat dependant species are not presently know to make significant use of the Malden River corridor, likely as a result of lack of wetland area and contiguous vegetated riparian buffer habitat.

5.2.2 SUMMARY OF PROBLEMS

The study team reviewed available reports, studies and investigations, and evaluated existing conditions to summarize the present environmental challenges and potential opportunities in the Malden River. Current impacts to the three ecosystem resource areas of interest (water quality, sediment quality and wetland habitats) are detailed below. The existing ecological impairments are depicted in Figure 5-2.

Water Quality

Water quality is probably the most important “driver” of environmental restoration in the Malden River. Current sources that may be contributing to the degradation of water quality within the Malden River include contaminated sediments, urban stormwater runoff and groundwater. The degradation of water quality is exacerbated by the lack of flushing in the river, either by sufficient freshwater inflow or by tidal exchange. Low channel gradients and little inflow result in low water velocities, creating impoundment-like conditions throughout the Malden River.

Insert Figure 5-2 Existing Ecological Impairments

Sediment Quality

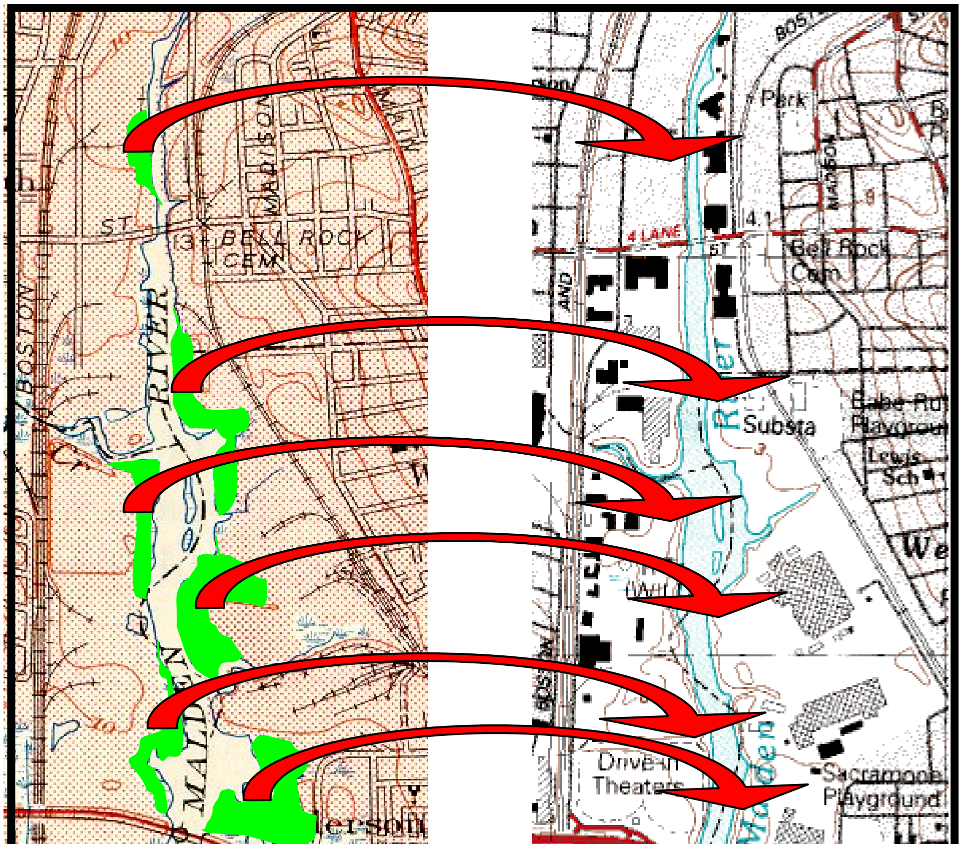
Regarding the current sediment quality in the Malden River, general conclusions are as follows:

- SVOCs are present at levels several orders of magnitude above the ecological screening benchmarks throughout the river. The highest levels of semivolatile organics are present near the Medford Street Bridge and at the confluence of Little Creek and the Malden River. SVOCs are present at levels exceeding the MA DEP upper concentration levels (UCLs) only in these areas. Separate phase pollutants may be present in sediments in these areas. SVOCs are present at elevated levels (over 100 ppm) in the immediate vicinity of the Medford Street Bridge.
- Metals were not detected at levels exceeding the UCLs, but they exceed the ecological screening benchmarks throughout the river. The highest levels of combined metals (e.g., arsenic, lead, zinc) are present above the Revere Beach Parkway. Elevated lead and zinc levels are present at various locations throughout the river.
- The thickness of sediment ranges from 2 to 18 feet. Pollutants are present at all depths. Remediation must consider the impact of contamination in sediments from all depths.
- Stormwater discharges as well as atmospheric deposition will continue to provide a degree of pollutant loading in the system. As stormwater practices improve, pollutant loading will be reduced.

Wetland Loss and Habitat Degradation

The review of historical maps and documents clearly indicates the loss of the majority of the wetland resources historically associated with the Malden River system. Figure 5-3 illustrates the loss of the historic wetland habitat, in green, over the last six decades.

Primary causes for wetland loss include filling for industrial and commercial development, channelization for navigation, and historic dredging by Federal, state and private interests. Wetlands that currently remain have undergone varying effects of anthropogenic degradation because of impacted stormwater runoff, industrial contamination, invasive species colonization, habitat fragmentation, and discontinuation of tidal cycling. The cumulative effects of wetland loss and degradation on the Malden River system are significant, and include: 1) loss of nesting and foraging habitat and travel corridors for wildlife, 2) loss of macroinvertebrate habitat among submergent and emergent wetlands, 3) reduced shade, cover, and structure (snags and detritus), 4) reduced nutrient, toxicant, and suspended solids removal from stormwater, and 5) reduced erosion protection along the river's shoreline.



1946 USGS Topo Map 2003 USGS Topo Map

Malden River - Malden, Medford & Everett, Massachusetts

Figure 5-3 U.S.G.S. Topographic Map Comparison

Removal of tidal cycling and saline influence upon wetlands has also had a massive impact upon the health and richness of the Malden River wetland system. Historic Malden River wetlands (pre-1966) were certainly composed of salt marsh, with cordgrass species (S*partina alterniflora* and *S. Patens*) representing the dominant community. While historic salt marshes may have actually had a lower overall vegetative diversity due to the tidal and saline influences, they are typically considered to be among the most valuable types of wetlands due to the high functional values associated with them, such as estuarine habitat provision, rapid nutrient cycling, dilution and stabilization of toxicants, and maintenance of a complex benthic community (Kadlec, 1996; Hammer, 1997). Removal of the saline influence ultimately allowed species such as *Phragmites* to become dominant.

Invasive plant species are common throughout the study area, particularly in areas of recent land disturbance. The majority of wetlands and large areas of adjacent riparian zone uplands are dominated by the invasive reed species, *P. australis*. Other invasive species, such as European buckthorn (*Rhamnus frangula*), tree-of-heaven (*Ailanthus altissima*), purple loosestrife (*Lythrum salicaria*) and water chestnut (*Trapa natans*) are also present within the study area, but in much smaller quantities over scattered areas. Previous studies, such as Natural Resource Inventory/ Assessment (Wetlands and Wildlife, 1999) confirm this condition. Causes for invasive species colonization include loss of saline influence, physical disturbances along the banks, stormwater and nutrient inputs, and wetland filling.

The effects of invasive species on the Malden River ecosystem are varied. Small patches of invasive species such as buckthorn and tree-of-heaven may be undesirable, but do not necessarily represent a significant system-wide impact. Their removal is typically simple, and they do not commonly out compete other native trees and shrubs. Rather, they are quick to colonize disturbed areas but represent an early stage of vegetative succession. Large contiguous expanses of invasive species such as *Phragmites* however, clearly do represent a degradation of ecological benefit in comparison to areas vegetated by native non-invasive species. Due to its growth habits, *Phragmites* forms dense, monotypic stands that crowd out all other plant species, provide minimal food and cover for wildlife, and as an ancillary impact, grow so tall (to 14 feet) as to obscure views of the river and detract from its aesthetics. *Phragmites* can spread quickly via both seed and rhizome (root stock), and due to its ability to grow both in wetlands, moist uplands, and among both fresh and brackish water habitats, its spread is very difficult to control. Growth patterns of *Phragmites* are often supported by anthropogenic activities in urban areas, such as fire suppression, which maintains a low successional stage for a long period (Burdick, 2003). Effective techniques for its removal and subsequent suppression do exist, however, and reestablishment of a native community of tree, shrub, and herb species in areas currently colonized by *Phragmites* is a high priority among currently proposed restoration measures.

5.3 ASSESSMENT OF OPPORTUNITIES

5.3.1 PROJECT GOALS AND OBJECTIVES

Based on the historic and existing conditions, the following restoration goals and objectives were developed for the Malden River. These include the primary ecosystem restoration goals, as well as unrelated stakeholder issues, and/or watershed activities.

5.3.1.1 Primary Ecosystem Restoration Goals and Objectives

The primary goal of the Malden River Ecosystem Restoration Project is to restore the ecosystem to the highest quality that it can reasonably support and sustain. The objectives described below support this overall goal. In accordance with the USACE ecosystem restoration guidelines, the major restoration objectives for the Malden River Feasibility Study are:

- Restoration of freshwater wetlands to provide habitats for native fish and wildlife; Reduction of current impacts caused by sediment quality and restoration of degraded benthic habitat; and
- Reduction of current impacts to water quality and water quality standard exceedances, to restore water quality as a structural component of the riverine migratory habitat.

Accordingly, the Malden River ecosystem restoration measures and plans were developed to deal with these three primary ecosystem interests.

5.3.1.2 Secondary Ecosystem Restoration Objectives

Based on pubic stakeholder meetings and comments, additional secondary objectives were identified for the Malden River Feasibility Study. These secondary objectives, while desirable to watershed stakeholders, address issues or interests that are outside, or subordinate to the programmatic objectives of the USACE Ecosystem Restoration Program. However, whenever feasible, secondary interests were considered when evaluating potential benefits of restoration plans, to help identify measures or plans that provided positive outcomes for primary objectives and incidental benefit for secondary objectives, including:

- Increase potential recreational use of the river;
- Increase potential public access to river channel; and
- Reduce potential human health risk concerns regarding exposure to the surface water and sediments.

5.3.1.3 Other Complementary Watershed Activities

Within the Malden River watershed, many other local, state, and federal programs and initiatives potentially influence the effectiveness of the ecosystem restoration measures and plans. These include, but are not limited to:

- Massachusetts Contingency Plan (MCP) or federal regulatory-driven hazardous materials site remediation;
- Coordination with 10-acre river corridor development and site improvements under the River's Edge project;
- Improved stormwater treatment programs (including USEPA-mandated Stormwater Phase II activities) and installation of stormwater BMPs in the watershed;
- Watershed land use and environmental stewardship programs sponsored by local Conservation Commissions or similar organizations;
- Shoreline clean-up activities sponsored by watershed associations (e.g., MyRWA);
- Similar types of water quality improvements in the Mystic River watershed since there is potential mixing between the two rivers above Earhart Dam;
- Recreational initiatives for increasing public access or easement such as the Bike-to-the-Sea project (MDH, 1996); or the planned elements of the Malden River Park (i.e., public parkland along the river, 10-ft. wide "riverwalk," benches and scenic overlooks); and
- Other permits, programs or initiatives that lead to improvement in water quality and/or sediment quality in the Malden River.

The study team incorporated the secondary and complementary objectives into the study process.

Completed Riverbank Enhancement, Everett

Ongoing Mitigation Project, Medford

New Stormwater Outfall Construction, Medford

Ongoing Debris Removal, Medford

5.3.2 IDENTIFICATION OF RESTORATION MEASURES

As the initial step in the development of the ecosystem restoration alternative plans, the potential restoration measures (e.g., specific methods or approaches that address one or more restoration components of the three resource interests) were compiled. These three resource interests are:

- Restoration Measures for Wetland Habitat
- Restoration Measures for Sediment Quality and Benthic Habitat
- Restoration Measures for Water Quality and Riverine Corridor

The first stage of identification of measures was very inclusive and included a wide spectrum of standard or generic measures. These were selected without critical scrutiny as to their effectiveness or relevancy for the Malden River. Table 5-1 provides the results of the screening process. At the first public stakeholder meeting (September 25, 2003), the measures that were obviously ineffective or not appropriate for use in the Malden River were screened out. During this first stakeholder meeting, measures that would be appropriate and effective for the Malden River, but which were not within the guidelines of the USACE Ecosystem Restoration mission, were also identified. These were noted as "Actions to be performed by Others." These measures were retained in the document for completeness but were not further evaluated.

