Feasibility Report and Final Environmental Impact Statement/Report
Water Resources Investigation

Saugus River and Tributaries, Lynn, Malden, Revere and Saugus, Massachusetts

Flood Damage Reduction

Main Report - Section 1 (Feasibility Report)

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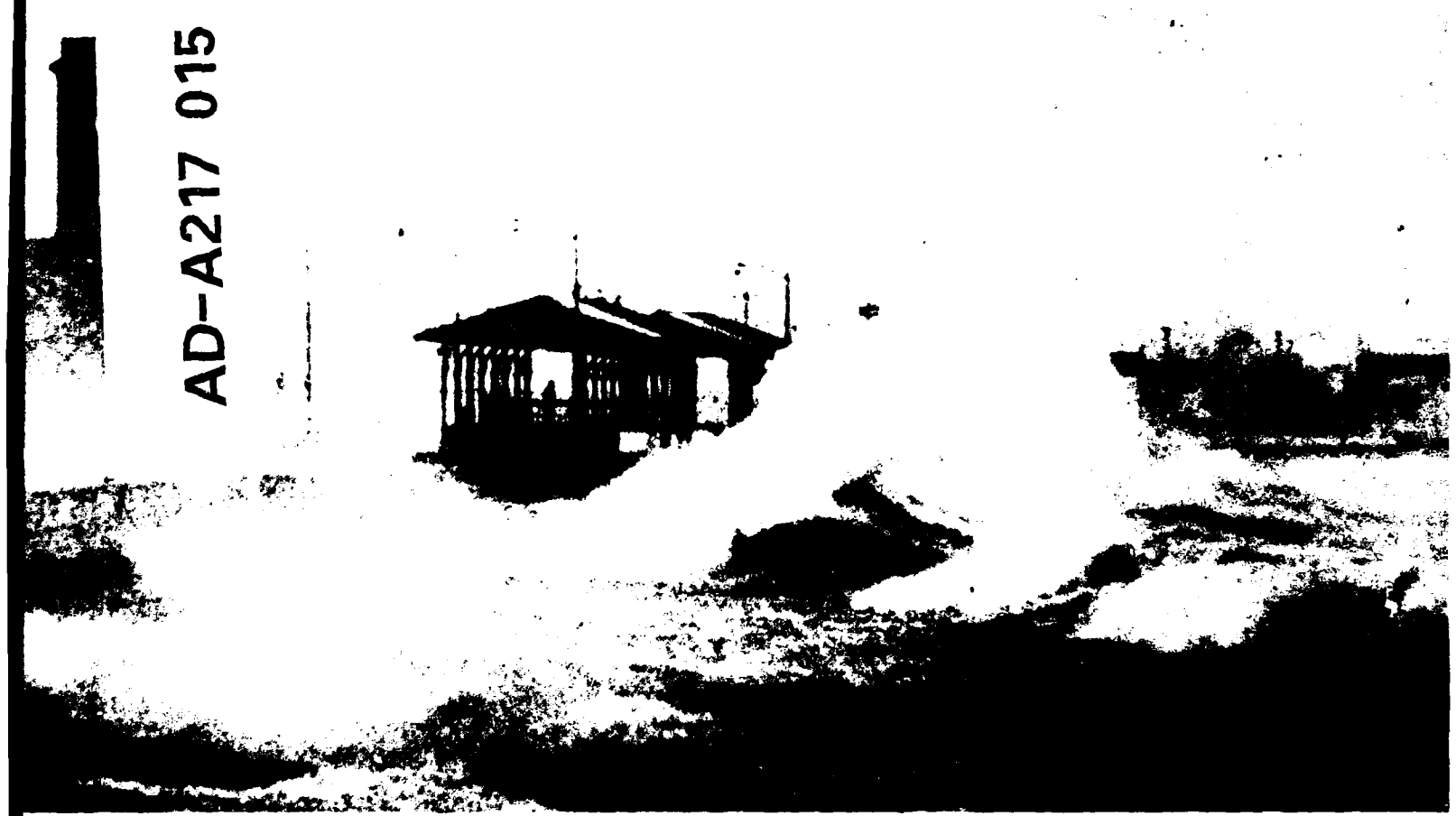

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This report describes possible solutions to the coastal flooding problems in the Saugus River and its tributaries. This volume is section 1 of the main report; there are 11 volumes: main report (2 sections) and nine appendices.
This recommended Regional Saugus River Floodgate Plan is economically justified and will maximize net economic benefits. The plan is also technically feasible.

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WATER RESOURCES INVESTIGATION
FEASIBLITY REPORT
FINAL ENVIRONMENTAL IMPACT STATEMENT
AND
FINAL ENVIRONMENTAL IMPACT REPORT
(EOEA FILE NUMBER 6497)

SAUGUS RIVER AND TRIBUTARIES FLOOD DAMAGE REDUCTION STUDY

LYNN, MALDEN, REVERE
AND SAUGUS, MASSACHUSETTS

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Section 1

FEASIBLITY REPORT

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December 1989

SAUGUS RIVER AND TRIBUTARIES
FLOOD DAMAGE REDUCTION STUDY
LYNN, MALDEN, REVERE AND SAUGUS, MASSACHUSETTS

EXECUTIVE SUMMARY

This report provides information on and describes possible solutions to the coastal flooding problems in the Saugus River and tributaries coastal floodplain.

THE PROBLEM

Lying approximately five to ten miles north of Boston, Massachusetts, the 4,000 acre study area includes portions of the cities of Lynn, Malden and Revere and the town of Saugus, and has a resident population of 20,000 people.

Early in 1978 this area was hit by one of the most severe weather events ever to strike the eastern New England coast. At 10:20 p.m. on Monday night, February 6, the first storm surge struck. Record high tides flooded thousands of homes and buildings, knocked out electricity in freezing weather, and forced the emergency evacuation of over 4,000 people. The following morning at 10:36 a.m., when a second tidal surge hit the study area with almost equal magnitude, many of the residents who had stayed in their homes were still stranded since access routes remained flooded. Record flood depths of up to seven feet caused damages to an estimated 3,100 buildings, and directly affected the lives of over 10,000 people and the employment of another 20,000 in the floodplain. The storm flooded major transportation arteries that are used on a daily basis by 100,000 commuters from Massachusetts' "North Shore" -- the coastal communities lying between Boston, Massachusetts and Portsmouth, New Hampshire. Flood-related problems disrupted utilities which serve the entire North Shore. Remembered as the "Blizzard of '78", the storm ranks among the worst disasters in New England's history.

The study area suffers frequently from coastal flooding. Including the Blizzard of '78, estimated as about a 100-year (1 percent annual probability) tidal event, the area has been hit by four major coastal storms in the past 17 years, and smaller storms disrupt the area yearly. Rising sea levels, a trend that appears to be accelerating, will only increase the vulnerability of the study area to future coastal storms. Moreover, the industrial, commercial and residential sectors within the study area continue to grow. A recurring '78 storm tide could cause damages estimated at over $100 million. The worst coastal storm reasonably likely to hit the area, the Standard Project Northeaster (SPN), could cripple the region, causing upwards of 10 feet of flooding and $500 million in damages — closing a General Electric plant, an important defense facility; affecting up to 5,000 residential, commercial, industrial and public buildings; threatening utilities serving the North Shore and disrupting the lives of over 300,000 residents and employees in these communities and commuters who use the major transportation arteries which traverse this urban floodplain.

Buildings Along Revere Beach are Vulnerable to Severe Overtopping.

The General Electric River Works Complex, a Defense Department Supplier, Suffers Disruption and Damages from Small and Large Coastal Storms.

Utilities and Businesses in Lynn Which Serve the Entire Massachusett's North Shore Lie in the Floodplain of the Study Area.

Only a slim margin exists between a coastal storm tide that causes little disturbance and one that is a major disaster. Because of the particular topography and tidal hydrology of the study area, flood waters and waves pushed inland from the ocean and which overflow seawalls become trapped. This phenomenon results in interior flood levels that are often significantly higher than high tide levels offshore. An ocean level of 1 foot above a yearly high tide results in wet basements in approximately 400 buildings. A storm tide level of just 2 feet above a yearly tide requires the emergency evacuation of people from several thousand buildings.

STUDY SCOPE AND PROCESS

The study area also has environmental resources of substantial importance to Metropolitan Boston. Situated around the largest saltwater estuary (1,660 acres) near Boston and along 5 miles of coastline, it provides nursery and habitat for fish resources, habitat for birds and wildlife, and opportunities for numerous other uses. The study area also harbors nearly 800 commercial and recreational navigation vessels, half of which are moored along the Saugus and Pines Rivers. Acceptable solutions to the coastal flooding problems could not come at the expense of these valued local resources. It was apparent from the start that public involvement and interagency coordination would have to play a major role in the study process because:

- ✔ the study was examining coastal flooding problems that affected eight separate areas within four jurisdictions, each with strong local authority under the Commonwealth's political system of Home Rule;

- ✔ recent growth had heightened concern about further damage to or loss of wetlands, threats to water quality, and about rising recreational needs; and

- ✔ the study was directed to explore **regional** approaches to coastal flooding problems — approaches that could require an unusual amount of broadmindedness and far-sightedness on the part of community and state leaders, and extensive cooperation among the diverse groups and state and Federal agencies whose interests were at stake in resolving the flooding problems; protecting the area's natural, scenic and/or recreational resources; improving the local economic climate, or all of these concerns.

With these factors clearly in mind, a public participation program was set up to provide continuous two-way communication throughout the planning process. By keeping all non-Corps of Engineers entities: Federal, state, local and regional agencies, as well as public and private organizations and the general public, informed about and involved with the study's progress, major decisions during the study were able to reflect the concerns and objectives of these multiple and varied perspectives. Four Citizens Steering Committees (one

from each community) and a Technical Group were formed and worked together throughout the study. These individuals, whose contributions have been significant, are listed in the report. In addition to regular meetings with the committees, over 100 meetings were held with the public, and nearly 2,000 interviews were conducted to gather information regarding flood problems and to explore the acceptability of alternative solutions.

In June 1989 the draft Feasibility Report, EIS/EIR and appendices were provided to nearly 500 Federal, state and local agencies, interest groups and individuals for a public review and to the Corps' Washington Level Review Center. The 45-day public review ended on August 7, 1989. The comments and Corps responses are included in Appendix J, along with information on project revisions resulting from the review process.

PLAN FORMULATION

Three potential solutions were developed and evaluated:

- THE LOCAL FLOOD PROTECTION PLAN looked at Local Protection Plans for each of the four communities. While economically justified, the plans (which would require nine miles of new structures along their shorefront and estuary) were not favored by the communities due to disturbance to real estate, financial constraints, and the potential loss of 32 acres of vegetated wetlands and intertidal habitat, impaired views and other aesthetic impacts.

- THE NONSTRUCTURAL FLOOD PROTECTION PLAN evaluated flood-proofing and the installation of improved warning systems. This plan had no support from the local communities because of its limited capacity to provide an adequate early warning and reduce flood impacts. Only about 7 percent of residents in the floodplain would have benefitted. An alternative to raise or floodproof all structures in the floodplain was also investigated. The plan was not economically feasible and would cost nearly twice as much as either of the other two plans investigated. Public safety could not be assured, since predicting the extent of coastal flooding for evacuation purposes is very unreliable.

- THE REGIONAL FLOODGATE PLAN evaluated a system of interrelated structural and nonstructural features, including a floodgate on the Saugus River. The plan was found to provide a very high degree of flood protection against the Standard Project Northeaster (SPN) event for nearly the entire study area. It yields the highest net economic benefits of all the solutions, has minimal impacts on the estuary, and minimal social impacts, although it must mitigate the loss of 3 acres of mostly intertidal or subtidal habitat along the coast. Because it offers the potential for a high level of regional flood protection and

ELEMENTS OF THE RECOMMENDED REGIONAL PLAN

also complements State and local environmental management goals, the plan has wide support. Indeed, while the estuary and surrounding marshlands have recently been designated as a Massachusetts Area of Critical Environmental Concern (ACEC) to provide the strongest protection possible under the current laws of the Commonwealth, the Saugus River Flood Damage Reduction Project has been exempted from ACEC requirements. This exemption was made because of the project's potentially broad public benefit and the belief that the existing process for review of Federal projects meets the intent of the ACEC program.

The Regional Saugus River Floodgate Plan combines 3 miles of existing flood damage reduction measures with 3.5 miles of new measures to create a linked defense line that will provide SPN protection to nearly the entire study area and prevent flooding up to 10 feet deep. The principal component of the flood damage reduction plan is construction of tidal floodgates at the mouth of the Saugus River which would prevent tidal surges from entering the river and flooding land throughout the study area. The floodgates would span 1,290 feet at the mouth of the river and include 600 feet of gated openings so as to maintain both safe passage for navigation and natural tide levels and flushing patterns in the estuary. The gates would only be closed when projected tide levels are expected to cause significant damages. Closure would initially occur two to three times each year, with closure lasting one to two hours during the peak of the tide. During very severe coastal storms, such as a recurrence of the Blizzard of '78, the gates would be closed for a longer period of time and possibly for more than one high tide. With sea level rise, the future frequency of closure would increase; however the project could be modified to return to closures of 2 to 3 times per year.

Integrated with the tidal gates which are important for regional protection, and to help reduce localized wave overtopping which has contributed to flood damages in the past, a combination of dikes, walls, stone revetments, beaches and sand dunes will be needed in Lynn and at Point of Pines. Preservation of three miles of existing seawalls at Revere Beach, as well as construction of a wall and a park dike behind that beach are also needed to reduce flooding for the region. Protection through purchase of a real estate interest in the tidal wetlands associated with the Saugus River estuary will permit use of the natural storage capacity of this area for temporary storage of estuary waters, freshwater runoff that occurs behind the floodgates and of salt water that may result from tidal overtopping at Revere during gate closure. The project causes a loss of approximately 2 acres of intertidal and 1 acre of subtidal habitat at the location of project features along the coast. This loss will be replaced through the creation of 2 acres of clam flats and 1 acre of subtidal habitat at the I-95 embankment.

The $88.5 million Regional Plan would have an average annual cost of $8,990,000 which includes $230,000 per year for operation, maintenance and major replacements. The plan produces average annual benefits of $11,390,000, primarily from flood damage reduction. Thus the project's net benefits are $2,400,000, with a benefit to cost ratio of 1.3 to 1. Benefits and costs are at 1989 price levels.

BENEFITS AND OPPORTUNITIES PROVIDED BY THE RECOMMENDED PLAN

The Regional Plan offers the following in direct benefits:

- Reduced flood damages to 5,000 buildings and major gas, electrical and wastewater treatment facilities serving the North Shore, thus providing an estimated $7.0 million in average annual benefits and the prevention of up to $500 million in damages in the event of an SPN flood.

- Prevention of damages and temporary public transportation costs along 20 miles of major floodprone public transportation arteries which serve Boston's North Shore.

- Reduced damages to existing shorefront storm-vulnerable infrastructure, saving about $1.7 million on an annual basis.

- Substantial reduction in the need for and costs of emergency public services.

- Development of a 3,400 foot long dike with joint flood control and public park land use.

- A reduction of $1 million in future average annual damages when a projected historical rate of sea-level rise is applied.

- Approximately $800,000 in reduced shorefront construction costs (dikes and walls) for the Metropolitan District Commission's (MDC) Town Line and Linden Brook project in Revere and Malden.

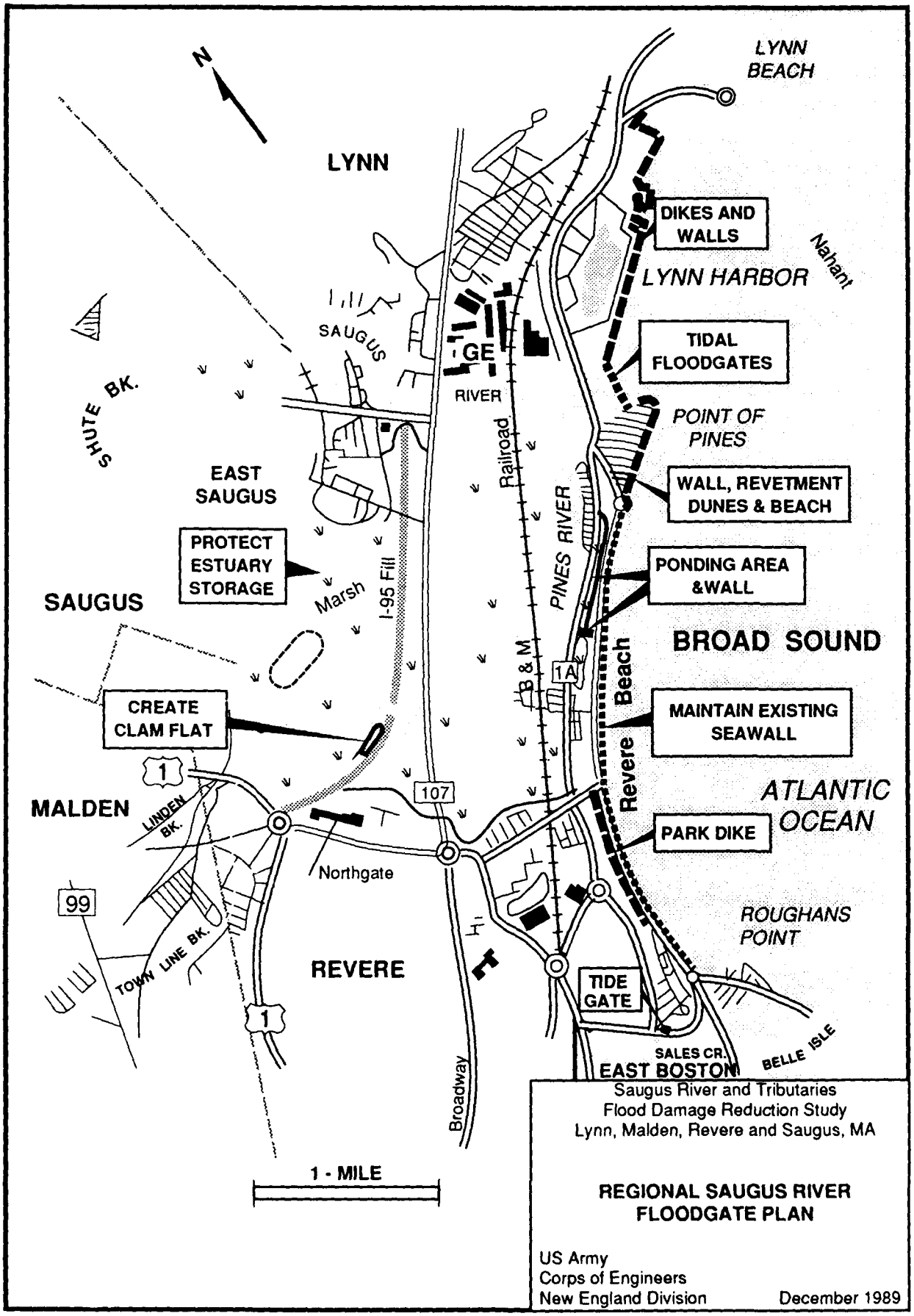
Additional benefits and opportunities associated with the plan for which economic benefits have not been taken include:

- Reduction in flooding from the backup of major drainage systems during high flood tides, benefitting areas in Malden, Revere, Lynn and Saugus.

- Reduction in the indirect impact on the local, regional, state and national economies from lost employment and sales.

- Improved protection for the resources of the saltwater estuary.

- A safer port of refuge during coastal storms and hurricanes for the 400 vessel fleet that is moored in the estuary.