Following further data review, contact with appropriate regulatory staff, and a more complete evaluation, many of the ecosystem measures were eliminated since they were not as effective, efficient or relevant as others were with respect to the scope of the study. The effective measures were retained as so-called "building blocks" to be combined in the ecosystem restoration alternative plans. A brief review of the measures that passed the preliminary screen and that were further evaluated is given below (see also Secondary Screen column in Table 5-1), organized by resource of interest.

5.3.2.1 Measures to Improve Water Quality to Support Fish and Wildlife Habitats

Water quality in the Malden River is degraded, owing to several sources of contamination (e.g., contaminated sediments, stormwater, historic releases of OHM), poor flushing and mixing. Degraded water quality conditions in the river were the focus of several studies. Inadequate mixing and stormwater run-off were identified as contributors to the poor water quality. In addition, a detailed inspection of the river system, performed by Harris (2000) revealed extensive accumulations of solid waste and debris as remnants of its past industrial setting. A number of organizations are implementing measures to address these sources of contamination. For instance, the cities of Medford, Malden and Everett are implementing Best Management Practices (BMPs) to address sixteen stormwater discharge outlets. Suitable stormwater outlets may be considered for reconstruction with hydrodynamic particle separators, sediment chambers, and open sedimentation basins. These BMPs are located throughout the 7,000 acre watershed and will complement the recommended plan by improving water quality. As discussed elsewhere in the report, PRPs are remediating sources of hazardous contamination in and adjacent to the river. These activities will provide an increment of water quality improvement to complement the plan recommended in the report. A NPDES Phase II Permit has been issued to the City of Malden (NPDES Permit # MA 041046). Measures included Public Education and Outreach Programs, Public Involvement and Participation, Illicit Discharge Detection and Elimination, Construction Site Stormwater Runoff Control, and Post-Construction Stormwater Management in New Development and Redevelopment.

The Mystic River Watershed Association (MyRWA) has initiated a Water Quality Awareness Program for the Mystic River Watershed. MyRWA's goal is to achieve a level of water quality that will allow the waters to be classified as "fishable and swimmable" by 2010.

MyRWA has requested a commitment from the Massachusetts Department of Environmental Protection and the Massachusetts Water Resources Authority to eliminate combined sewer overflow discharges into the Mystic River watershed. MyRWA and Massachusetts Executive Office of Environmental Affairs have also partnered to continue and increase water quality monitoring.

TABLE 5-1 ENVIRONMENTAL RESTORATION MEASURES EVALUATION AND SCREENING SUMMARY

	Potential Benefits			Evaluation Factor				Result of Screening	
Environmental Restoration Measures	**Riverine Corridor**	**Benthic Habitat**	**FW Wetland Restoration**	**Technically Feasible**	**Effectiveness**	**Acceptable Permitable**	**Adverse Long-term Effects**	**Preliminary Screen**	**Final Evaluation**
No Action	Partial	Partial	No	Yes	No	Yes	No	Yes	**Yes**
Restoration Measures for Water Quality and Riverine Corridor									
Adoption/installation of Best Watershed Management Practices (BMPs)	Yes	Partial	Partial	Yes	Partial	Yes	No	Yes	**Yes ***
Re-routing/by-passing of Stormwater Flows	Yes	Partial	No	No	Yes	No	?	No	No
Control Toxic Releases at Hazardous Materials Sites	Partial	Yes?	No	Partial	Partial	Yes	No	Yes	**Yes ***
Watershed Flow Management (i.e., storage and release of water from Spot Pond)	Yes	Partial	Partial?	No	Partial	No	?	Yes	No
Incorporate Vegetated Upland Buffers	Partial	No	Partial	Yes	Partial	Yes	No	No	No
Aeration/Recirculation of Water	Yes	Partial	No	Yes	Partial	Yes	?	Yes	Phase II
Increase Flushing by Changed Management of the Dam or Surface water (pool) Elevation Management	Yes	Yes	Yes	Yes ?	Partial	Yes	Yes ?	Yes	No
Re-institution of Estuarine Tidal Cycling	Yes	Yes	Yes	No	Partial	Yes	Yes ?	Yes	No
Enhanced Fish Passage	Yes	No	No	Yes	Partial	Yes	No	Yes	**Yes**
Restoration Measures for Sediment Quality and Benthic Habitat									
Dredging of Sediment - in channel disposal	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No
Dredging of Sediment – alternative disposal and/or reuse	Partial	Yes	Yes	Yes	Yes	Yes	No	Yes	**Yes**
Localized Dredging of Sediment – in channel disposal	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	**Yes**
Localized Dredging of Sediment – alternative disposal and/or reuse	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	**Yes**
Capping of Sediment- Full Cover	Partial	Yes	No	Yes	No	Yes	No	No	No
Thin Layer Sediment Cover	Partial	Yes	No	Yes	Yes	Yes	No	Yes	No
In Situ Chemical Treatment/Stabilization of Sediment	Partial	Yes	No	No	No	No	No	Yes	Phase II
In Situ Biological Treatment of Sediment	Partial	Yes	No	No	No	No	No	Yes	No
Monitored Natural Recovery	No	Yes	No	Yes	Partial	Yes	No	Yes	No
Re-configuration of Channel Location/Morphology	Partial	Yes?	Yes	Yes	Partial	Yes	No	No	No
Restoration Measures for Wetland Habitat									
Vegetation Cutting and follow-up procedure	No	No	Yes	Yes	Partial	Yes	No	Yes	**Yes**
Root rhizome excavation; alter wetland elevation	No	Partial	Yes	Yes	Partial	Yes	No	Yes	**Yes**
Herbicide Treatment (stand-alone)	No	No	Yes	Yes	No	Yes	?	Yes	No
Establish Native Vegetation	No	No	Yes	Yes	No	Yes	No	Yes	**Yes**
Incorporate Structural Habitat Improvement Measures	No	No	Yes	Yes	Partial	Yes	No	Yes	**Yes**
Expand/enhance existing tributaries and creeks	Partial	Partial	Yes	Yes	Partial	Yes	No	Yes	**Yes**
Combination of approaches	Partial	Partial	Yes	Yes	Partial	Yes	No	Yes	**Yes**

Yes * = recommended measure, but Action to be performed by Others.

Phase II = eliminated as an overall restoration measure in Phase I, but will be considered for limited application in Phase II

Water quality is an important component of the ecosystem and water quality improvements have been identified and evaluated in the following subsections. However, water quality improvement measures associated with urban and industrial nonpoint/point pollutant sources can not be implemented under the Corps Ecosystem Restoration Program unless justified based on benefits to aquatic resources. These associated improvement measures were determined to be the responsibility of other parties who have a legal obligation for remediation.

Though Corps can not participate in water quality improvement, several potential options were identified to improve water quality in the Malden River and are intended to be performed by others. These options include improvements to flushing, artificial mixing/aeration, and removal of sediment hotspots. These options are presented for consideration of others and are discussed briefly below.

Improved Flushing

Two feasible options were identified to improve flushing of the system. The first option identified is to allow fresh water stored upstream in the upper watershed (e.g., in Spot Pond) to be released during the summertime to reduce toxic concentrations, turbidity, and improve dissolved oxygen (DO) concentrations. This option maintains (or improves) the existing freshwater ecosystem. The implementation of this option requires a sufficient "excess" supply of freshwater in the watershed, as well as adequate conveyance to transport the water into the Malden River. Currently, inadequate volume of flows is available to provide sufficient flushing through this method. Following further review and evaluation, this measure was eliminated from consideration.

The second option identified involves the reintroduction of tidal flows into the river by altering the operation of or retrofitting the Amelia Earhart Dam. From a hydrodynamic standpoint, this alternative shows much promise as a means to increase flows. However, the introduction of tidal flow into the Malden River would alter the current ecosystem, creating a brackish environment, and has potential to cause severe water quality problems in the Mystic River. The Amelia Earhart Dam is currently operated to maintain the basin's water elevations upstream of the dam, by sluicing water out of the basin at low tide and pumping water into the harbor during high tides. Options such as changing the upstream basin water elevation and/or regulating downstream releases to promote additional circulation are not practicable. The operators are required to maintain adequate water levels for boating and to protect spawning fish areas. Following further review and evaluation, this restoration measure was eliminated from consideration.

Aeration

Aeration or artificial circulation in the water column can potentially improve dissolved oxygen (DO) concentrations and has been suggested for potential application in the Malden River (Harris, 2000). Aeration is generally aimed at DO improvements in the hypolimnion (i.e., the deepest, denser layer in a stratified water column), which is not present in the Malden River. It is believed that no significant seasonal thermal stratification develops in the Malden River due to the shallow water depths (≤ 6-8 ft) in most of the river. Some DO gradient may be seen with depth due to high oxygen demand from the sediments.

Although an artificial circulation system in the Malden River would serve to increase DO locally, they provide the most benefit in areas with seasonal thermal stratification and where the induced high DO concentrations can be retained by the density barrier.

Any form of aeration in the Malden River would be a challenge due to shallow water depths and lack of stratification. While such a device may lead to localized increased DO concentrations, these concentrations will not be retained long in the river once the system is turned off. This would result in a simple degassing of the oxygen into the upper layers and ultimately to the atmosphere. This would not lead to either of the typical goals of aeration being achieved – either increasing DO concentration in a confined layer or in significant oxidation of reduced chemical forms in the water column or in the sediments. Therefore, aeration is not considered as a restoration measure for the Malden River in this report.

Removal of Sediment Contamination

Poor quality sediments provide a potential source of contamination to the overlying water column via resuspension, desorption or diffusion. Dredging and/or capping of contaminated sediments would reduce the amount of toxics that can enter the water column. Either of these options could result in a slight improvement in overall water quality, particularly as they pertain to the removal of the upper loose or unstable sediment layer. They are not cost effective means of restoration of the water column within the entire river system due to the nature and extent of contaminated sediment deposition. However, since this option directly affects sediment quality and may have an incremental benefit to water quality within discrete or target area.

5.3.2.2 Measures to Improve Sediment Quality and Benthic Habitat

Dredging

Dredging may be used to remove all or a portion of contaminated sediments from the system. Dredged material could be reused beneficially or dispose at a suitable upland site. Removal of the existing material from the river bottom would reduce or eliminate negative impacts of the contaminants to the water column and to benthic habitat. While beneficial, the costs for full river restoration exceed the cost guidelines of the feasibility study. Although, the cost and authority for removal of contaminated sediments exceed the scope, model results demonstrates that improvement in habitat quality would rise through varied amounts of sediment removal followed by capping. It is technically challenging and costly to remove material down to a clean substrate due to the depth of contaminated sediments. Dredging to significant depths could also result in areas of reduced dissolved oxygen (DO), which would have a negative impact on water quality. Rather, partial removal and capping would be a more practical option. Capping of underlying contaminated material would be required to complete the effectiveness of sediment removal. This measure was retained for further evaluation.

In-Situ Treatment

In-situ treatment of contaminated sediments involves the injection and mixing of chemicals or biological agents into the sediments to reduce or eliminate contamination to acceptable levels. There are two basic types of in-situ treatment applicable to sediments in the Malden River. These two types are in-situ biological treatment and in-situ stabilization.

In-situ biological treatment method works by providing the right conditions (oxygen levels, nutrient levels, etc) for microbes (either indigenous or introduced) to break down pollutants to non-toxic by-products. The process is most effective for organic pollutants but can, in some cases, help immobilize metals.

Site conditions at the Malden River are not compatible with the use of in-situ biological treatment. In-situ biological treatment is not effective for the high molecular weight hydrocarbons (benzo(a)pyrene, benzo(b)fluoranthene, and benzo(a)anthrene) (USEPA, 2000) that are the primary concern in the Malden River. Delivery and adequate mixing of biological reagents in the mixture of soft muck, silts and sand in the river would be very difficult. Reagents would tend to flow through the sands and higher permeability material and not penetrate the silts and muck. Verification of the effectiveness of in-situ biological treatment is often difficult. Compared to other alternatives, the time required to achieve remediation goals with biological treatment are often much longer. Primarily in consideration of the difficulty degrading high molecular weight hydrocarbons, in situ biological treatment is eliminated from further consideration.

In-situ stabilization does not destroy or remove pollutants from sediment. Reagents are added and mixed with the sediment to immobilize the sediments. The pollutants would be bound in a solid or semi-solid matrix. In theory, pollutants bound in the matrix would not be available to come in contact with human or ecological receptors. In-situ stabilization is most applicable to metal pollutants but is also used effectively for some SVOCs. Effective delivery and mixing of the stabilization agents may be very difficult for the Malden River. The light sediments and thick organic sediments will be difficult to contain and mix. The stabilization reagents themselves may be toxic to ecological receptors. However, work is being done to overcome the disadvantages of in-situ stabilization for sediments. While still an emerging technology for sediments, full-scale application has occurred (Zeller, 2004). For the Malden River, in-situ stabilization may have application in areas near the river bank (application through several feet of water column in the middle of the river may not be feasible) and in areas where separate phase liquids are not present. In-situ stabilization may be ideal for treatment of metals in sediments in limited areas of the Malden.

Capping

Existing contaminated sediment may be capped to isolate contaminants from the water column and the ecological system. The cap material may also provide improved benthic habitat. For cost estimating purposes, the team assumed a minimum cap thickness of one foot would be sufficient to isolate underlying sediments from the water column and from erosion, benthic intrusion or seepage. This measure would be implemented by partially responsible parties (PRPs) and would require further evaluation to determine the appropriate cap thickness. Further, the capping of all contaminated sediments would require capping of a majority of the river bottom, which be constrained by the instability of the upper sediment layer and depth of the first confining stratum.

Capping as to be used in conjunction with wetland restoration a compliment to the USACE ecosystem restoration project was retained for further consideration.

Fish Spawning Habitat Restoration

The lower reach of the Malden River has the potential to attract and support significant population of anadromous fish. This study concentrated only on improving the availability of spawning habitat in additional to improving passing procedures of anadromous fish through the dam. The availability of spawning habitat will be improved by placing appropriate gravel/sand substrate in selected areas throughout the river. The selected areas are generally in the vicinity of other waterbodies confluences and inlets.

5.3.2.3 Measures to Improve Wetland Habitat

Varieties of measures were evaluated to aid in the restoration of existing and former wetland and riparian buffer areas within the study area. Factors in the selection of these measures primarily included expected degree of ecosystem improvement, feasibility of completion, and constructability, but also considered cost, permitability, land availability and access, and how each measure complemented the others. The following list of proposed measures presents and briefly describes the results of this analysis of proposed activities for the improvement of Malden River wetland and riparian zone:

Wetland Restoration

Existing wetlands presently impaired by invasive species growth, altered hydrologic regime, or excessive debris or sedimentation may be restored to a more functional state, allowing for additional habitat features, improved stormwater treatment, and a more native and diverse vegetative scheme. While the restoration methodology would differ among the areas proposed for restoration, typical sequential steps would involve harvesting and protection of suitable plants, regrading to remove invasive vegetation and allow for a suitable wetland hydrologic regime, and replanting with native species. In some cases, regrading to create a pool combined with dense, native emergent vegetation may provide stormwater treatment in or adjacent to tributaries, or stormwater flow may be directed through a sinuous channel with high vegetation-water interspersion. The measure was retained for further evaluation.

Wetland Pattern Restoration

This measure involves the restoration of a vegetated wetland where one did not exist previously, such as in the shallow open water area in and among existing tributaries to the Malden River, to restore the historic pattern of wetlands relative to the open water component of the ecosystem. As discussed previously, the Malden River was once surrounded by extensive bordering wetlands, which were filled through dredged material disposal and other actions. New areas of open water were created to straighten the Federal navigation channel. Increasing the area of wetlands would help to restore some of the historic habitat pattern. To restore such a wetland within an existing waterway, fill material would need to be imported to provide a substrate suitable for wetland plant installation at an elevation chosen to support the desired community. In areas with existing water flow, channel construction and installation of a flow control device (weir or flashboard riser) may need to be installed to control flow. Slowing of tributary flow and improvement of substrate (sand and gravel replacing silt or organic muck) can vastly improve stormwater treatment (Hammer, 1997, Kadlec, 1996) and provide fish spawning habitat. In addition, planting of emergent species such as bulrush (*Scirpus spp.*), often support a macroinvertebrate community providing significant fish and amphibian foraging opportunities. The measure was retained for further evaluation.

Riparian Zone Restoration/Revegetation and Invasive Species Removal

Measures to restore the riparian buffer zone within the study area are proposed. Riparian zone restoration efforts focus on: 1) reestablishment of native herbaceous and woody vegetation, 2) reconnection of fragmented riparian areas, 3) stabilization of erosion-prone slopes and riverbank, and 4) removal of debris. In many areas presently occupied by grass or unvegetated, minor seedbed/planting substrate preparation may be immediately followed by replanting using erosion control and/or shoreline conservation seed mixture. Woody species such as arrowwood (*Viburnum recognitum*), highbush blueberry (*Vaccinium corymbosum*), rose (*Rosa spp.*), red cedar (*Juniperus virginiana*), birch (*Betula spp*.), cottonwood (*Populus deltoides*), willow (*Salix spp.*), and white pine (*Pinus strobus*) are excellent fast-growing native species proposed for use in the riparian zone. Benefits of the proposed measures include stormwater treatment, shade provision, wildlife habitat improvement, shoreline stabilization, and improved screening and aesthetics. Riparian zone cleanup and replanting may be a prime candidate for work to be done by volunteers. This measure was retained for further evaluation.

5.3.2.4 Improvements to *Anadromous* Fish Passage

The Amelia Earhart Dam obstructs upstream migration of anadromous fish, principally alewife and smelt. Considerable public and regulatory interest exists for enhancement of these runs into the Mystic River system and could also improve the Malden River fish community.

The Amelia Earhart dam was designed to allow migratory fish to pass into the Malden and Mystic Rivers. It is generally believed that this design has never been effective at allowing all historic species of fish to pass. Periodically, the daytime lock operators will open the locks to let the fish upstream when they gather below the dam, and this system has been effective for alewives. To improve fish passage for all species, and allow passage independent of the operators, the dam could be retrofitted with an effective fish ladder. Although the improvement of fish passage operations would increase fish passage into the Mystic River there is some question as to the effectiveness of this alteration to bring fish into the Malden

River, as adequate high quality habitat is not yet available. Improvements to fish habitat in the Malden River are discussed later in this report – they would improve the capacity of the Malden River to support anadromous fish.

Three primary measures were considered to improve anadromous fish passage through the Amelia Earhart Dam, including: 1) operational changes to the existing lock system, 2) installation of a fish structure, such as an Alaskan steep pass or Denil fishway, and 3) installation of a bypass channel to the east of the dam, culverted beneath the existing dam service road.

Based upon discussions with the Massachusetts Division of Marine Fisheries (MADMF) and the National Marine Fishery Service (NMFS), there's consensus that improving the current procedures used for the existing lock system via standardized practices is generally preferable. Two specific reasons for procedure changes over an installation of a fish passage structure at the dam are 1) installation of a structure may unintentionally induce a lapse in the current non-standardized practice of passing fish through the dam (while not optimal, this practice is known to be effective, at least for blueback herring migrating to Lower Mystic Lake), and 2) there is some consensus that the lack of flow and/or lack of control of water elevation on either side of the Dam will make a new fishway ineffective. Better results may be obtained through preparation of a management plan for this purpose rather than retrofitting or constructing a physical structure. Significant additional information on water flow through the dam, dam structural specifications, fishery conditions and trends on both sides of the dam, and existing management procedures for fish passage would be required to further determine the efficacy of a new fishway at the Earhart Dam.

Table 5-2 provides some detail on the advantages and disadvantages, as well as costs, on these three alternatives to improve fish passage.

TABLE 5-2 ALTERNATIVES FOR FISH PASSAGE IMPROVEMENT AT AMELIA EARHART DAM

	Operational Changes to Existing Lock System	**Installation of Fish Structure within Dam**	**Fish Bypass Channel Installation**
Advantages	• Low initial costs • Suitable to pass all potential fish species • Little or no permitting costs • Preferred alternative by regulators	• Minimal operational requirements • Does not require significant changes to existing dam structure • Uses existing lock system to accommodate construction	• Not constrained by dimensional characteristics of existing dam and locks • Allows dam to maintain existing operational structure • Potential to maintain or slightly increase flood passage capacity depending on spillway design
Disadvantages	• Requires additional staffing at dam during evenings from March to June, and September to October • Requires monitoring to effectively pass fish	• Space limitations may inhibit type of structure • Cannot operate continuously due to tidal conditions, which exceed upstream pool elevation 40% of time • Maintaining required water level conditions may interfere with dam operations • Waterway and Wetland Protection Act permits required • Cannot pass many smaller fish	• May require modification of existing dam or earthen berm • Maintaining required water level conditions may interfere with dam operations • Cannot operate continuously due to tidal conditions, which exceed upstream pool elevation 40% of time • Waterway and Wetland Protection Act permits required • May not be suitable to pass all of fish
Cost	• $50K initial cost • $38-$40K annually thereafter	• $400K initial cost • $25K annually thereafter	• $740K initial cost • $25K annually thereafter
Notes	Proposed parameters to be included in an operational plan, included in Alternative J	Structure similar to Alaskan steep pass considered. Not included in Alternatives.	Structure similar to rock fishway and culvert to east of dam considered. Not included in Alternatives.

5.3.2.5 Summary of Viable Restoration Options

Table 5-3 summarizes the restoration measures that were determined to be viable option.

Table 5-3 Restoration Measure Summary

Restoration Measure	**Resource**	**Description**	**Results**
Improved Flushing	Water Quality	Spot Pond Releases	Eliminated from further consideration
Improved Flushing	Water Quality	Tidal Exchange	Eliminated from further consideration
Aeration	Water Quality	Mechanical, O_2 Injection & Air injection	Eliminated from further consideration
Sediment Contamination Removal	Water Quality & Riverine Corridor	Full-depth Removal	Eliminated from further consideration
Anadromous Fish Passage	Riverine Corridor	Operational changes at Amelia Earhart Dam	Viable option
	Riverine Corridor	Install New Structure at Amelia Earhart Dam	Eliminated from further consideration
	Riverine Corridor	Install Rock Bypass Channel at Amelia Earhart Dam	Eliminated from further consideration
Dredging	Sediment Quality	Partial Dredging with Capping	Viable option
In-situ Treatment	Sediment Quality	Biological & Stabilization Treatment	Eliminated from further consideration
Capping	Sediment Quality	In conjunction with Wetland Creation	Viable option
Habitat Restoration	Wetland Habitat	Wetland Restoration	Viable option
	Wetland Habitat	Wetland Creation	Viable option
	Wetland Habitat	Riparian Zone Restoration	Viable option

5.4 EVALUATION PROCESS

The evaluation process compiled a list of five important and relevant ecosystem measures that would restore the Malden River ecosystem to the highest quality use resource that the system could reasonably support and sustain. These six measures include:

- Fish Habitat Enhancement – This measure includes the placement of potential spawning substrate (i.e., clean gravel/sand material) at tributary confluences or other appropriate sites;

- Invasive Species Control (wetland & riparian) – This measure includes invasive species (*Phragmites australis*) removal by either cutting and herbicide spraying, regrading followed by re-establishment of native wetland and riparian species, or cover with mulch and/or geotextile;

- Wetland Restoration – This measure involves the restoration of a historic scrub-shrub swamp located along South Creek from an existing degraded *Phragmites*-dominated wetland, "daylighting" a section of the creek by the removal of intervening culverts, the restoration of the Mall Creek wetlands, and removal of existing trash and debris in riparian wetland areas, and;

- Wetland Creation – This measure involves the creation of palustrine emergent marsh (PEM) wetland within the confines of the former natural channel of the Malden River Oxbow to restore some of the bordering wetland areas lost by previous filling along the banks of the Malden River, and;

- Benthic Restoration – This measure includes sediment and toxic contaminant removal by dredging followed by capping of the area with 1-foot of clean material. The cap will isolate the contaminated sediments and provide clean habitat for benthic organisms. This alternative includes the potential to re-use the dredged material as underlying substrate for the in-channel creation of emergent wetlands.

The most important "driver" of environmental restoration for Malden River is remediating the historic sediment contamination. Removal of the upper loose sediment layer directly affects sediment quality. Achieving improved sediment quality by performing limited removal and capping activities would complement the Federal project and ongoing work by MVDC and others. During the development of this report, it was understood that MCP response actions will be performed by others to address key areas of environmental concerns within the river corridor.

5.5 PLAN FORMULATION RATIONALE

The consideration of the problems and needs within the Malden River study area led to the formulation of alternative plans. These plans are developed and designed to achieve the planning goals and objectives previously identified. Sponsor objectives are important considerations in the evaluation of alternative plans.

The formulation of ecosystem restoration plans for Malden River watershed is based on a standard set of criteria. Alternative plans must be complete in that they provide and account for all necessary investments or other actions to ensure the realization of the planned effects. Alternative plans must be effective to alleviate the specified problems and achieve the desired goals. Alternative plans must be efficient, demonstrating a cost effective means of alleviating the specified problems and realizing the specified opportunities. Alternative plans must also be acceptable to state and local entities and the public and be compatible with existing laws, regulations, and public policies.

Each alternative is considered on the basis of its effective contribution to the planning objectives. Selection of a specific plan is based on technical, economic, and environmental criteria, which permit the fair and objective appraisal of the impacts and feasibility of alternative solutions.