LYNN BEACH
LYNN
DIKES AND WALLS
Nahant
LYNN HARBOR
SAUGUS
GE
RIVER
TIDAL FLOODGATES
SHUTE BK.
POINT OF PINES
Railroad
EAST SAUGUS
WALL, REVETMENT DUNES & BEACH
PINES RIVER
PROTECT ESTUARY STORAGE
PONDING AREA &WALL
SAUGUS
Marsh
I-95 Fill
BROAD SOUND
B & M
1A
Revere Beach
CREATE CLAM FLAT
MAINTAIN EXISTING SEAWALL
1
107
ATLANTIC OCEAN
MALDEN
LINDEN BK.
PARK DIKE
Northgate
99
ROUGHANS POINT
TOWN LINE BK.
REVERE
TIDE GATE
1
SALES CR.
EAST BOSTON
BELLE ISLE
Broadway
1 - MILE
Saugus River and Tributaries
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Lynn, Malden, Revere and Saugus, MA
REGIONAL SAUGUS RIVER FLOODGATE PLAN
US Army
Corps of Engineers
New England Division
December 1989

CONCLUSION

The recommended Regional Saugus River Floodgate Plan is economically justified and maximizes net economic benefits. The plan is technically feasible, as similar projects have been constructed and operated by the New England Division for more than 20 years. Following the draft review of this document, the state sponsor, the Metropolitan District Commission(MDC), provided a letter supporting the project. Also the MDC indicated that funding would be requested from the state legislature and the local cooperation agreement would be signed at the appropriate time in cooperation with the four sponsoring communities. The cities of Lynn, Malden and Revere and the town of Saugus also provided letters supporting the project and agreeing to meet those items of local cooperation not within the direct control of the MDC. The non-Federal cost of the project is 35.3 percent or $31,200,000 (includes $9,200,000 in Real Estate and relocation or alternations to existing utilities). The state sponsor would be required to provide cash contributions estimated at $22,000,000 during construction which is currently scheduled to start in fiscal year 1994, in addition to meeting the real estate and relocation requirements. Following completion of the project, an estimated $230,000 per year operation and maintenance cost would be a continuing non-Federal responsibility. The sponsors would also protect the existing flood storage capacity of the estuary by acquisition in fee or easement of the approximate 1650 acre estuary. The Federal Government would finance 64.7 percent or $57,300,000 of the project cost. With no known significant adverse environmental or socioeconomic impacts, the recommended plan enjoys wide and very active public support.

SAUGUS RIVER AND TRIBUTARIES
FLOOD DAMAGE REDUCTION STUDY

Main Report - Section 1 (Feasibility Report)

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FINAL ENVIRONMENTAL IMPACT STATEMENT/REPORT, including Section 404 (B)(1) Evaluation (see Main Report - Section 2)

SEPARATE APPENDICES AVAILABLE FROM THE NEW ENGLAND DIVISION

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Volume 2	**Appendix B - Hydrology and Hydraulics**
	Appendix C - Water Quality
Volume 3	**Appendix D - Design and Costs**
	Appendix E - Geotechnical
	Appendix F - Real Estate
Volume 4	**Appendix G - Economics**
	Appendix H - Socioeconomic
Volume 5	**Appendix I - Planning Correspondence: U.S. Congress, State Legislatures, Federal and State Agencies**
Volume 6	**Appendix I - Planning Correspondence: Lynn, Malden, Revere, Saugus, Interest Groups, and News Articles**
Volume 7	**Appendix J - Feasibility Study and EIS/EIR Comments and Responses**
Volume 8	**Appendix K - Environmental**

SAUGUS RIVER AND TRIBUTARIES FLOOD DAMAGE REDUCTION STUDY

Lynn, Malden, Revere and Saugus, Massachusetts/Summary of Study Reports:

Main Report and Environmental Impact Statement/Report (EIS/EIR): Summarizes the coastal flooding problems in the study area and alternative solutions; describes the selected plan and implementation responsibilities of the selected plan; and identifies environmental resources in the study area and potential impacts of alternative solutions, as required by the Federal (NEPA) and state (MEPA) environmental processes.

Plan Formulation (Appendix A): Provides detailed information on the coastal flooding problem and the alternatives investigated; includes: sensitivity analyses on floodgate selection (including location and size of gates and sea level rise); optimization of plans; comparison of alternative measures to reduce impacts; and public concerns.

Hydrology and Hydraulics (Appendix B): Includes descriptions of: the tidal hydrology and hydrology of interior runoff in the study area, and of wave runup and seawall overtopping, interior flood stage frequencies, tide levels, flushing, currents, and sea level rise effects without and with the selected project for various gated openings.

Water Quality (Appendix C): Includes descriptions of existing water quality conditions in the estuary and explores potential changes associated with the selected plan.

Design and Costs (Appendix D): Includes detailed descriptions, plans and profiles and design considerations of the selected plan; coastal analysis of the shorefront; detailed project costs; scope and costs of engineering and design; scope and costs of operation and maintenance; and design and construction schedules.

Geotechnical (Appendix E): Describes geotechnical and foundation conditions in the study area and the design of earth embankment structures in the selected plan.

Real Estate (Appendix F): Describes lands and damages, temporary and permanent easements and costs of the selected plan, including the five floodgate alignments studied.

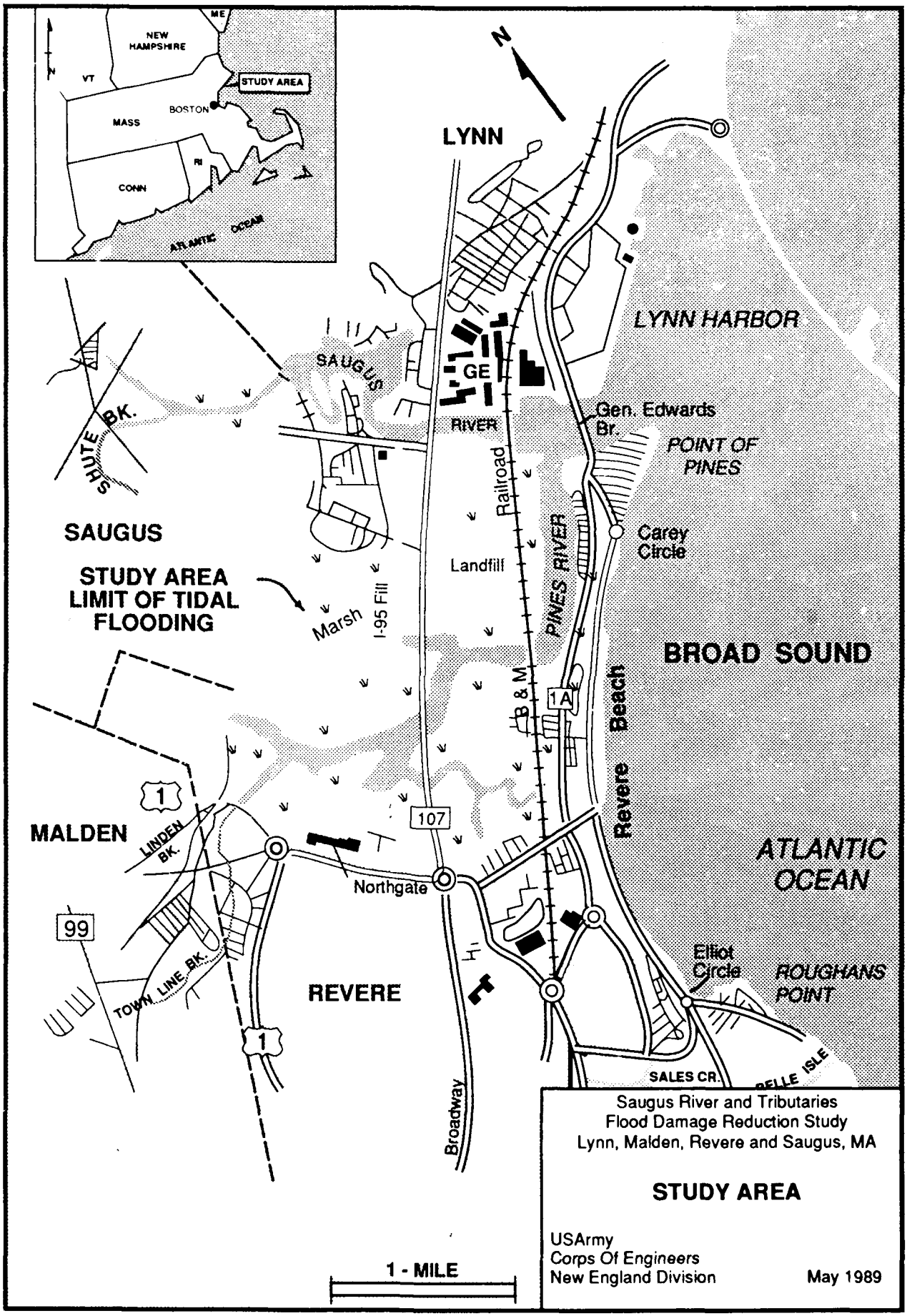
Economics (Appendix G): Describes recurring and average annual damages and benefits in study area floodzones; economic analysis and optimization of alternative plans.

Socioeconomic (Appendix H): Describes the socioeconomic conditions in the study area and the affects of the selected plan on development in the floodplain and estuary.

Planning Correspondence (Appendix I): Includes all letters between community officials, agencies, organizations and the public and the Corps prior to agency and public review of the draft report.

Feasibility Study and EIS/EIR Comments and Responses (Appendix J): Includes all project revisions,and comments and Corps responses to letters received during agency and public review.