The incremental cost analysis evaluates implementable plans and determines an array of the most efficient alternative plans referred to as “Best Buy” plans. These “Best Buy” plans provide the greatest increase in output for the least increases in cost. The “Best Buy” plans have the lowest incremental costs per unit of output. The incremental cost analysis by itself will not direct the decision making team to the selection of any single plan for recommendation. The incremental analysis must be synthesized with other decision-making criteria such as planning objective consistencies, constraints, acceptability, completeness, risk and uncertainty, and effectiveness to assist the decision-making team in selecting a recommended plan for implementation.

Environmental criteria require that the selected plan incorporate measures to preserve and protect the environmental quality of the project area. This includes (1) identification of impacts to the natural and social resources of the area and the minimization of those impacts that adversely affect the surrounding environment, (2) assessment of impacts that are incurred during the construction of the proposed ecosystem restoration measures and those activities attracted to the area after the plan implementation, and (3) assessment of opportunities to enhance the environment consistent with the baseline project purpose.

The project delivery team applied a "building block" concept and its relationship to the overall goals for the Malden River ecosystem restoration. During the initial process of evaluating restoration measures, some measures were retained from the preliminary all-inclusive list. The following sections describe how some of these were subsequently eliminated while others were retained. The latter measures formed the core components of the integrated ecosystem restoration alternative plans. Since it was recognized early in the feasibility study phase process that individual measures were usually insufficient by themselves to significantly restore the resources of interest, various combinations of these measures were assembled as alternative plans.

5.5.1 SUB-AREA DEVELOPMENT

The study team divided the study area into sub-compartments to reflect the differences in the sources, concentrations and types of contaminants in various parts of the river. This step in the process will allow the sponsor to assign remediation activities to PRPs based on their contribution to degradation of the Malden River. It is also anticipated that a further definition of sub-basin characteristics will be performed during the completion of response actions designed to address historic releases of OHM by others as part of the overall river restoration program. The study area was divided into six (6) smaller sub-areas based upon the following characteristics:

(a) Spatial distribution of surface water and sediment/soil sampling locations

(b) Historic dredge and filling practices.

(c) Physical characteristics of river bottom sediments and underlying native strata.

(d) Identified contaminant distribution and migration/transport potential.

(e) Surface water hydrology and contributing watershed characteristics

To assist in the review of environmental land use characteristics pertaining to each of the sub-areas, a summary of predominant physical features is provided in Table 5-4.

Table 5-4. Physical Characteristics of Sub-Areas

Area	Total Area (Sq/Ft)	Bordering Banks (Linear Ft)	Number of Sediment Samples	Average Water Depth (Ft)	Number of Surface Water Sample
Sub-Area 1	60,103	894	4	6.2	1
Sub-Area 2	220,970	2,234	5	7	2
Sub-Area 3	180,713	1,390	18	4.6	3
Sub-Area 4	250,393	4,087	11	2.4	1
Sub-Area 5	674,038	5,444	6	8.4	6
Sub-Area 6	1,995,000	8,500	-	9.5	-

Note: Sediment and surface water locations have not been established within Sub-area 6.

A sketch plan of the site depicting the location of these sub-areas with respect to the overall study area is presented in Figure 5-4. The northernmost five (5) Sub-Areas are situated between the Medford Street and Route 16 bridges, while Sub-Area 6 is bounded by the Route 16 Bridge and the Amelia Earhart Dam. The following provides a brief description of each sub-area:

Sub-Area 1 – Sub-area 1 is the upstream input or northerly limits of the Malden River study area immediately adjacent to and downstream of the Medford Street Bridge crossing (see Figure 5-5). This portion of the Malden River was straightened and deepened by the USACE under the authority provided by the U.S. Rivers and Harbors Act (June 14, 1880). Elevated concentrations of coal gasification residuals were identified within the sediment deposits along the easterly and westerly banks of the Medford Street Bridge.

The restoration opportunities within this sub-area that were evaluated included benthic habitat restoration and fishery habitat restoration. Benthic habitat restoration involves dredging the entire Sub-area 1 or selected areas to remove contaminated sediment and recapping with clean material. Fishery habitat restoration involves improving spawning habitat by placement of a sand and gravel substrate. Two areas adjacent to the Medford Street Bridge have been identified for fishery habitat restoration. This restoration measure is dependent on work being performed by others. Another party must remove a minimum of 3-foot depth of existing river bottom in order to obtain a suitable and stable base prior to the placement of the spawning habitat substrate.

Sub-Area 2 – Sub-area 2 extends southerly from Sub-area 1 to River's Edge Parcel 5-2 and encompasses a majority of the 1970s Federal Navigation Dredging Project (see Figure 5-6). Sub-area 2 consists of approximately 221,000 square feet of surface area, with an average water depth of 7.0 feet ±. Sub-area 2 contains approximately 2,200 linear feet of bordering banks. The advancement of test borings within Sub-area 2 revealed a higher degree of river bed competency reflective of the historic dredging activities that have been conducted in this portion of the project study area.

The restoration opportunities evaluated within this sub-area included benthic restoration and wetland restoration. Benthic restoration involves dredging northern section of sub-area 2 to remove contaminated sediment and recapping with clean material. Wetland restoration involves removing invasive species along the eastern banks of the river and replanting with native wetland species.

Sub-Area 3 – Sub-area 3 is the Little Creek portion of the project study area (see Figure 5-7). The greatest degree of sediment variations and contaminant accumulation within the Malden River exists at its confluence with Little Creek. Sediment accumulation is highest along the easterly banks of the Malden River, reflective of once tidal dispersion and settling patterns. During NCA's initial assessment of baseline characteristics, Sub-area 3 was identified as a target area for further evaluation due to the nature of sediment deposition and corresponding magnitude of MGP residuals. The evaluation of contaminant distribution in Sub-areas 1 and 3 suggests that separate and discrete source conditions are responsible for contaminant distribution identified during site characterization.

The restoration opportunities evaluated within this sub-area included benthic restoration, wetland restoration and fishery restoration. Benthic restoration involves dredging the entire sub-area or selected areas to remove contaminated sediment and recapping with clean material. Wetland restoration involves removing invasive species along the eastern banks of the river and replanting with native wetland species. Fishery restoration involves improving spawning habitat by placement of a sand and gravel substrate at the confluence of Little Creek. This restoration measure is dependent on work being performed by others. Another party must remove a minimum of 3 feet on existing river bottom to obtain a suitable and stable base prior to the placement of the substrate.

Sub-Area 4 – Sub-area 4 is described as an oxbow of the original Malden River that appears to have not been disturbed during the historic dredging activities (see Figure 5-8). This oxbow receives surface water recharge from an unnamed creek (hereby referenced throughout this Report as "North Creek") situated along the northerly boundary of Rivers Edge Parcel 2-5.

The restoration opportunities evaluated within this sub-area include wetland restoration, wetland creation and fishery restoration. Wetland restoration involves removing invasive species along the eastern banks of the river and the islands and replanting with native wetland species. Fishery restoration involves improving spawning habitat by placement of a sand and gravel substrate at the confluence of North Creek.

Sub-Area 5 – Sub-area 5 extends southerly from Sub-area 3 to Route 16 Revere Parkway Bridge (see Figure 5-9). Sub-area 5 receives surface water recharge from the unnamed creek situated along the southerly boundary of Parcel 2-5 (hereby referenced as “South Creek”).

The restoration opportunities evaluated within this sub-area included benthic restoration, wetland restoration and fishery restoration. Benthic restoration involves dredging the northern section of this sub-area to remove contaminated sediment and recapping with clean material. Wetland restoration involves removing invasive species along the eastern and western banks of the river and replanting with native wetland species. Fishery restoration involves improving spawning habitat by placement of a sand and gravel substrate at the confluence of South Creek and an area along the western riverbank.

Sub-Area 6 – Sub-area 6 extends southerly from Route 16 Revere Parkway Bridge to the Amelia Earhart Dam. Sub-area 6 receives surface water recharge from unnamed creek (hereby referenced as “Mall Creek”) situated along the northerly boundary of the Gateway Mall.

The restoration opportunities evaluated within this sub-area included wetland restoration and fishery restoration. Wetland restoration involves removing invasive species along the eastern banks of the river and an area adjacent to the MBTA tracks and replanting with native wetland species. Fishery restoration involves improving spawning habitat by placement of a sand and gravel substrate at the confluence of Mall Creek, an area near the confluence of Mystic River and adjacent to the Revere Parkway Bridge.

Insert Figure 5-4 – Sub-Area Delineation

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Insert Figure 5-5 – Sub-area #1

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5.5.2 SUMMARY OF RESTORATION MEASURES WITHIN SUB-AREAS

Table 5-5 summarizes each restoration measure for sub-areas within the Malden River study limits.

Table 5-5 Malden River - Acreage of Restoration Measures by Sub-Area

	Sub-areas						
Restoration Measures	**#1**	**#2**	**#3**	**#4**	**#5**	**#6**	**Total**
Invasive Species Removal	0	1.29	1.37	6.31	7.24	15.23	*31.44*
Wetland Restoration (planting)	0	1.16	1.23	5.68	6.52	13.71	*28.30*
Wetland Creation (filling)	0	0	1.53	3.84	0	0	*5.37*
Gravel/Sand Placement	0.07	0	0.68	0.81	0.44	0.76	*2.76*
Fish Passage							

The ecosystem restoration measures, Fish Habitat Enhancement, Invasive Species Control, Wetland Restoration, Wetland Creation, Benthic Habitat Restoration and Anadromous Fish Passage Improvements have been evaluated consistent USACE guidance (ER 1105-2-100, Planning Guidance Notebook, ER 1165-2-501, Civil Works Ecosystem Restoration Policy, ER 1165-2-502 Ecosystem Restoration – Supporting Policy Information).

5.6 INCREMENTAL ANALYSIS

The incremental analysis measured the habitat benefits associated with the restoration of Malden River by various restoration measures. We used the incremental/cost effectiveness analysis to combine the measures discussed previously into alternative restoration plans. This involved selecting appropriate models, using the models to determine the effects of the measures, combining the measures in various ways, compared the measures based on cost effectiveness, then developed their incremental costs to identify the Best Buy plans. The complete incremental analysis process is presented in Appendix C. Summary of the results is included in this section.

5.6.1 METHODS

This analysis compares several restoration measures for the Malden River. These measures have the potential to directly and indirectly impact the existing natural resources in the study area. The incremental analysis used the Habitat Evaluation Procedures (HEP) developed by US Fish and Wildlife Service to quantify the changes in habitat quality and area for each restoration alternative. HEP measures the suitability of a given habitat for one or more species. These models use habitat criteria (variables) that are necessary to support various species (and their life stages) in a given habitat.

The first step in developing the benefits for the incremental analysis was to identify appropriate models to consider the existing and future value of the habitats affected by the project. Table 5-6 summarizes the justification for the selected species for the HEP study.

Table 5-6 Habitat Evaluation Procedure (HEP) Models

Model	*Status*	*Reasons for Selecting*
Green-backed Heron	Selected	Applies to the piscivourous feeding guild in wetland areas and contains variables that will be affected by the alternatives.
Marsh Wren	Selected	Applies to species nesting in herbaceous vegetation (e.g, *Typha* and *Phragmites*) and contains variables that will be affected by the alternatives.
Common Yellowthroat	Selected	Applies to species inhabiting shrub communities near open water and wetland areas and contains variables that will be affected by the alternatives.

USFWS HEP models were used to assess benefits from wetland restoration activities to fish eating (piscivirous) wildlife (Green-backed Heron) and wetland dependent songbirds (Marsh Wren and Common Yellow Throat). The assessment of benefits from benthic habitat restoration relied on a sediment toxicity model by Ingersoll et. al. (2000) that relates sediment toxicity to benthic invertebrates to concentrations of PAHs, metals, and PCBs in sediment. The fish habitat restoration HU's were based on area (in acres) available to anadromous fish species following increased fish passage efficiency.

Green-backed Heron

Marsh Wren

Common Yellowthroat

5.6.2 CALCULATIONS

Habitat Units for each of the Malden River restoration alternatives were calculated according to the method described in Appendix C and E, where the indices obtained for both the lacustrine/anadromous (i.e. fisheries) habitat and wetland (i.e. waterfowl) habitat were applied to the total acres of each of these respective habitat types that will become available with each alternative. The results in terms of habitat units for each alternative are provided in Table 5-7.