Environmental (Appendix K): Includes basic data from investigations of environmental resources in the study area and presents the Mitigation Incremental Analysis.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Gen. Edwards Br.
POINT OF PINES
SHUTE BK.
Railroad
PINES RIVER
Carey Circle
SAUGUS
STUDY AREA LIMIT OF TIDAL FLOODING
Landfill
Marsh
I-95 Fill
BROAD SOUND
B & M
1A
Revere Beach
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MALDEN
LINDEN BK.
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ATLANTIC OCEAN
Northgate
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Elliot Circle
ROUGHANS POINT
TOWN LINE BK.
REVERE
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SALES CR.
BELLE ISLE
Broadway
1 - MILE
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Flood Damage Reduction Study
Lynn, Malden, Revere and Saugus, MA
STUDY AREA
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New England Division
May 1989

INTRODUCTION

STUDY AUTHORITY

The Southeastern New England Study (SENE) was authorized on September 12, 1969, by a resolution that read:

> "Resolved by the Committee on Public Works of the United States Senate, that the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act approved June 13, 1902, be, and is hereby requested to review the report on the Land and Water Resources of the New England-New York Region, transmitted to the President of the United States by the Secretary of the Army on April 27, 1956, and subsequently published as Senate Document Numbered 14, Eighty-fifth Congress, with a view to determining the feasibility of providing water resource improvements for flood control, navigation and related purposes in Southeastern New England for those watersheds, streams and estuaries which drain into the Atlantic Ocean and its bays and sounds in the reach of the coastline of Massachusetts, Rhode Island and Connecticut southerly of, and not including the Merrimack River in Massachusetts, to, and including, the Pawcatuck River in Rhode Island and Connecticut, with due consideration for enhancing the economic growth and quality of the environment."

HISTORY OF INVESTIGATION

A comprehensive investigation, the SENE Water and Related Land Resources Study, was initiated in 1969 with the Corps of Engineers, other appropriate Federal agencies, and the states of Massachusetts, Rhode Island and Connecticut participating. The study was chaired by the New England River Basins Commission (NERBC) which has since been discontinued.

Completed in 1975, the SENE study identified critical problems with tidal flooding even before the disastrous "Blizzard of '78". Among the nearly 200 recommendations in the NERBC final SENE report were calls for:

- improved protection against flood threat,
- use of nonstructural measures wherever possible, and
- early attention to the highly vulnerable Massachusetts coastal area.

The SENE report recommended that the Corps of Engineers be directed by Congress to investigate solutions to the coastal flood problems. Consequently, following the severe flood damages and problems that accompanied the Blizzard of '78, the mayor of Revere requested assistance from the Corps. The Corps responded immediately under the Section 205 Flood Damage Reduction Program. For the purposes of study, the area was divided into four separate zones: (1) Roughans Point, (2) Revere Beach, (3) Point of Pines, and (4) Oak Island and Vicinity. The goal in each zone was to evaluate the extent of damages experienced and conduct a preliminary investigation of possible solutions. It was soon determined, however, that answers to the area's flooding problems could not come through the Corps smaller scale Continuing Authority Program, for all of the flood damage reduction alternatives that were studied had project first costs that exceeded the existing Federal limitation of the Section 205 program.

Because of the recurring flood-induced hardships in the four communities, particularly from major coastal storms which had occurred in 1978, 1972 and 1959, the Corps initiated

further large-scale study of the Revere coastal flooding area under the ongoing SENE resolution. Between FY 1980 and 1985, separate reconnaissance investigations examined flood damage reduction alternatives for Roughans Point and Point of Pines, and a reconnaissance study was initiated for the Revere Beach Backshore area. A feasibility report containing recommendations for Roughan's Point was completed in October 1983. The project was authorized for construction in 1986, and pre-construction engineering and design (PED) studies are underway.

When the Federal limitation on allowable project first costs under the Corps Section 205 program was raised, an investigation of tidal flooding problems and solutions was undertaken for Point of Pines. The Detailed Project Report, which was completed in October 1984, recommended a Federal project.

In 1985, the study covering the Revere Beach area found a wide range in 1978 water levels reported by residents along the Pines River. As part of design studies underway for Roughans Point, gaging stations were installed in Broad Sound and on the Saugus and Pines Rivers to calibrate a tidal model. The results indicated the potential for higher flood levels on both rivers for the 1978 coastal storm. Extensive interviews followed, which provided hundreds of high water marks and information revealing a more complete story of the widespread regional flooding that occurred as a result of the Blizzard of 1978 and of recurring flooding problems. By mid-1985, the interviews had confirmed that higher flood stages had indeed occurred, resulting in a substantial rise in estimates of the potential for future damages not only in Revere, but in Lynn, Malden and Saugus. Officials of the four communities, and the area's congressmen and state officials made a formal request for a study that would explore the possibility of a regional approach to flood damage reduction. The Saugus River and Tributaries Flood Damage Reduction Feasibility Study was initiated in October 1985 in response to this request.

In June 1988 the mayor of Revere advised the Corps that the city of Revere was unable to commit to its share of the recommended Section 205 project for Point of Pines, and requested that protection of Point of Pines be integrated into the regional flood damage reduction study. Consequently, shorefront features critical to the integrity of two of the alignments then under study for the floodgate structure were incorporated into the regional plan. One of the alignments was subsequently chosen as the selected plan.

PRIOR REPORTS

As can be concluded from the above, a considerable number of water resource investigations have been carried out within the study area by Federal, state, regional and local agencies. Extensive use was made of these studies and reports to avoid duplication of effort. Very brief descriptions follow of the reports which have addressed flood problems along Revere Beach and flood problems and navigation along the Saugus and Pines Rivers. The studies, and the dates on which they appeared on the scene include:

- 1 June 1949. A Division Engineer's report on Restoration of Revere Beach was submitted to the Chief of Engineers and later printed in House Document No. 146, 82nd Congress, 1st Session. The 1954 River and Harbor Act authorized a Federal project for the protection and improvement of the shore of the Revere Beach Reservation. The Metropolitan District Commission (MDC) constructed part of the project in 1954.

• March 1968. A Beach Erosion Control Report on Cooperative Study of Revere and Nantasket Beaches, Massachusetts, was completed by the Corps of Engineers and later printed in House Document No. 211, 91st Congress, 2nd Session. The 1970 River and Harbor Act authorized Federal participation in widening Revere Beach by placement of suitable sandfill along 13,000 feet of beach fronting the MDC Reservation. During preconstruction planning, it was found that projected recreation use provided by the MDC was insufficient to justify the project and thus Federal participation was not warranted. Later investigations of coastal flooding in the Revere Beach Backshore area, found significant additional benefits associated with substantial reductions in repair and replacement costs of seawalls along the beach. Design of the erosion control project was resumed on 1 October 1984 following receipt of letters of support. A General Design Memorandum/Beach Erosion Control Project, Revere Beach, MA, was completed in August 1985 and revised in June 1986. It is estimated to cost $8.9 million. Construction is scheduled to start Fall 1989.

• June 1970. A report entitled Flood Control and Navigation Saugus and Pines Rivers Basin was submitted by the Division Engineer to the Chief of Engineers. The report focused on flood problems in the Saugus and Pines River Basin and along 6.5 miles of tidal shorefront in Revere and Lynn. No structural improvements were recommended at that time due to the lack of economic feasibility.

• 1 December 1978. The state completed the Master Plan for the Restoration of the Revere Beach Reservation. It emphasizes preservation and extension of the beach landscape as a predominantly naturalized seaside parkland, along with needed flooding, storm drainage, and traffic improvements, construction of contemporary facilities and restoration of historic structures. Land and Water Conservation Funds were used to develop Phase 1 of the plan, but funding constraints have temporarily halted further action.

• September 1979. A favorable Reconnaissance Report for the Saugus River, completed by the New England Division of the Corps under Section 107 of the 1960 River and Harbor Act, as amended, recommended designating the Saugus River from Broad Sound to above the General Edwards Bridge as a Federal Channel. A Detailed Project Report has been completed and is going through its environmental review process by the state of Massachusetts. The Saugus River and Tributaries Study will be consistent with recommendations of this navigation study.

• September 1979. A preliminary study of recreational navigation needs in the Pines River area, by the New England Division under Section 107 of the 1960 River and Harbor Act, as amended, resulted in approval of a reconnaissance report by the Chief of Engineers. Preparation of a draft detailed project report was completed in 1985, but subsequently discontinued due in part to changed policies which place lower priority on Federal participation in recreational navigation projects.

• 1980. Improvements to alleviate periodic flooding along Sales Creek, near the Revere-East Boston boundary, were initiated by the Massachusetts Department of Environmental Quality Engineering (DEQE), based on flood control works that had been studied for the city of Revere by consulting engineers in 1978. The proposed major facilities consist of a pumping station at Bennington Street (at the point of Sales Creek discharge into Belle Isle Inlet), improvements to existing drainage culverts, and debris removal.

• February 1980. The initial study of coastal flood protection problems and needs of Revere, performed under Section 205 of the 1948 Flood Control Act, as amended, and initiated as a result of the Blizzard of '78, was submitted by the Division Engineer to the Chief of Engineers. It provided an impetus for further investigations by the Corps of Engineers in the Saugus River and Tributaries Study.

• October 1983. In response to another request for assistance following the Blizzard of '78, a feasibility report recommending a flood control project for Roughans Point, Revere was completed. The recommended plan includes 4,080 feet of armor stone revetments sloping seaward along the Roughans Point shore to dissipate incoming waves, along with interior drainage provisions and an improved flood forecast, warning and evacuation plan. This plan provides protection to over 300 structures in the Roughans Point flood plain and would prevent 93% of the potential average annual damages at an estimated first cost of $8.7 million. Authorized by the Water Resources Development Act of 1986, the plan is currently under design by the Corps of Engineers, and would provide coastal flood protection to the area which abuts the southern terminus of the study area investigated in the Saugus River and Tributaries Study.

• May 1983. A reconnaissance report on local flood protection for Saugus, Massachusetts was completed by the Corps of Engineers, in response to a 1981 request for assistance from the town. The report found

that over 300 residences and 22 commercial establishments were in the 500-year floodplain. Local flood protection plans were investigated but were not economically justified. Flood protection for this area has been investigated under the Saugus River and Tributaries Study.

• October 1984. A Detailed Project Report on flood protection needs for Point of Pines was prepared by the New England Division, Corps of Engineers, under Section 205 of the 1948 Flood Control Act. Flooding, due to storm tides and wave overtopping, is a constant concern in Point of Pines, with average annual flood losses at over $1.3 million. A recurrence of the "Blizzard of February 1978", the flood of record, would result in over $5.3 million in damages. Nearly 360 structures, almost all homes, would suffer flooding to an average of 4 to 6 feet in depth. The Detailed Project Report showed protection through a Federal project to be economically justified. However, design of the project was discontinued in June 1988 when the city was unable to meet the non-Federal cost sharing requirement. Updated recommendations for protection to the Point of Pines area are included in the Saugus River and Tributaries Study.

• October 1985. An engineering report entitled Flood Control Plan for Town Line Brook and Linden Brook, Revere and Malden, MA, recommended improvements based on a 50 year design storm. The recommendations included a storm water pump station at the Pines River at Route 1; major channel and culvert improvements along Town Line Brook; and major culvert improvements along Linden Brook. The MDC is currently preparing the design for this project.

In October 1985 the Saugus River and Tributaries Flood Damage Reduction Feasibility Study was initiated in response to requests from officials from Lynn, Revere, Saugus and Malden to investigate regional approaches to the coastal flood problems that affect all four of the communities in the study area.

STUDY PURPOSE AND SCOPE

The Saugus River and Tributaries Flood Damage Reduction Study is a feasibility investigation being carried out in partial response to the 1969 SENE study authority. This report presents the Corps investigation of potential regional solutions to serious and recurring coastal flooding problems in eastern Massachusetts.

The scope of this study is considerable in that the process was dealing not only with a hydrologically complex and densely developed geographic area, but with four independent political jurisdictions: the cities of Lynn, Revere and Malden, and the town of Saugus, Massachusetts. Initial study efforts concentrated on defining the flooding problems and needs in the study area, developing planning objectives, and identifying constraints. During plan formulation all potential alternative solutions to the problems in the area have been evaluated. Data from previous water resource studies were updated and used in the investigation; additional data were gathered and used where no existing information was available.

Extensive interaction with the public progressed in tandem with technical data gathering, analysis and planning. The key steps included:

- gathering photographs; preparing topographic and aerial maps of the study area.
- conducting a total of nearly 2,000 interviews to discuss past flooding problems, collect high water marks, and survey damage potential to 3,700 buildings at varying flood heights.
- gathering tide data to calibrate a numerical model used to estimate future tide levels with the floodgate structure; and conducting hydraulic evaluations to estimate the storage capacity of the estuary and associated marshlands, and currents in the rivers.

- surveying thirty miles of existing shorefront to assess physical condition and estimate the potential for overtopping; surveying existing structures to determine current condition and vulnerability to flood damages.

- preparing flood stage and frequencies of recurrence analyses for 24 flood zones under both non-project and with project conditions.

- collecting existing data and obtaining new samples and surveys of environmental resources and water quality for the study area.

- formulating structural and nonstructural solutions including preliminary design, costs and impacts to reduce flooding and overtopping along over ten miles of shorefront and to individual buildings in the floodplain.

- conducting about 100 meetings with the public to coordinate the formulation, evaluation and determination of support of various solutions.

DESCRIPTION OF THE STUDY AREA

THE STUDY AREA – The study area (see Plate 1) is comprised of the land within Lynn, Saugus and Revere that is subject to inundation by the Standard Project Northeaster (SPN); it also includes sections of Malden.

THE STANDARD PROJECT NORTHEASTER – The Standard Project Northeaster (SPN) is a theoretical coastal storm that portrays what would most likely occur if the worst reasonably likely combination of a high moon tide and storm surge conditions hit a study area. In the Saugus River study area the SPN (at 1989 tide levels) would cause damages four to five times more severe than the record 1978 flood, with flood levels 3 to 6 feet higher than that storm. Flood levels would be expected to go even higher with anticipated sea level rise. The intensity of the SPN storm, including the rapid rise of tides, overtopping of seawalls and high flood levels, would likely cause loss of life as well as catastrophic damages. For reasons that will be made clear in this report, the SPN is the goal for the level of protection that has been selected in this study area.

The study area covers approximately 4,000 acres of which 60 percent is existing residential, industrial and commercially developed land and about 40 percent (1,660 acres) is wetlands. Only about 237 acres (153 developable) are currently vacant and available for new development at the present time. The study area lies within the 47 square mile watershed of the Saugus and Pines Rivers in Suffolk, Essex, and Middlesex Counties, Massachusetts. All four communities have always been strongly influenced by their proximity to downtown Boston, which is less than ten miles away. Serving historically as "bedroom" communities and sources of labor supply for Boston, the area is also traversed by major gas and electric utility lines which serve Boston's North Shore communities, as well as by rail, mass transit and highway transportation arteries which link the North Shore with the state capitol. For over a hundred years, large numbers of Boston residents have also joined local people at Revere Beach for amusement and recreation.

FLOOD VULNERABILITY IN THE STUDY AREA

The vulnerability rises out of the fact that the four coastal communities all have lands that border the estuary of the Pines and Saugus Rivers, front on the ocean, or do both. These low-lying sections suffer from tidal surges in the Saugus and Pines Rivers and from wave overtopping along Revere Beach, at Point of Pines, and in Lynn Harbor when severe coastal disturbances, deep low-pressure systems, pass offshore. The most frequently threatening storms are known locally as "northeasters" because of the strong northeast winds that accompany them. Such storms can cause very high ocean levels and wave heights. Northeasters are most likely to occur between November and April; hurricanes and tropical storms may bring high waves and storm surge to the area from early August to the end of October. Historically, however, hurricanes and tropical storms have rarely caused serious tidal flooding in the study area. Precipitation from northeasters and tropical storms and hurricanes can be very heavy, causing significant freshwater runoff; however, heavy runoff coincident with high tidal surges occurs infrequently.

This study area includes densely developed areas bordering the coastal beaches and the estuary of the Saugus and Pines Rivers. With each high tide, ocean water funnels up the mouth of the estuary, inundating varying portions of the tidal marshland and receding when the tide turns. When driven by a coastal storm, huge amounts of water may be pushed up the estuary, and at the same time, larger-than-normal waves may overtop the coastal beaches and existing flood protection structures that lie along the beachfront. Driven inland and overland by the natural forces of rising tides and winds, the storm waters are trapped within the saltwater wetlands. The waters rise higher and higher in the wetlands, spreading into developed areas of the floodplain, and often reaching interior flooding levels that exceed the coastal high tide levels. Only when the storm abates can the floodwaters slowly drain back out through the estuary, the single outlet to the sea. During such storm events, neighboring communities along the coast will also suffer damages from wind-driven waves and high tides, but they may not suffer the additional problems that the impounded waters cause in the study area.

All areas within the study area were investigated in detail with the exception of the Town Line and Linden Brook watersheds in Revere and Malden, and the Upper Saugus River and Shute Brook areas in Saugus. The Town Line and Linden Brook area will receive significant reduction in interior and coastal flood damages from the MDC project that is currently under design. Residual flood damage is still likely to result when interior runoff and coastal events exceed the design levels of the MDC project, but such events are expected to be extremely rare. The Saugus River and Tributaries Study excluded detailed investigation of these watersheds because their flooding problems were principally due to interior runoff and because of the high study costs involved in evaluating the areas (due to tidal influence) to reduce the remaining damages.

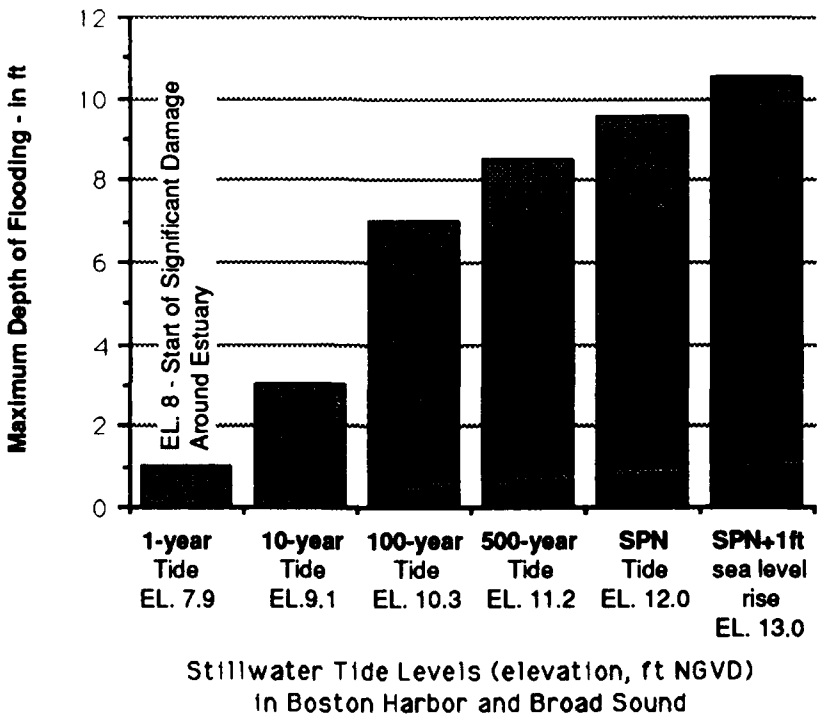
The topography, high water marks and tidal overtopping within the study area explain why, during the Blizzard of '78, flood levels in some parts of the study area were several feet higher than the recorded stillwater tide, and why the flood waters remained in place long after the storm ended. The ocean stillwater level in 1978 reached elevation 10.3 in Boston -- the record tide. Within the study area the problems were even more severe. North Shore Road, Route 1-A, which runs north from Boston through Revere and Lynn, was reported under four feet of water along the Pines River. Water levels behind Revere Beach were reported as as high as El. 12.5 ; and reached 11.8 in Saugus and 13.4 behind Lynn Harbor. Flood depths of approximately 7 feet were reported in several locations. Flood waters trapped by plugged culverts remained up to a week around houses in Revere and for several days in Lynn and Saugus. Emergency measures during the Blizzard were made more difficult because of the trapped floodwaters; and the recovery period was slowed. For example, the Massachusetts Bay Transportation Authority's "Blue Line," a key link in the mass transit system that serves the Greater Boston area, traverses the floodplain area. It was out of operation for six weeks after the '78 Blizzard.