Table 5-7 Alternative Costs and Outputs

IWR-Plan Designator	*Description*	*Cost ($000)*	*HU*
A1	Remove Invasive Species sub-area 2	792.7	0.54
B1	Remove Invasive Species sub-area 3	1,096.8	0.67
C1	Remove Invasive Species sub-area 4	1,443.9	1.02
D1	Remove Invasive Species sub-area 5	1,091.3	2.57
E1	Remove Invasive Species sub-area 6	8,080.1	4.12
F1	Rem Inv Species & Replant Native sub-area 2	812.1	3.65
G1	Rem Inv Species & Replant Native sub-area 3	1,150.4	8.52
H1	Rem Inv Species & Replant Native sub-area 4	1,500.5	9.26
I1	Rem Inv Species & Replant Native sub-area 5	1,137.1	12.05
J1	Rem Inv Species & Replant Native sub-area 6	8,279.7	39.41
K1	Create Wetland sub-areas 3 & 4	1,322.2	15.71
L1	Placement of Fish Substrate sub-area 1	7.8	0.70
M1	Placement of Fish Substrate sub-area 3	75.1	0.69
N1	Placement of Fish Substrate sub-area 4	76.7	0.84
O1	Placement of Fish Substrate sub-area 5	48.7	0.42
P1	Placement of Fish Substrate sub-area 6	84.1	0.79
Q1	Fish Passage Improvement – Operational Changes	716.4	49.04

Column 1 shows plan designators as shown in the IWR-Plan program. These are the measures from the previous section. Column 2 is a brief description of each plan. Column 3 shows total project implementation cost including interest during construction (IDC). Column 4 shows habitat units (HU) relative to the no action alternative. With the exception of fish passage, the other four measures are evaluated over the six sub-areas. Plans A through E have the removal of invasive species in sub-areas 2 through 6. These plans are not complete since they do not include planting that is necessary to establish native vegetations and have been eliminated from further consideration. Plans F through J add restoration of wetlands component to sub-areas 2 through 6, respectively. Plan K provides for the restoration of wetlands in sub-areas 3 & 4. Plans L through P places sand/gravel substrate in sub-areas 1 and 3 through 5, respectively. Plan Q provides for fish passage improvement through operational changes at the Amelia Earhart Dam. All of these remaining plans can be combined with any other combination of plans to create a restoration alternative.

5.6.3 INCREMENTAL COST CURVE

The costs of the alternative restoration plans are compared with the environmental benefits, within the framework of an incremental cost analysis, to identify the most cost effective alternatives. An incremental cost analysis examines how the costs of additional units of environmental output increase as the level of environmental output increases. For this analysis, the environmental outputs are measured in habitat units. The analysis is in accordance with IWR Report 95-R-1, Evaluation of Environmental Investments Procedures Manual-Interim: Cost Effectiveness and Incremental Cost Analyses, May 1995; and ER 1105-2-100, Planning Guidance Notebook, Section 3-5, Ecosystem Restoration, April 2000. The program IWR-PLAN, developed for the Institute for Water Resources (IWR), was used to conduct the analysis.

An incremental cost curve can be identified by displaying cost effective solutions. Cost effective solutions are those increments that result in the same output, or number of habitat units, for the least cost. An increment is cost effective if there are no others that cost less and provide the same, or more, habitat units. Alternatively, for a given increment cost, there will be no other increments that provide more habitat units at the same, or lower, cost.

There are five management plans being evaluated to improve environmental conditions in each sub area of the Malden River. The management plans are: removal of invasive species, removal of invasive species coupled with restoration of wetlands, creation of wetlands, dredging, placement of gravel or sand, and provision for fish passage. Project description, project cost, and the number of habitat units created by each plan are shown in Table 5-7. Costs are discounted at an interest rate of 5 1/8 %. This interest rate, as specified in the Federal Register, is to be used by Federal agencies in the formulation and evaluation of water and land resource plans for the period October 1, 2005 to September 30, 2006. A 50-year project economic life is assumed.

Management plan cost derivation is shown in Table 5-8.

Table 5-8 Management Plan Costs ($000)

No.	*First Cost*	*IDC*	*Plan Cost*	*OM&R Cost*	*Total Plan Cost*	*Construct. Period (months)*
A1	774.2	18.4	792.7	0.0	792.7	12
B1	1,071.3	25.5	1,096.8	0.0	1,096.8	12
C1	1,410.3	33.6	1,443.9	0.0	1,443.9	12
D1	1,065.9	25.4	1,091.3	0.0	1,091.3	12
E1	7,892.1	188.0	8,080.1	0.0	8,080.1	12
F1	793.2	18.9	812.1	0.0	812.1	12
G1	1,123.6	26.8	1,150.4	0.0	1,150.4	12
H1	1,465.6	34.9	1,500.5	0.0	1,500.5	12
I1	1,110.6	26.5	1,137.1	0.0	1,137.1	12
J1	8,087.0	192.7	8,279.7	0.0	8,279.7	12
K1	1,291.4	30.8	1,322.2	0.0	1,322.2	12
L1	7.6	0.2	7.8	0.0	7.8	12
M1	73.4	1.7	75.1	0.0	75.1	12
N1	74.9	1.8	76.7	0.0	76.7	12
O1	47.5	1.1	48.7	0.0	48.7	12
P1	82.1	2.0	84.1	0.0	84.1	12
Q1	0.0	0.0	0.0	716.4	716.4	0

First cost includes all contingencies, overheads, real estate and study costs (Detailed Plans & Specifications development). Interest during construction (IDC) is then calculated assuming a construction period of two consecutive season months for each alternative. IDC is an economic cost and not a financial cost. This needs to be estimated for purposes of project justification. Essentially, IDC represents the opportunity cost of funds tied up in investments, before these investments begin to yield benefit. Once project benefit starts, the IDC process stops.

In the incremental analysis, the 17 alternative increments listed in Table 2, alternatives A through Q, are analyzed in all possible combinations to identify cost effective plans. A total of 31,104 possible combinations were analyzed, and the incremental analysis identified 276 of those combinations as cost effective. Figure 5-10 shows all cost effective plans and best buy plans. A plan is not cost effective if compared with another alternative, it provides fewer or the same number of habitat units at a higher cost. Best buy plans are a subset of cost effective plans. For each best buy plan, there are no other plans that will give the same level of output at a lower incremental cost. There are 13 best buy plans including the no action alternative.

The best buy plans that comprise the incremental cost curve are shown on Figure 5-11. As in Figure 5-10, the horizontal axis represents habitat units created by each project. However, the vertical axis represents the incremental cost per incremental output as output increases with project size. The units on the vertical axis are thousands of dollars. Best buy plans are a subset of cost effective plans. For each best buy plan there are no other plans that will give the same level of output at a lower incremental cost. There are 13 best buy plans labeled in Figure 5-11 by their HU and cost.

Thirteen plans comprise the best buy plan curve. The best buy plan curve is the incremental cost curve. Incremental cost and incremental output are the changes in cost and output when the cost and output of each successive plan in terms of increasing output are compared. Incremental cost per output is the change in cost divided by the change in output, or incremental output, when proceeding to plans with higher levels of output. Table 5-9 shows incremental cost per habitat unit for each best buy alternative. In the incremental cost curve (shaded area in Table 5-9), incremental cost per unit increases with output, or habitat units. In this study, the incremental cost curve consists of 13 points. The largest relative increase in the curve occurs between Increments 3 and 4, an increase of approximately 476 percent.

Figure 5-10
Cost Effective Plans

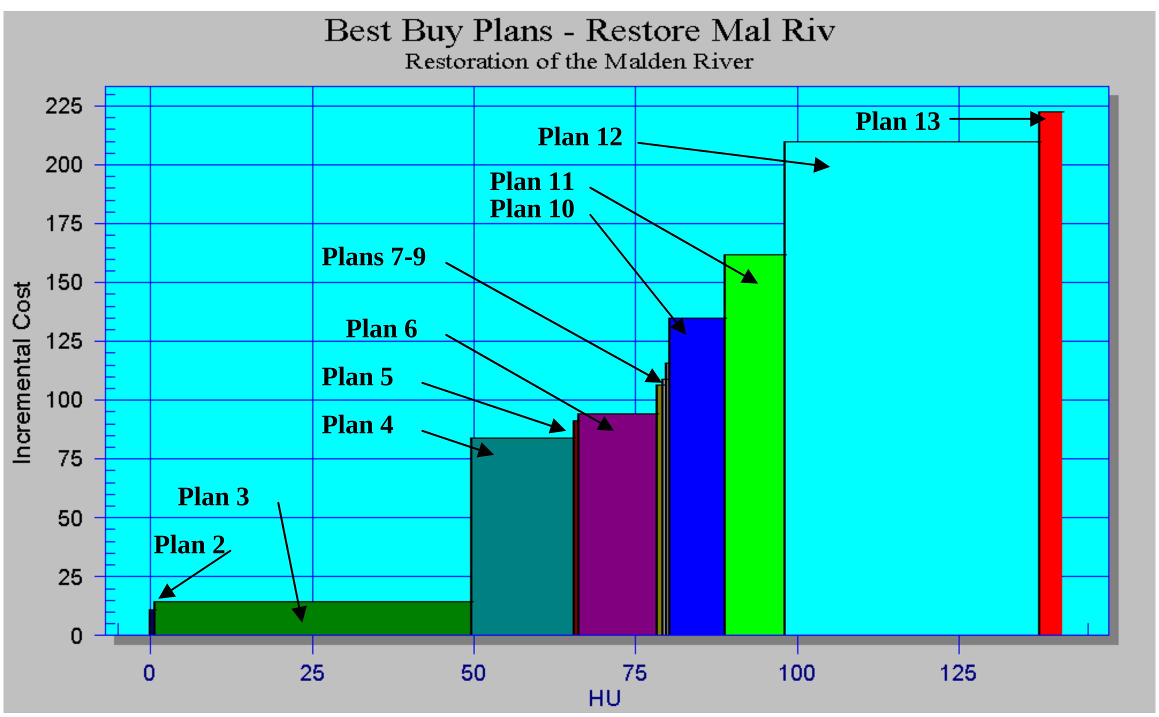

Figure 5-11

Best Buy Plans

Table 5-9 Alternative Plans and Costs

Plan #	Alternative Plans and Components	HU	Cost	Incremental Cost	Incremental Output	Cost/ Output
1	**No Action**	0.00	0.0	0.0	0	0.0
2	**L1 (Fish substrate sub-area 1)**	0.70	7.8	7.8	0.7	11.1
3	**L1, Q1 (add Dam Operational Changes)**	49.74	724.2	716.4	49.04	14.6
4	**K1, L1, Q1 (add Wetland Creation)**	65.45	2,046.4	1,322.2	15.71	84.2
5	**K1, L1, N1, Q1 (add Fish substrate sub-area 4)**	66.29	2,123.1	76.7	0.84	91.3
6	**I1, K1, L1, N1, Q1 (add Removal & Replanting sub-area 5)**	78.34	3,260.2	1,137.1	12.05	94.4
7	**I1, K1, L1, N1, P1, Q1 (add Fish substrate sub-area 6)**	79.13	3,344.3	84.1	0.79	106.5
8	**I1, K1, L1, M1, N1, P1, Q1 (add Fish substrate sub-area 3)**	79.82	3,419.4	75.1	0.69	108.8
9	**I1, K1, L1, M1, N1, O1, P1, Q1 (add Fish substrate sub-area 5)**	80.24	3,468.1	48.7	0.42	116.0
10	**G1, I1, K1, L1, M1, N1, O1, P1, Q1 (add Removal & Replanting sub-area 3)**	88.76	4,618.5	1,150.4	8.52	135.0
11	**G1, H1, I1, K1, L1, M1, N1, O1, P1, Q1 (add Removal & Replanting sub-area 4)**	98.02	6,119.0	1,500.5	9.26	162.0
12	**G1, H1, I1, J1, K1, L1, M1, N1, O1, P1, Q1 (add Removal & Replanting sub-area 6)**	137.43	14,398.7	8,279.7	39.41	210.1
13	**F1, G1, H1, I1, J1, K1, L1, M1, N1, O1, P1, Q1 (add Removal & Replanting sub-area 2)**	141.08	15,210.8	812.1	3.65	222.5

The results of combining the measures (plans) led to the formulation of the following alternatives.

- The first plan (Alternative 1) is the no action alternative that provides no additional HU with zero cost.

- The second plan (Alternative 2) provides for the placement of sand or gravel in Sub-area 1. This plan would yield 0.7 HU at a cost of $7,800.

- The third plan (Alternative 3) provides for the operation of a fish ladder combined with the placement of sand or gravel in Sub-area 1. This plan would provide an additional 49.04 HU with an additional cost of $716,400, resulting in a cost per HU of $14,600.

- The fourth plan (Alternative 4) is similar to the third with the addition of wetland creation in Sub-areas 3 & 4. This plan would provide an additional 15.71 HU with an additional cost of $1,322,200, resulting in a cost per HU of $84,200.

- The fifth plan (Alternative 5) would add to increment 4 the placement of sand or gravel in Sub-area 4. This plan would provide an additional 0.84 HU at an additional cost of $76,700, resulting in a cost per HU of $91,300.

- The sixth plan (Alternative 6) is the same as Increment 5 with the addition of removal of invasive species and restoration of wetlands in Sub-area 5. This plan results in an additional 12.05 HU and an additional cost of $1,137,100 for an incremental cost of $94,400 per HU.

- The seventh plan (Alternative 7) is the same as Increment 6 with the addition of sand and gravel placed in Sub-area 6. This plan would provide for an additional 0.79 HU at a cost of an additional $84,100, resulting in a cost per HU of $106,500.

- The eighth plan (Alternative 8) is the same as Increment 7 with the addition of sand and gravel placed in Sub-area 2. This plan would provide for an additional 0.69 HU at a cost of an additional $75,100, resulting in a cost per HU of $108,500.

- The ninth plan (Alternative 9) is the same as Increment 8 with the addition of sand and gravel placed in Sub-area 5. This plan would provide for an additional 0.42 HU at a cost of an additional $48,700, resulting in a cost per HU of $116,000.

- The tenth plan (Alternative 10) is the same as Increment 9 with the addition of the removal of invasive species and wetland restoration in Sub-area 3. This plan would provide for an additional 8.52 HU at a cost of an additional $1,150,400, resulting in a cost per HU of $135,000.

- The eleventh plan (Alternative 11) is the same as Increment 10 with the addition of the removal of invasive species and wetland restoration in Sub-area 4. This plan would provide for an additional 9.26 HU at a cost of an additional $1,500,500, resulting in a cost per HU of $162,000.

- The twelfth plan (Alternative 12) is the same as Increment 11 with the addition of the removal of invasive species and wetland restoration in Sub-area 6. This plan would provide for an additional 39.41 HU at a cost of an additional $8,279,700, resulting in a cost per HU of $210,100.

- The thirteenth plan (Alternative 13), the last increment, adds removal of invasive species and wetland restoration in Sub-area 2 to Increment 12. This plan would provide for an additional 3.65 HU at a cost of an additional $812,100 resulting in a cost per HU of $222,500.

5.7 COMPARISON OF PLANS

Cost effectiveness and incremental analysis do not, by themselves, identify a unique plan recommendation for implementation. The information generated through the cost effectives and incremental analysis is considered with information, such as resource significance, other effects, and absolute costs, to identify the recommended plan. Development of the incremental cost curve facilitates the selection of the best alternative. The question that is asked at each increment is: is the additional gain in environmental benefit worth the additional cost?

Based upon the results of the incremental cost analysis, thirteen plans were identified as Best Buy Plans. For ecosystem restoration projects, the National Ecosystem Restoration (NER) plan is defined as the plan that reasonably maximizes ecosystem restoration outputs and associated benefits compared to costs, consistent with the Federal objective. The recommended NER plan is cost effective and achieves the desired level of output. The recommended NER plan meets planning objectives, constraints and reasonably maximizes environmental benefits, while passing tests of significance of outputs, acceptability, completeness, efficiency, and effectiveness.

Plan 11 allow restoration conductivity for approximately 1.25 miles along the eastern banks of the Malden River by eradicating evasive plant species, reestablishing native plant species and creating an additional wetland area within the oxbow. Plan 11 complements the sponsor's overall Master Plan for a river walkway development and is within their funding constraints.

The recommended NER plan for the Malden River Ecosystem Restoration Feasibility Study is Best Buy Plan #11. Mystic Valley Development Commission has also selected Best Buy Plan #11 as the "Locally Preferred Plan."

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6.0 RECOMMENDED PLAN

6.1 PLAN COMPONENTS

The recommended features of the NER plan consist of the following restoration measures and are illustrated in Figure 6-1:

- Removal of 36,100 cubic yards of invasive species plants and root matter along 14.9 acres of the riverbank corridor within sub-areas 3, 4, and 5 and replanting with native wetland plant species;
- Creation of 5.4 acres of emergent wetland within the existing oxbow (sub-areas 3 & 4);
- Placement of 4,400 cubic yards of gravel/sand substrate to create 2.8 acres of fish spawning habitat within sub-areas 1, 3, 4, 5, and 6;
- Miscellaneous debris removal and disposal within the proposed construction work limits; and
- Operational changes at the Amelia Earhart Dam to improve fish passage.

Wetland Restoration - Wetland restoration involves the removal of 14.9 acres of invasive species and replanting of native wetland species to create a freshwater emergent/shrub wetland. This recommendation consists of cutting, clearing and grubbing existing *Phragmites* stands, excavation of the *Phragmites* stubs and root matter, the placement of a layer of clean soil and the planting of native wetland seedlings.

Phragmites stubs and root matter will be removed by excavating a minimum depth of 18 inches. The generated volume is estimated at 36,000 cubic yards. This excavated material will be used as a sub-base for the wetland creation component of the NER plan.

Recommended techniques for removal of invasive species will include regrading and replanting, and cutting and spraying.

These excavated areas would be capped with a one foot layer of new soil prior to the planting of native wetland seedlings. Typical wetland plant species would include pickerel weed (*Pontederia cordata*), arrow-arum (*Peltandra virginica*), tussock sedge (*Carex stricta*), rush (*Juncus* spp.), wild rice (*Zizania aquatica*), blueberry (*Vacinium corymbosum*), and winterberry (*Ilex verticillata*).

Insert Figure 6-1 - NER Recommended Plan

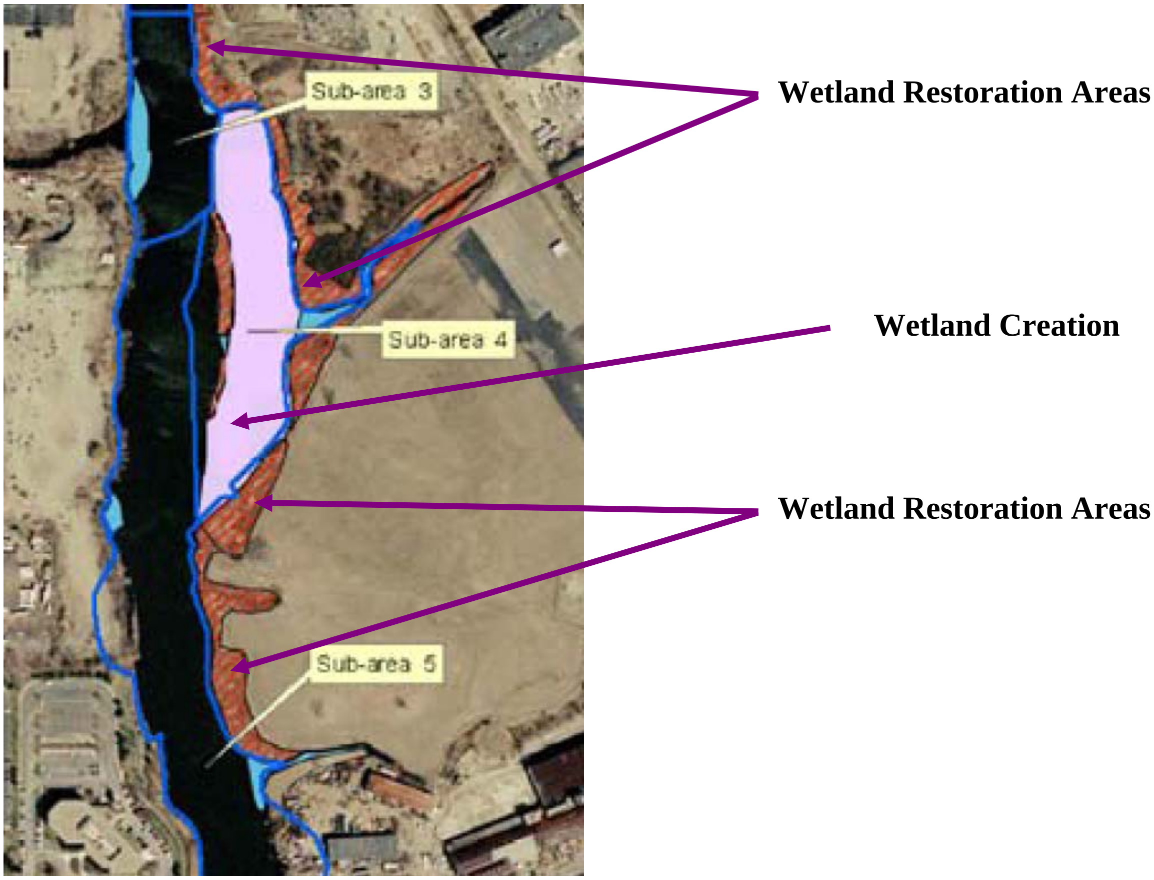
Removal of invasive species, targeting *Phragmites* in particular, is proposed for a large portion of the existing wetlands and riparian zone. The discussion that follows is applicable to both the wetland and riparian areas. With regard to *Phragmites*, nearly all parts of the plant are capable of regeneration, including seed heads, freshly cut stalks, and especially rhizome material (Burdick et al., 2003). Removal of all plant parts cut during eradication to an approved disposal destination (e.g. incinerator) is absolutely essential to prevent the accidental spread within or outside of the study area.

Cut and Spray: Using this method, plant (*Phragmites*) stems are cut mechanically or by hand depending on the size of the area to be treated. Typically, this method does not alter the ground surface, and as such is more acceptable for use in sensitive areas where ground disturbance may be difficult to permit. A glyphosate-based herbicide (such as Rodeo®, Accord®, or Roundup®) is then applied sparingly via broadcast spraying, or preferably direct stem application if labor assistance is available. Herbicide spraying would be restricted to a back pack sprayer system when winds were less than 5 miles per hour or physically applying the herbicide directly on the cut stems. Follow up herbicide treatments are generally completed yearly for 2-3 years following the original treatment. All cut plant materials must be removed from the site.

Regrade and Replant: Typically, the most effective method for invasive species removal, regrading using heavy equipment, removes the surface layer (1 to 2 feet) of soil, including all rhizome material. Soil and all plant material removed must be taken off the site. In addition to completely removing the plant material, the lowering of the ground surface allows the site to become saturated or inundated for longer periods, further discouraging plant growth. This methodology is best employed in conjunction with wetland restoration or creation, in which regrading is already a necessity to ensure appropriate wetland hydrology. In uplands or areas not slated for wetland restoration, reseeding and replanting should immediately follow regrading, assuming that no herbicides are used. Follow up treatment via hand picking or herbicide application may still be necessary for 1-3 years following original treatment.

Cover: This methodology is not commonly used over large areas but may be very effective in select areas where minimal follow-up treatment is desired. In essence, the plants are cut or pressed to the ground, and a relatively heavy, dark-colored landscape fabric (such as 4.1 oz. Woven Weed Restrictor or equivalent) is overlain and stapled in place. While the fabric is semi-permeable to water, if it is installed firmly plants cannot grow through it. In conjunction with heat generated from the dark color of the fabric, plant growth is severely restricted as long as the material stays in place. Following one to two growing seasons, the fabric may be removed and the area replanted or reseeded. Herbicide use is optional using this treatment.

Shrubs and trees may be planted through small incisions in the fabric, and the fabric may be mulched over in high-visibility areas.



Wetland creation involves the establishment of a vegetated wetland within the river's oxbow to create 5.4 acres of emergent wetlands. This wetland creation will restore the historic marsh areas that were once predominant. Most of the excavated material from the wetland restoration component would be used as a substrate. A one foot layer of new soil would be placed prior to the planting of native wetland seedlings. The required volume of clean fill is estimated at 9,000 cubic yards. A flow control device such as a weir or flashboard riser would be installed within the existing tributary to control flow. The flow control device would diverse the flow and provide improve stormwater treatment.

Fish habitat restoration involves the placement 4,400 cubic yards of clean gravel/sand substrate to create 2.8 acres of fish spawning habitat. Some proposed areas (sub-area 1 & 3) require work by others. Another party must remove a minimum of 3-foot depth of existing river bottom in order to obtain a suitable and stable base prior to the placement of the substrate. Ten identified areas comprise the fish habitat restoration measure. Three of the ten proposed areas require work by "others" before placement of the gravel substrate. Another party must remove/dispose a minimum of 3-foot depth of existing river bottom in order to provide a suitable and stable base prior to the placement of the proposed gravel substrate. Negotiations with the responsible parties are ongoing. If responsible party negotiations are unsuccessful, these 3 sites will be eliminated from the NER recommended plan.

Miscellaneous debris removal and disposal is recommended within the construction work limits. This recommendation involves the removal of existing debris (e.g. shopping carts, tires, appliances…) and transporting to an upland disposal site. The generated volume is estimated at 450 tons.

Fish Passage improvement involves operational changes to the Amelia Earhart Dam locking system. This recommendation consists of expanding the periods of operation of one or more of the locks to provide a more effective passage of fish. In particular, the operation would be modified to attain greater transfer of Atlantic rainbow smelt. This would require operating the locks not only during the daytime periods (which has proved reasonably effective for alewives), but also during evening and early morning hours during the smelt migration period.