Substantial sections of the study area are already heavily developed, and pressures for further growth are strong. Damages now occur on an annual basis, with significant flooding on an average of every 4 or 5 years.

Figure 1

Sensitivity of Tide Elevations and Depth of Flooding -

Maximum Depth of flooding in Residential and Commercial Areas



NGVD - National Geodetic Vertical Datum replaces the Mean Sea Level Datum of 1929

HISTORIC FLOODING PROBLEMS – The study area has suffered from coastal flooding since its early days. The more notable storms, described below, all had tide levels which likely or reportedly caused significant flooding within the study area:

- 26 December 1909 - the "Christmas Gale" produced a tide of 9.9 feet NGVD at Boston. Historic records indicate that winds of 85 mph were experienced.
- 4 March 1931 - a "nor'easter" brought severe winds and high seas and a maximum high tide of 8.8 feet NGVD at Boston.
- 21 April 1940 - storm with high tides and strong winds resulted in a maximum stillwater tide height of 8.9 feet NGVD at Boston.
- 30 November 1944 - another "nor'easter," this one producing tides of 8.8 feet NGVD in Boston.
- 29 December 1959 - a "nor'easter" in which tides rose to 9.3 feet NGVD at Boston. Heavy wave action caused extensive damage at Revere Beach with considerable loss of sand and undermining along the seawall. Major damage occurred to 45 homes in Roughans Point, 120 homes at Point of Pines, and 30 homes in the Riverside area. Many commercial operations were affected by flooding in low areas that resulted from overtopping of beaches and seawalls.
- 26 May 1967 - A very late season, slow moving "nor'easter" coincided with spring tides and gale-force winds which caused extensive beach erosion. In Boston, high tide reached 8.9 feet NGVD.
- 19 February 1972 - A deep low-pressure area moving at about 25 miles per hour over outer Cape Cod and coinciding with spring tides produced storm surges of 4.0 feet at Boston. Observed maximum tidal elevations in Boston reached 9.1 feet NGVD. Flooding was experienced around the study area.
- 6 & 7 February 1978 - The Blizzard of '78 hit while the area was still recovering from the effects of another blizzard that had occurred on 20 January 1978. One of the most persistent and severe winter storms on record, the '78 Blizzard produced strong winds with recorded gusts of 79 mph, and great amounts of snow over most of southern New England. Tidal elevations in Boston Harbor reached the highest level ever recorded: 10.3 feet NGVD on the morning of the 7th and 10.0 ft. NGVD the evening of the 6th.
- 25 January 1979 - Heavy rains and strong onshore winds from the northeast created high tides and flood conditions. Tide levels at Boston Harbor reached EL. 9.3. Interior flood elevations reached 8.5 feet NGVD behind Revere Beach; 10.1 along Lynn Harbor, and 9.2 in East Saugus. High tides contributed to flooding from interior runoff in the Town Line Brook and Upper Saugus River. Fortunately, just before the high tide, winds shifted unexpectedly, and flood losses were substantially lower than they might have been.
- 2 January 1987 - Boston tide levels reached 9.4 feet NGVD and 9.6 in the Saugus River. The nor'easter appeared to be heading toward 1978 tide levels when the wind suddenly shifted averting more severe damage. Flooding occurred throughout the study area except in the Town Line Brook section of Revere and Malden.

SUMMARY OF FLOODING PROBLEMS IN THE STUDY AREA – The region has experienced four major coastal storms in the last 17 years of 10- to 100- year frequency. The Problem Identification section which follows, shows that damages from these events would range from $18 to $114 million, respectively.The problem of coastal flooding in the study area is not new; what is new are the rising damage potentials, and the increasing costs of losses suffered. The floodplain is densely developed, and available land is at a premium. Any solution to these flooding problems must also take into consideration other water resource concerns that are also of high interest to the affected communities.

February 1972 - A 10-Year Tidal Storm In Which Revere Alone Reported "$ 5 Million In Damages and 700 Homes Evacuated " ($13 Million in 1988 Dollars)

January 1978 - A 4-year Tide Storm - One Month Before The "Blizzard Of 78"

The Estuary Includes Over 1,000 Acres of Vegetated Wetlands

OTHER WATER RESOURCE CONCERNS IN THE STUDY AREA

Settled over 350 years ago as predominantly farming and fishing communities, the communities in which the study area lie have long since evolved into an integral part of the urban ring next to the state capitol. With its current mix of residential, commercial, industrial, transportation and recreational land uses, the study area has numerous other water resource-related concerns that interact with each other and with the coastal flooding issue in multiple and complex ways. The Corps study team has had to develop close working relationships with the interest groups and state and local governmental agencies that are concerned with all of these water resource issues, build greater understanding and tolerance with and among them, and then shape a recommended plan that reflects as many of the area's total water resource concerns as possible.

WETLAND LOSSES — Massachusetts, like many other states across the nation, has supplemented Federal efforts to stop the loss of wetlands by adopting and enforcing its own Wetlands Protection Act. Within Lynn, Saugus and Revere, growth and development have historically had a profound effect on the loss of salt marsh, particularly within the Saugus and Pines River estuary. Significant losses occurred prior to 1951, as land was drained or filled for farming and community development. Between 1951 and 1971, a 33 percent loss (613 acres) of salt water wetlands has occurred within the three communities. In Saugus, alone, between 1951 and 1971, some 325 acres — more than one-third of the total salt water wetlands in the town were lost to filling. Most of this loss was associated with two projects that were to serve regional, not purely local needs: fill that was deposited for a never-completed segment of interstate highway I-95, and for construction of the landfill, part of which is now used for the RESCO refuse recycling plant. These two projects, located in the central portion of the estuary, consumed 300 acres of salt marsh. A similar amount has been lost around the perimeter of the estuary in Saugus and Lynn.

Between 1971 and 1980 only about 10 acres were reported lost in the three communities. Corps surveys estimate only about 5 acres were filled between 1978 and 1988 and enforcement actions are currently open on most of these filled areas. Interest is now very high at the local and state levels in seeing that the remaining wetlands are protected. Between the existing legislation and the recent designation of the estuary and surrounding wetlands as an Area of Critical Environmental Concern (ACEC) by the state, approval for any additional wetland filling is highly unlikely other than for improvements to existing or construction of new public roads or transportation facilities which may be exempted under the state programs. But there is justifiable concern over the cumulative effects of incremental illegal wetland losses along the upland edges of the salt marsh area.

OTHER ENVIRONMENTAL RESOURCES — The Saugus and Pines River estuary supports a great diversity of natural resources within an otherwise highly urbanized setting. Habitat resources include vegetated wetlands, mudflats and lotic (flowing) deep water areas all linked together through a regular schedule of tidally induced flooding. Approximately 1,550 acres of the 1,660 acre estuary of the Saugus and Pines Rivers lie in the open estuary, the remaining acreage is partially land locked. The 1,660 acres include low (flooded twice daily) and high (flooded less than twice daily to monthly) salt marsh and tidal freshwater/brackish marsh. The wetland changes gradually from a salt water influenced habitat to one which is more strongly influenced by freshwater inflow. Collectively these wetlands provide a number of values to the environment, including: fisheries and wildlife habitat, pollution attenuation, limited flood storage, erosion control, and recreational and aesthetic values.

The shorefront and harbor waters along Revere Beach, Point of Pines and Lynn Harbor abut seawalls, bulkheads, and some sand dunes. The sandflats and subtidal habitat in these areas support a number of species.

Nearly 40 species of finfish are recorded in the study area waters, including anadromous species, species of commercial and recreational importance and forage fish. Anadromous species which pass into the estuary to spawn are shad, rainbow smelt, alewife, and blueback herring. Several species of flounder and other species use the estuary to spawn or as a nursery area. Bluefish, pollock and other species which feed in the study area waters provide important recreational fishing opportunities.

COMMERCIAL FISHING — Lobster harvesting is the predominant commercial fishing-related activity within the study area. The lobster is captured in Boston Harbor and beyond, and the 1,060,000 pounds harvested in 1986 from this area equalled 7.2 percent of the total Massachusetts harvest that year. Saugus is the seventh highest ranking port in the state for pounds of lobster landed. Little commercial fishing of any type occurs within the estuary itself. However, the estuary plays an important role for other commercial fisheries by providing spawning and nursery grounds, as previously noted. The study area contains shellfish resources which could be of considerable commercial value. However, except for limited areas in which harvesting by licensed master diggers only is permitted and followed by depuration, the shellfish beds have been closed to harvesting for many years because of water pollution problems associated with domestic sewage disposal. These problems may abate as local pollution control efforts and the $6+billion cleanup of Boston Harbor proceed.

Saugus' Fishing Fleet Represents 1/4 of the Estuary's Navigation Fleet

WATER QUALITY — The inland waters of the Saugus and Pines Rivers have been designated class B, and the coastal waters of these rivers have been designated class SB by the Massachusetts Division of Water Pollution Control (MDWPC). Class B waters are suitable for swimming, other recreation, and for protection and propagation of fish, other aquatic life and wildlife. Class SB waters, in addition to those uses approved for class B waters, are suitable for shellfish harvesting with depuration. Shellfishing is the most carefully controlled activity in the coastal area due to the stringent requirements established to prevent human consumption of contaminated clams and other bivalves. According to the "Saugus River Basin Water Quality Survey" prepared by the MDWPC in November 1982, the Saugus and Pines Rivers generally meet class B and SB standards during dry weather flows. During interior storm events, however, discharges from storm drains and overland flow have an adverse impact on the quality of the upper estuary (above the Route 107 bridge on the Saugus River). In the lower basin the impact is not as severe because of the large tidal interchange. However, coliform levels are high enough that the mudflats within the estuary have not been classified as open for shellfish harvesting in recent years, although a few areas have been classified as restricted. In these sections, licensed master diggers and their employees may harvest shellfish and then have them depurated. MDWPC testing for cadmium, chromium, mercury and zinc show that concentrations in the lower estuary generally met the latest Quality Criteria for Water (1986) published by EPA. Corps testing showed a number of metals exceeding chronic criteria to protect sensitive marine aquatic life, although the more stringent acute criteria were usually met.