This fish passage improvement includes the following measures:

- Installation of portable or permanent lighting near the freshwater end of the lock, to attract fish into the structure during operation;

- Development of a protocol for lock operation to address the transfer of migrating fish, consistent with prevention of excessive saltwater intrusion into the freshwater basin (locking of fish must be coordinated with tide levels lower than the freshwater basin level);

- Staffing the lock during the anticipated spring fish migration period (March thru May) is recommended. This element is assumed to require an evening and a morning shift, each of four hours, staffed by two operators; and

- During the first year of the modified operation, the operating cycle would be periodically monitored to assess fish movement and transfer. Based on this monitoring, the operating protocol may be modified.

The recommended NER plan meets the following ecological concepts: scarcity, status and trends, connectivity, critical habitat, and biodiversity.

- Scarcity: The coast of Massachusetts historically provided exceptionally productive fish and wildlife habitat through its numerous salt marshes and rivers. Over the last 300 years, these natural salt marshes and embayments have been degraded or lost through the development of transportation facilities and other coastal development. Restrict tidal flow, disposal of dredged sediment on the surface of the marshes, filling for business and residential development, and stormwater related sedimentation resulted in the loss of estuarine habitat and its associated values to fish and wildlife resources. In addition, the construction of dams and other structures along rivers and river channelization have prevented anadromous fish from accessing historic spawning and nursery habitat areas and have resulted in the loss of fish populations.

The Malden River currently provides about 140 acres of degraded aquatic and wetland habitat in an otherwise heavily developed city landscape. The river is the only remaining resource in Malden that may provide significant aquatic and riparian habitat, including spawning habitat for anadromous fish. Other streams that once flowed freely in the area were culverted long ago and cannot be restored due to dense urbanization.

- Status and Trends: The Malden River system is a remnant of an extensive tidal wetland system, much of which was filled in during the 19th century. Past dredging and filling activities has created small disconnected aquatic and wildlife habitats. These remaining habitats are currently highly degraded, and in decline due to proliferation of Phragmites, sedimentation, and continued contaminant loading. These areas do not function as a self-sustaining interconnected ecosystem. Without action, some conditions are expected to improve through the ongoing restoration efforts by others. The construction and current operations at the Amelia Earhart Dam has eliminated the historic fish runs throughout the Malden and Mystic River systems.

MVDC has promoted an ecosystem restoration approach to the Malden River corridor. Their goal is to restore and sustain the health, biological diversity and productivity of the river corridor. MVDC has begun integrating social and economic goals with ecosystem restoration efforts along the western riverbanks. MVDC's economic and ecosystem restoration initiatives consider interrelationships of aquatic and wetland habitats associated with disturbed and degraded ecosystem resources. MVDC is continuing their restoration efforts along the western side of the river corridor, which provides self-sustaining and functioning aquatic and wetland systems among a revitalized residential and employment community.

USEPA Brownfields Showcase Community designation of the Malden River corridor has involved numerous public and private entities, including the Malden Redevelopment Authority, Massachusetts Electric/National Grid, KeySpan, Tufts University, Exelon, ENSR, and Preotle Lane and Associates have joined MVDC and USEPA in addressing the systematic problems of the river system. These entities, as well as other riverfront property owners, watershed associations, and citizens of the three host communities, which number in excess of 140,000, share a common goal of restoring this long neglected Malden River corridor. Restoration efforts include remedial activities for Little Creek, high voltage cable relocation with sediment cleanup, Phase IV Remedy Implementation Plan (Mass Electric) and future site development for the General Electric property.

- Connectivity: The value of natural areas is enhanced by existence of habitat corridors that allow for movement and dispersal of native species between resource areas. Restoration alternatives that improve connectivity are considered technically significant. Restoration of in-stream, wetland and riparian habitat along the Malden River will be significant in providing a resting area (habitat island) for migratory songbirds passing through the highly urbanized Malden-Medford-Everett area. Restoration of the Malden River provides and essential link between freshwater and estuarine and marine habitats. Restoration of fish passage capacity will link anadromous fish to their historic spawning grounds.
- Critical Habitat: This is habitat that is essential for the conservation, survival, or recovery of one species listed as rare or endangered under the Federal Endangered Species Act or other significant federally interest species. The Malden and Mystic Rivers provide potential spawning habitat for the Blue-black Herring and possible spawning habitat for other anadromous species. Given the scarcity of anadromous fish spawning and rearing habitat in the greater Boston area, restoration of the Malden River is considered technically significant.
- Biodiversity: Restoration alternatives that improve biodiversity (either species richness or evenness) are considered technically significant. The NER plan would eradicate the monospecific stands of Phragmites, increasing the biodiversity (species richness) of emergent wetland and riparian communities. Removal of contaminated sediments would likely increase diversity of the benthic community, by increasing both the number of species and reducing the dominance of tubificid worms and oligiochaetes. Based on these criteria, restoration of the Malden River is considered technically significant.

6.2 DESIGN ASSUMPTIONS/CRITERIA

The wetland restoration alternative assumption during this study is based on the following general requirements:

- Natural wetland locations and elevations will be used as a benchmark for developing wetland restoration profiles;

- Restoration projects will be designed and developed to maximize functional benefit values and to minimize wetland and other adverse environmental impacts; and

- Restoration projects will be designed and developed to minimize project costs for each alternative.

Potential conflicts with existing utility lines, including telephone, gas, electric, sewer, storm, cable and water were considered. Utility companies were contacted about the proposed sediment restoration and/or each of the proposed wetland restoration sites. No specific utilities have been identified that would have to be relocated.

Though the proposed wetland restoration component requires Phragmites stem and root matter to be removed by excavating a minimum depth of 18 inches, the objective is to excavate to the first stable substrate layer.

On Tuesday, 20 March 2007, a meeting was held at the office of Massachusetts Department of Environmental Protection, Northeast Region to discuss the ecosystem restoration approach for the Malden River. The primary elements of the Malden River Ecosystem Restoration Project were presented. The wetland restoration component of this project involves the removal of 14.9 acres of invasive species and replanting of native wetland species to create a freshwater emergent/shrub wetland. The generated volume is estimated at 36,000 cubic yards. The wetland creation component of this project involves the establishment of a vegetated wetland within the river's oxbow to create 5.4 acres of emergent wetlands. It is anticipated that the majority of the excavated material from the wetland restoration component would be used as a substrate. The excavated material for the wetland restoration component may be managed under existing State programs. The excavated volume (30,000 c.y.) is proposed as a substrate layer to the wetland creation component. Excess material (6,000 c.y.) may be reused within the study area as a part of the redevelopment plan for the Rivers Edge project. Compensatory flood storage was also discussed. The Medford-side restoration efforts have exceeded the minimum requirement for the compensatory flood storage. Credits may be used for the Federal plan. An area adjacent to North Creek has also been identified for additional flood storage, if needed.

6.3 RECOMMENDED PLAN CONSTRUCTION COSTS

The NER Recommended Plan (Best Buy Plan #11) has a construction cost estimated at $3,825,000. Incorporating 2008 Effective Pricing Levels, the total construction costs will be reported as $5,127,600. This construction cost estimate includes site preparation, earthwork, permanent sheeting, and the proposed restoration measure activities. Site preparation costs includes mobilization, brush clearing, timber matting, stone, erosion control, debris removal, temporary access bridge and demobilization. Table 6-1 presents the estimated construction costs for the recommended NER plan.

Table 6-1 Project Construction Costs (2008 Pricing)

Task/Item	Quantity	Estimated Costs
Mob, Demob & Work Storage Yard	1 L.S.	$ 279,600
Invasive Species Removal & Disposal	14.9 ac	$ 2,659,200
Native Species Replanting	1 L.S.	$ 156,000
Wetland Creation	5.4 ac	$ 1,592,400
Fish Substrate Placement	2.8 ac	$ 328,800
Debris Removal, Testing, Misc	1 L.S.	$ 111,600
Estimated Construction Cost		**$ 5,127,600**

6.4 PRELIMINARY PROJECT SEQUENCING

Implementation of the recommended NER plan is subject to the USACE review, approval and funding processes, and participation of the local sponsor, including execution of a Project Cooperation Agreement (PCA). Upon receiving approval from the USACE, North Atlantic Division, New England District must prepare detailed plans and specifications prior to solicitation of bids and contract award. The finalization of the detailed plans and specifications are tentatively schedule for March 2009. It's assumed that 75% level design plans will be able to initiate the permit application submissions, tentatively scheduled for completion by November 2008.

The preliminary quarterly project sequencing is as follows:

January-March 2010

1) Secure permits.

April-June 2010

2) Initiate land, access and rights-of-way appraisals;
3) Complete land, access and rights-of-way appraisals.

July-September 2010

4) Secure lands and easements.

October-December 2010

5) Solicit bids;
6) Contract Award to lowest responsible bidder;
7) Issue Notice to Proceed.

January-March 2011

8) Review Submittals
9) Initiate Construction activities

6.5 OPERATION AND MAINTENANCE

No permanent structures are proposed within the NER plan. The development of an Operation and Maintenance Manual will not be required

6.6 MONITORING

Due to the uncertainty of achieving project outputs is considered high, a monitoring program will require periodic observations to determine the success rate for the restored native plant wetlands and to determine if Phragmites eradication has been achieved. The monitoring program would require periodic inspections for 3 years commencing 3 months after construction has been completed. A three-person team will conduct inspections from both the land side and by the river. An annual monitoring inspection report would be prepared and distributed to the local sponsor. The total monitoring program costs are projected to be $30,000. The observations will determine if the major restoration objectives have been met. These restoration objectives include:

- Restoration of freshwater wetlands to provide habitats for native fish and wildlife;

- Reduction of current impacts caused by sediment quality and restoration of degraded benthic habitat; and
- Reduction of current impacts to water quality and water quality standard exceedances, to restore water quality as a structural component of the riverine migratory habitat.

6.7 REAL ESTATE REQUIREMENTS

In considering potential ecosystem restoration measures and plans in this report, it is assumed that any necessary land acquisition, temporary and permanent easements, property transfers, etc. associated with restoration are obtainable. Appendix H discusses necessary land acquisitions and easement requirements.

The effects of various wetland and sediment restoration alternatives were investigated for their impact on the acquisition of real estate to support the restoration alternatives. No structures would be acquired for the various wetland or sediment restoration alternatives; however, some land areas will be needed to construct the wetland site. A two year temporary construction easement will be required for construction activities, ingress and egress and temporary staging areas. Permanent easements will be required for evaluating/monitoring the long-term health and success of the ecosystem restoration of the Malden River.

During the feasibility study, land parcels were identified within the project area for temporary construction staging areas and temporary/permanent easements required to construct and maintain the project (see Figure 6-2).

Temporary staging areas were identified during this phase of the study. These staging areas were evaluated based on their proximity to the individual restoration sites and availability for consideration. Table 6-2 identifies the parcel, ownership, functioning sub-area, and availability.

Table 6-2 Temporary Staging Areas

Parcel	Ownership	Functioning Sub-area	Availability
Block 5/4 &4A	City of Malden	Sub-area 2 & 3	Moderate
Block 2/ 5	National Grid	Sub-area 2, 3 & 4	Moderate
Block 2/ 7-10	MVDC	Sub-area 4 & 5	High
Block 6/ 8	Gateway Mall Properties	Sub-area 6	Moderate

Insert Figure 6-2 – Real Estate Proposed Work Limits

The National Grid parcel (Block 2 Parcel 5) is the most favorable staging site due to its approximation to the proposed work activities, lot size (2.0 acres), and availability. The real estate cost for using the National Grid parcel (2 acres) as a temporary staging area is estimated at $55,000 per construction year.

Permanent easements are required to construct, operate and maintain both the wetland restoration and wetland creation components. These components are located within some privately held lands and would have to be acquired by the sponsor.

The total real estate cost for the Malden River Ecosystem Restoration Project is projected to be $500,000, which includes the temporary staging cost. A description of the Lands, Easements and Rights-of-Way (LER) required for the project including the tract number, ownership, acreage and estimated value are shown in Table 6-3.

Table 6-3 Tract Register

Tract No.	Ownership	Acreage	Gross Value	Remarks
Block 2/3	National Grid	1.9 ac	$230,000	Perm wetland area easement
Block 2/5	National Grid	3.7 ac	$ 70,000	Perm wetland area easement
Block 2/5	National Grid	2.0 ac	$110,000	Temp const/staging easement
Block 2/6	General Electric	4.6 ac	$ 35,000	Perm wetland area easement
Block 4/18	MVDC (Sponsor)	3.7 ac	$ 25,000	Perm wetland area easement
Block 4/19	MVDC (Sponsor)	1.9 ac	$ 20,000	Perm wetland area easement
		TOTAL	**$ 490,000**	

6.8 TOTAL PROJECT COSTS

For the NER plan, total project implementation costs were calculated and average equivalent costs based on a 50-year evaluation period were derived. Table 8-4 includes all construction costs, supervisory and administration costs, real estate costs, detailed plans and specification development costs and a contingency factor of 15 percent. Cost sharing implementation has been included in Table 6-4.

Table 6-4 Total Project Implementation Costs

Task/Item	*Estimated Costs*
Construction	$ 5,127,600
Contingencies (20%)	$ 1,025,400
Construction Management	$ 314,000
Engineering & Design	$ 102,000
Real Estate Costs	$ 500,000
Subtotal	$ 7,069,000
Monitoring Program	$ 30,000
Plans & Specification	$ 245,000
Total Project Implementation Costs	**$ 7,344,000**

6.9 ASSUMPTIONS

Assumption used to determine the alternative costs included the following:

- Two year construction period;
- Staging area (parcel 2-5) can access all proposed work within sub-areas 3 thru 5;
- Proposed fish substrate placement within sub areas 1and 3 are contingent on work to be performed by others. Removal of a minimum of 3-foot depth of the existing contaminated river bottom is required to obtain a suitable and stable base prior to placement of the sand/gravel substrate;
- Average 1-1/2 -foot thickness of material to be excavated to remove *Phragmites* root matter and areas to receive a maximum cover of one foot of clean material;
- Proposed excavated material will be used as a substrate to the wetland creation;
- Operational locking changes at the Amelia Earhart Dam will be acceptable to Massachusetts Department of Conservation and Recreation; and
- All miscellaneous debris/trash removal will be hauled and disposed of in a non-hazardous landfill.

7.0 NON-FEDERAL RESPONSIBILITIES

7.1 COST ALLOCATION AND APPROPRIATIONS

A non-Federal sponsor is required to provide at least 35 percent of the implementation costs of Section 206 aquatic ecosystem projects. Implementation costs include preparation of this report, preparation of the project plans and specifications, and construction of the project. The provision of work in-kind can be credited against the sponsor's cost-sharing requirement as specified under EC 1105-2-214, paragraph 12.b, which states, "For section 206 projects, the entire non-Federal share of the total project cost may be credited work in-kind." Mystic Valley Development Commission is the non-Federal sponsor for this project and acknowledges the 35 percent non-Federal contribution requirement. This non-Federal contribution will be met with a combination of funding obtained from the Commonwealth of Massachusetts through its Department of Conservation and Recreation (formerly the Department of Environmental Management), funding provided by the cities, work in-kind provided by city forces, and by the value realized by use of the city-owned staging, dewatering and disposal sites.

At this time, the costs for the development of the detailed plans and specifications, and construction costs including post-construction monitoring are estimated as shown in Table 7-1.

Table 7-1 Total Project Costs and Cost-Sharing Appropriations

	Total Project Cost	Federal Cost	Sponsor Cost
Cost Sharing Implementation	$7,344,000	$4,773,600	$2,570,400

7.2 FINANCIAL ANALYSIS

The intent is to transfer this project from the General Investigation to the Continuing Authorities Program (Section 206) prior to initiating the Detailed Plan and Specifications phase. The non-Federal sponsor for this project will be the Mystic Valley Development Commission. Cost sharing implementation for ecosystem restoration project is specified in Section 206 of the Water Resource Development Act of 1996, as amended. The Commission has acknowledged their cost sharing requirements (35%) and their willingness to execute the model Project Cooperation Agreement with Government. MVDC's acknowledgement of these requirements are outlined in a letter dated **MONTH DAY**, 2006 (see Appendix A). The Commission expects to pay for their share with assistance from the Massachusetts

Department of Conservation and Recreation, local funds, and the cost share credit they will receive for lands, easements, rights-of-way, relocations and disposal areas (LERRD) required for the restoration project. The Commission has acknowledged their responsibility for 100 percent of the Operations, Maintenance, Replacement, Repair and Rehabilitation (OMRR&R).

8.0 SUMMARY OF PUBLIC INVOLVEMENT AND STAKEHOLDER ISSUES

Public stakeholder involvement was an important component of this Malden River Feasibility Study. Three invited stakeholder meetings were held to allow comment and discussion on the project. A brief summary of these two meetings and the stakeholder issues raised are given below, while the minutes and attendance list of each meeting are included in Appendix A-2 Public Involvement.

Coordinated Site Meeting, Malden Town Hall

On September 25, 2003, the MVDC, USACE, and ENSR hosted a working meeting of resource agencies and stakeholders in the Malden City Hall, Malden MA to discuss restoration alternatives and measures being considered for evaluation in the Malden River Ecosystem Restoration Feasibility Study. The invited participants were selected on the basis of prior involvement in the study to date, watershed involvement, relevant experience, and/or representation of regulatory agency interest. The purpose of the meeting was to discuss the spectrum of potential ecosystem restoration measures and discuss how these could be combined into ecosystem restoration alternative plans. Participants also had the opportunity to raise other issues of interest at the meeting or to provide written comments at a later date. Comments raised or later received included those on: the mandatory No Action alternative, on watershed best management practices, rerouting/bypassing of stormwater flows, watershed flow management for Spot Pond, operations and fish passage at the Amelia Earhart Dam, use of in situ chemical and biological treatment, monitored natural recovery, use of herbicides for *Phragmites* control, and the importance of the human heath aspect of restoring the River.

Alternative Analysis Meeting, USACE Headquarters

On December 10, 2003, USACE hosted a Sponsor/Stakeholder's meeting to present the ecosystem restoration measures being considered as part of the feasibility process. The invited stakeholders were allowed an opportunity to comment on the candidate ecosystem restoration alternative plans being considered for the Feasibility Study. The five alternative plans presented were the No Action, Invasive Species Replacement and Fish Habitat Enhancement, Wetland Restoration and Fish Habitat Enhancement, Wetland Restoration /Creation and Benthic and Fish Habitat Enhancement, and Benthic and Fish Habitat Enhancement. Stakeholders also had the opportunity to raise other issues of interest at the meeting or to provide written comments at a later date. Comments raised or later received included those on: the amount (volume vs. mass) of toxic materials proposed for dredging, potential disposal of dredged material, impact of actions on water column DO, the appearance of the proposed created wetlands, the potential for treating stormwater via wetland treatment in Little Creek, evaluation of the potential for anadromous fish passage at the Amelia Earhart Dam.

Plan Formulation Meeting, USACE Headquarters

On July 13, 2005, the MVDC and USACE hosted a presentation to the stakeholders at the USACE headquarters in Concord, MA. The purpose of this presentation was to discuss the results of the plan formulation and incremental cost analysis process. This initial process identified 39 cost effective restoration plans of which eight were considered Best Buy Plans. However, several minor inconsistencies required adjustments/corrections to the incremental analysis process. The final analysis identified 276 cost effective plans and thirteen Best Buy Plans.

Fish and Wildlife Coordination Act

In a letter dated March 28, 2007, U.S. Fish and Wildlife Service informed that no federally-listed or proposed, threatened or endangered species or critical habitat under their jurisdiction is known to occur in the project area. No further Endangered Species Act coordination is required. In regards to the Fish and Wildlife Coordination Act, U.S. Fish and Wildlife Service have no objections. Letter is appended in Appendix A-1 Resource Agencies Correspondence.

Ecosystem Restoration Approach Meeting, MA DEP Northeast region Office

On Tuesday, 20 March 2007, a meeting was held at the office of Massachusetts Department of Environmental Protection, Northeast Region to discuss the ecosystem restoration approach for the Malden River. Though the proposed wetland restoration component requires Phragmites stem and root matter to be removed by excavating a minimum depth of 18 inches, the objective is to excavate to the first stable substrate layer. The excavated material for the wetland restoration component can be managed under existing State programs. One option involves using the excavated volume of 30,000 cy as a substrate layer to the wetland creation component. Excess material may be reused within the study area as a part of the redevelopment plan for the Rivers Edge project. Compensatory flood storage was discussed. The Medford-side restoration efforts have exceeded the minimum requirement for the compensatory flood storage. Credits may be used for the Federal plan. An area adjacent to North Creek has also been identified for additional flood storage, if needed.

Potentially Responsible Parties Discussions

MVDC's representatives have held detailed meetings with each of the PRPs associated with historic sediment contamination. It is envisioned that further discussions/negotiations will be driven by the elements of this Detailed Project Report when it is released for public review. The purpose of recent meeting with the Allied consultant arose from the fact that they were now assuming responsibility for the completion of necessary MCP response actions as they pertain to the former Barrett Coal Gas manufacturing facility. Allied has indicated to MA DEP that Ma-Tec are now their LSP of Record for this release condition. Allied has filed a Phase IV Remedy Implementation Plan (RIP) for Little Creek. Mass Electric is agreeable to including that minor portion of the river system to the south of the Medford Street Bridge within their remedial action program for upstream sediments.

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9.0 SCHEDULE FOR ACCOMPLISHMENTS

A projected schedule has been developed based on the assumption that Federal and non-Federal funds will be available. The tentative schedule for project completion is as follows:

	Estimated Date
Project Approval by North Atlantic Division	September 2008
Execute Project Cooperation Agreement	October 2008
Initiate Design Plans & Specifications	November 2008
Initiate Permit Process	April 2009
Obtain State & Local Permits	March 2010
Finalization of Detailed Plans and Specifications	May 2010
Complete Appraisals Process	June 2010
Secure Lands and Easements	August 2010
Initiate Solicitation Process	October 2010
Contract Award	December 2010
Initiate Construction	March 2011
Complete of Construction	June 2013
Monitoring	June 2013 thru November 2016

A list of potential permits required for the Recommended Plan has been determined. The Government is required to secure the Section 401 Water Quality Certification and the General Permit to Discharge Storm Water from Construction Site (NPDES).The non-Federal sponsor, Mystic Valley Development Commission is responsible to obtain the following:

1. Massachusetts Environmental Protection Act (MEPA) Certification,
2. Order of Conditions pursuant to MA Wetlands Protection Act - Conservation Commission,
3. Chapter 91 License - Massachusetts Department of Environmental Protection,
4. Special Permit for Processing Site - Malden, Medford & Everett Planning Boards.

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10.0 FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

I recommend that the habitat restoration project described in the report be approved and implemented. This report presents a National Ecosystem Restoration (NER) plan that reasonably maximizes environmental restoration benefits and is consistent with the Federal objective. The recommended plan is shown to be cost-effective and justified to achieve the desired level of environmental output. National Environmental Policy Act (NEPA) documentation required for implementation of the proposed actions, in the form of an Environmental Assessment (EA) and a Finding of No Significant Impact (FONSI), is included in this report.

The recommended NER plan consists of the following actions:

- Removal of 36,100 cubic yards of invasive plant species along 14.9 acres of the riverbank corridor and replanting with native wetland plant species;
- Creation of 5.4 acres of emergent wetland within the existing oxbow;
- Creation of 2.8 acres of fish spawning habitat;
- Miscellaneous debris removal and disposal within the construction limits; and
- Operational changes at the Amelia Earhart Dam to improve fish passage.

A monitoring program would be conducted for three years as a cost-shared post-implementation work item. The monitoring plan would be performed by or under the guidance of the New England District in cooperation with MVDC. The plan is intended to measure achievement of the goals and objectives established during planning.

After consultation and coordination with the non-Federal sponsor, the Federal Government is responsible for determining the lands, easements, rights-of-way, relocation (utility or public facility), and excavated material disposal areas (LERRD) required for the implementation, operation and maintenance of the project. Except in circumstances involving land owned by the United States or where the Government can properly exercise its navigation servitude rights, all land determined by the Government to be required to support the project must be provided by the non-Federal sponsor. Fee interest is not necessary for the project and a Wetlands Restoration Easement is recommended. Upon completion of the project, the ownership and operation and maintenance responsibilities for all restoration sites will be transferred to the non-Federal sponsor. Project real estate rights acquired will be transferred to the non-Federal sponsor.

The aquatic habitat outputs from the separable elements of the NER plan represent resources of federal significance and are institutionally recognized in the Clean Water Act (vegetated wetlands). The additional benefits of forage and passage to spawning grounds for anadromous fish make restoration a critical Federal interest in this highly urbanized watershed. Federal interest in establishment and protection of anadromous fish is recognized in the Anadromous Fish Conservation Act and the Fish and Wildlife Conservation Act. Federal interest in invasive species control (*Phragmites*) is institutionally recognized by Executive Order 13112 of February 3, 1999 -- Invasive Species.

In my judgment, the selected plan is a justifiable expenditure of Federal funds and appropriate for implementation under the authority of Section 206 of the Water Resources Development Act of 1996 (PL 104-303). The total estimated project cost is $7,344,000. I also recommend that no further study be conducted under this General Investigation authority at this time.

I acknowledge that the recommendations were given consideration to all significant aspects in the overall public interest. Those aspects considered included environmental, social, and economic effects; engineering feasibility; and regional significance to a scarce habitat resource.

The recommendations contained herein reflect the information available at this time and current Departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before they are authorized for implementation funding. However, prior to executing a Project Cooperation Agreement, the non-Federal sponsor will be advised of any modifications and will be afforded an opportunity to comment further.

28 July 08
Date

PHILIP T. FEIR
Colonel, Corps of Engineers
District Engineer

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