Current point and nonpoint sources of pollution within the estuary include three thermal water discharges — the General Electric River Works Plant (31 discharge locations); the RESCO plant and the Eastern Tool Manufacturing Company (one pipe each); intermittent discharge from the combined sewer overflow (CSO) at Summer Street in Lynn,

which occurs an estimated 40-50 times a year during periods of freshwater runoff; and leachate from the extensive landfill area located within the salt marsh near the junction of the Pines and Saugus Rivers. The landfill includes four major sites: the Saugus landfill which occupies almost 200 acres; the RESCO facility which covers approximately 100 acres; the RESCO ash landfill which covers approximately 11 acres, and the GE landfill, which covers approximately 10 acres.

GROUNDWATER/WATER SUPPLY — Groundwater levels in the study area are controlled by tidal action. According to data published by the U.S. Geological Survey in 1980, there are no municipal or industrial wells within one-half mile of the Saugus/Pines River estuary. Water supply for the town of Saugus and the city of Revere, and the emergency supply for the city of Lynn comes from the Massachusetts Water Resources Authority's water supply system. Normal supply for the city of Lynn is from treated surface water from the upper Saugus and Ipswich Rivers. Neither groundwater levels or water supply are expected to be affected by flood damage reduction actions studied.

BEACH EROSION — Although there are parts of Revere Beach that are relatively stable and expected to remain so in the future, there are significant erosion problems, especially where protective seawall structures have been erected. The seawalls have eliminated the sources of supply of localized littoral materials and resulted in an insufficient supply of replenishment material. The existing elevation of the beach at Revere Beach ranges from 0 to 15 feet above mean sea level near the seawalls. Due to the existing beach elevation and/or slope of the beach fronting the seawalls, half of the seawalls are subject to daily wave action, frequent overtopping and/or rapid deterioration. The authorized Revere Beach Erosion Control Project, currently under design, would restore the beach and cause waves to make their landfall and break more than 100 feet from the seawalls. The beach, however, is not designed for severe coastal storms, but to prevent less severe but more frequent storm tides from reaching the seawalls.

EXISTING SHOREFRONT STRUCTURES — In all, the study area has over 30 miles of existing shorefront extensively lined with walls and stone-faced embankments along Revere Beach, Point of Pines, Lynn Harbor and the Saugus and Pines Rivers. The structures include steel, concrete, granite and timber walls; and rock, rubble and grass-faced embankments. These structures act as retaining walls to prevent soil erosion, break waves, and reduce water overtopping and flooding. They represent the first line of defense against tidal surges, flooding and wave action along the coast and riverbanks. About two miles of boat, fishing and commercial piers are also located along the Saugus and Pines Rivers. From 1986 to 1988 an inventory was carried out along the shorefront. Replacement costs, maintenance and structural life were assessed. Slight to severe deterioration was found evident all along the shoreline. The shoreline takes a significant pounding and great deal of abuse from coastal storms. Many of the structures were not designed to withstand the wave action, high saltwater, or the saturated soil and flood conditions that occur because of overtopping. Rapid deterioration of structures, erosion and displacement of embankment material have all occurred. Wave action has damaged piers by uplifting decks, loosening fasteners, and rotting connections. The lives of these structures generally range from 30 to 50 years.

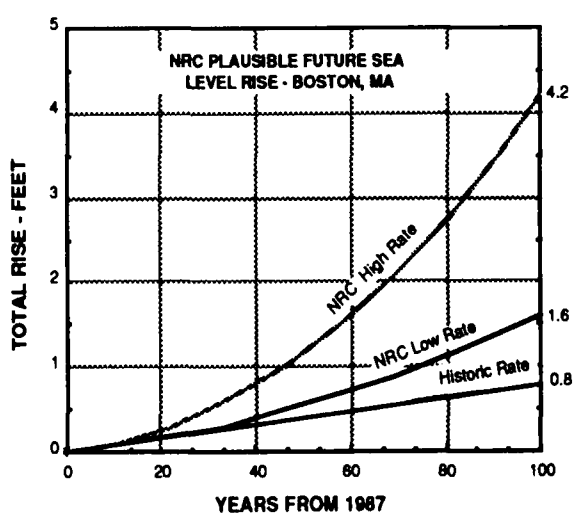
The Revere Beach Reservation Was The First Public Beach In The Nation. Near Metropolitan Boston, And Served By Mass Transit, It Remains A Popular Public Beach And Valuable Regional Recreational Resource.

Saugus River Estuary Below the General Edwards Bridge, Route 1A

RECREATION — The study area has provided local and neighboring Boston residents with recreational opportunities for many years. While many forms of active and passive recreation have occurred, Revere Beach has historically been the center of much of the activity. The Revere Beach Reservation was the first public beach with facilities established in the nation, and was served by a narrow gage railroad. In its heyday, when not only beach facilities but a large amusement park built in 1906 were located there, crowds of up to 500,000 a day visited the area. Visitation dropped dramatically as the amusement park facilities deteriorated. More recently, with the amusement park now removed, crowds of up to 25,000 a day use the site. Population growth plus major improvements underway and planned by the Massachusetts Metropolitan District Commission (MDC) should lead to increasing numbers of users in years to come. Another form of water-dependent recreation, sport fishing, remains popular year-round in Broad Sound and in the estuary of the Saugus and Pines rivers.

NAVIGATION — Navigation is important to the study area for a variety of reasons, including recreation. A fleet of about 400 vessels uses the Saugus and Pines Rivers. Most enter and exit through the existing 100 foot wide, 27 foot high (when the bridge deck is closed) navigation opening under the General Edwards Bridge. Upstream of the General Edwards Bridge this fleet includes 280 recreational power and sail boats and 70 commercial lobster and/or finfish boats. The rivers also serve as a port of refuge during coastal storms and hurricanes and are reported packed with vessels during such storms. In addition, the General Electric plant is serviced by a fuel barge or small tanker about once a month. An additional 450 vessels are moored at Lynn Harbor and the Point of Pines Yacht Club. At least one more marina has been proposed for the Lynn South Harbor area and expansion of one on the west side of the General Edwards Bridge.

RISING SEA LEVEL — The most recent historic rate of sea level rise in the study area has been based on data collected from the Boston tide gage from 1922 to 1980. The recorded rise is estimated at about 0.008 foot/year or slightly less than 1 foot/100 years. In recent years there has been much discussion regarding a potential increase in the future rate of sea level rise. A gradual warming of the Earth's atmosphere, associated with increased emissions of carbon dioxide and other gases on the planet, may promote an expansion of near-surface ocean water and an increase in the rate at which glaciers melt, thereby hastening the rate at which ocean levels rise. The scientific community appears in general agreement that the rate of global sea level rise will increase; however, there is a lack of precision and agreement as to how much the increase will be. The Corps' latest guidance, dated 20 June 1988 recommends that Corps projects be evaluated using the historic rate of rise, and also completing a sensitivity analysis for the project using the highest rate suggested in a 1987 study by the U.S. National Research Council (NRC), which reported that sea levels may rise 1.6 to 4.2 feet over the next 100 years. This Corps' guidance has been followed in this study. The graph shows the historical, NRC low and NRC high rates of sea level rise.



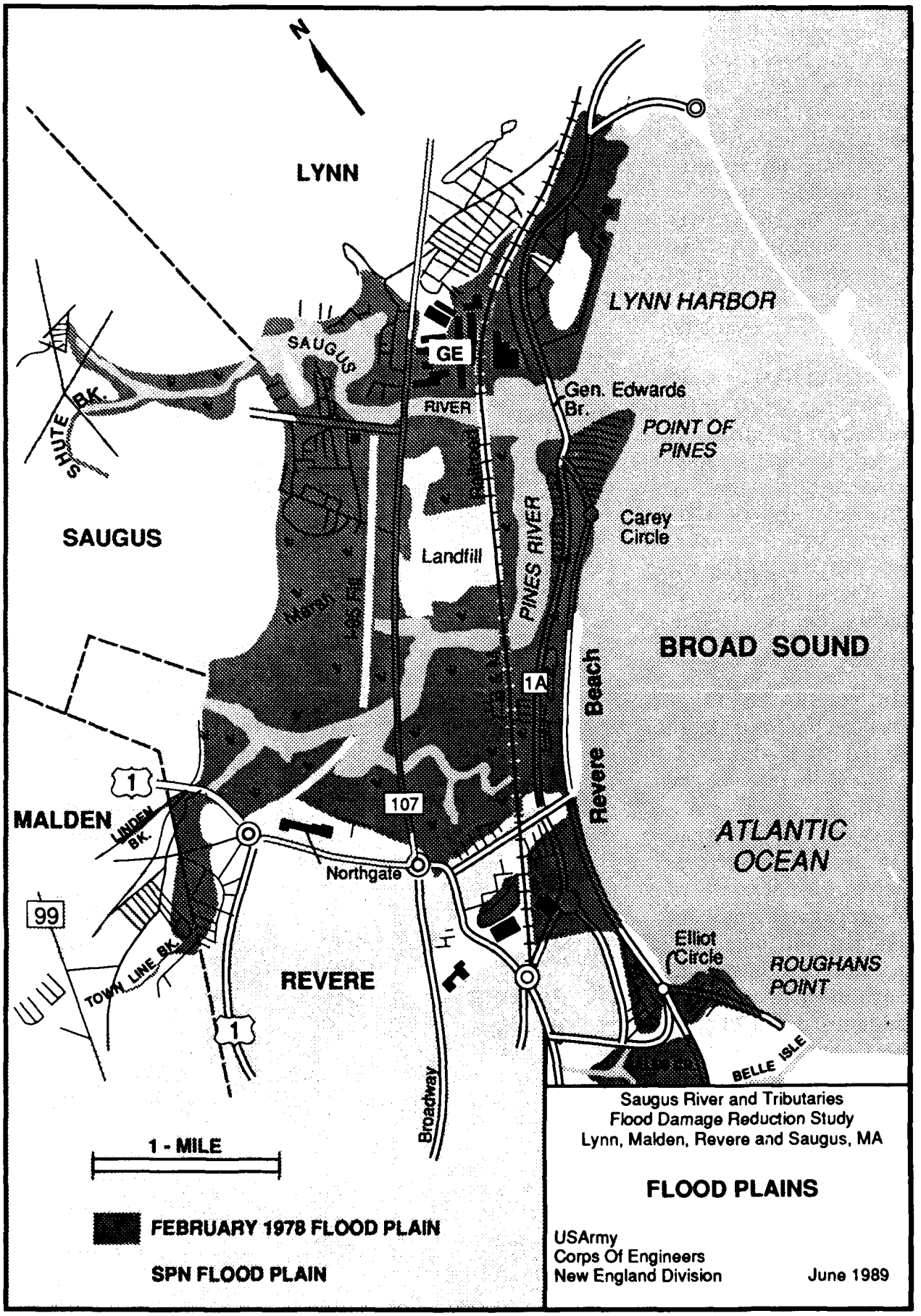

N
LYNN
LYNN HARBOR
SAUGUS
GE
RIVER
Gen. Edwards Br.
POINT OF PINES
SHUTE BK.
SAUGUS
Carey Circle
Landfill
PINES RIVER
BROAD SOUND
1A
Revere Beach
1
107
MALDEN
LINDEN BK.
ATLANTIC OCEAN
Northgate
99
TOWN LINE BK.
REVERE
Elliot Circle
ROUGHANS POINT
1
BELLE ISLE
Broadway
1 - MILE
FEBRUARY 1978 FLOOD PLAIN
SPN FLOOD PLAIN
Saugus River and Tributaries
Flood Damage Reduction Study
Lynn, Malden, Revere and Saugus, MA
FLOOD PLAINS
USArmy
Corps Of Engineers
New England Division
June 1989

PLATE 2

PROBLEM IDENTIFICATION; THE WITHOUT PROJECT CONDITION

This section identifies the problems, needs and opportunities associated with flooding in the study area: the tidal floodplains of the cities of Lynn, Revere and Malden and the town of Saugus. What is notable about these flooding problems is not only their very substantial local impacts, but their influence on utilities, public transportation, work force and other aspects of the economy of the surrounding region.

EXISTING CONDITIONS

FLOOD PROBLEMS IN THE STUDY AREA

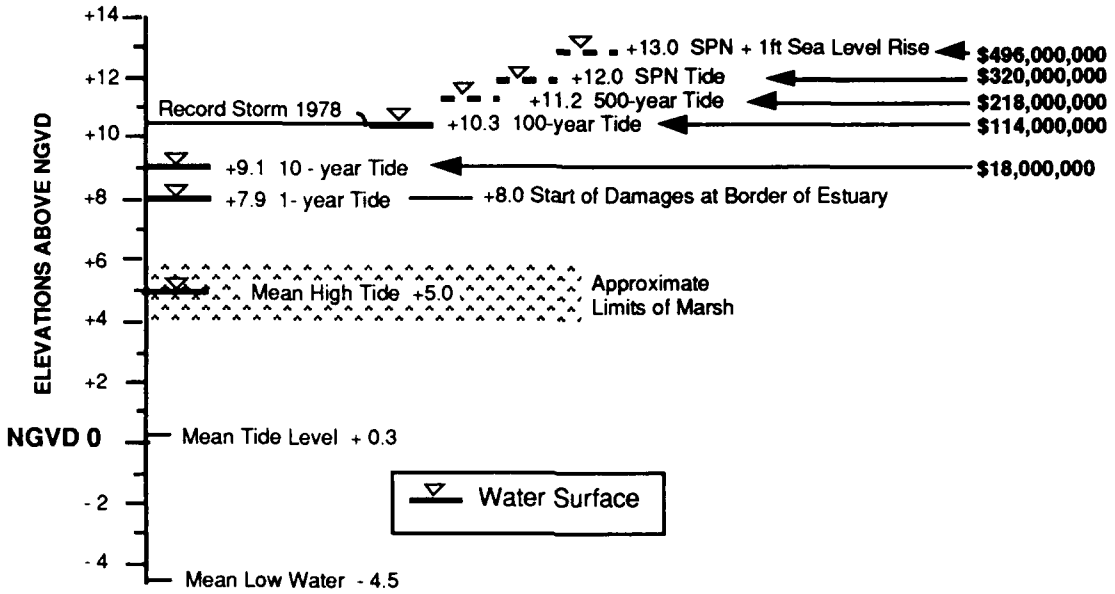
In total, the study area includes about 5,000 buildings, including over 8,000 housing units, approximately 4,000 acres of residential, industrial and commercially developed land and tidal wetlands, and major transportation arteries and utilities that serve Boston's North Shore. The following information on conditions that were experienced during the '78 Blizzard and subsequent storm events was obtained during over 2,000 interviews with residents, business owners and officials familiar with the study area.

At 10:20 p.m. on Monday night, February 6, 1978, the first storm surge associated with the Blizzard of '78 hit the study area. Record high tides flooded thousands of homes and buildings, knocked out electricity in freezing weather, and forced the emergency evacuation of over 4,000 people. The following morning at 10:36 a.m., when a second tidal surge hit the study area with almost equal magnitude, many of the residents who had stayed in their homes were still stranded since access routes remained flooded. Record flood depths of up to seven feet caused damages to an estimated 3,100 buildings, and directly affected the lives of over 10,000 people and the employment of another 20,000 who lived or worked in the floodplain. The storm flooded major transportation arteries that are used on a daily basis by 100,000 North Shore commuters, and caused disruption to utilities which serve the entire North Shore. The residential, commercial, industrial and commuter population affected by the flood was nearly 400,000.

In the past 17 years, a total of four major floods of 10 to 100 year frequency have occurred in the study area (1972, 1978, 1979 and 1987). Because of growth within the study area and increased costs associated with damages and losses, a recurring '78 storm tide would now cause damages estimated at over $100 million (1989 tide levels). The Standard Project Northeaster if it occurred, would damage close to 5,000 buildings. With one foot of sea level rise, the SPN event could cause damages in the range of $500 million. In addition, damages to homes and businesses from coastal storms happen every year within the study area, although on a smaller scale. There is a relatively small hydrologic difference between coastal floods which are mere inconveniences and those which trigger very severe damages. A flood of 1 foot above a yearly high tide means wet basements in about 400 buildings; a flood of 2 feet above a yearly high tide requires the emergency evacuation of thousands of people from thousands of buildings. Forecasted accelerated rates in sea level rise, with estimated increases ranging from 1.6 to 4.2 feet over the next century, indicates a growing potential for repeated catastrophic flooding in the study area.

Figure 2

Sensitivity of Damages to Tide Elevations



NOTE: Once overtopping of the shorefront occurs, damages within the flood plain start at El. 3.0

STUDY AREA DAMAGES ASSOCIATED WITH THE BLIZZARD OF '78 AND SUBSEQUENT STORMS

COASTAL STORM DAMAGES IN LYNN

The portion of the study area in Lynn, the SPN flood plain (at 1989 tide levels), includes a total of about 1,200 buildings, half of which are commercial and industrial. One section, the Lynn Harbor shorefront, includes some residences as well as the commercial and industrial district along Route 1-A, known as the Lynnway in this area. This highway serves about 30,500 vehicles transporting North Shore commuters each day and is also a direct access route for many of Lynn's businesses and industries. The floodplain also houses major North Shore utilities including electric and gas distribution centers and a Regional Wastewater Treatment facility which serve North Shore communities that lie outside the study area. Also notable are the new North Shore Community College, West Lynn Creamery, Phillips Lighting, Norelco, MBTA facilities, many new and used car dealers, service stations, the Boston & Maine Commuter Rail and the Salem Turnpike (Route 107).

In the Blizzard of '78, tides overtopped the entire Lynn Harbor and Saugus River shorefront, flooding businesses with water depths of up to four feet. Recurring 1978 flooding could cause damages approaching $65 million, while damages from a disastrous SPN

storm plus one foot of sea level rise would be $378 million. In 1987 flood waters again overtopped the Lynn Harbor and Saugus River area, causing erosion behind bulkheads and flooding commercial properties to depths of several feet. Even during years without major storms, high tides frequently cause saltwater to pond around parking areas, on streets, and unloading zones, leading to damages and delays in commercial activities and transportation.

Also located in Lynn, the General Electric River Works complex includes about 265 buildings and a work force of 8,000-10,000 with a payroll worth $300-400 million a year. In 1978 the complex was shut down at the start of the Blizzard in advance of high tides, preventing considerable damage. Floodwaters of 1 to 2 feet were reported in the complex, with much greater depths in parking areas which are flooded frequently. Flooding to SPN levels at 1989 tide levels could reach depths of 4 feet around the complex, or higher with sea level rise. With such an event, operations normally carried out at the plant may need to be transferred on an emergency basis to another GE plant in Ohio, thereby threatening the steam turbine generator and jet engine production and other military and civilian contracts worth $2-4 billion which this plant completes each year.

COASTAL STORM DAMAGES IN SAUGUS

The portion of the study area within Saugus includes the community of East Saugus, an area with 600 homes and businesses located between the Saugus and Pines River marshes. During the Blizzard of '78 saltwater was up to 5 feet deep in this area, and hundreds of people had to be evacuated to emergency shelters. The area also includes Route 107, the Boston and Maine Commuter Rail, most of the town's commercial navigation fleet and related facilities, elderly housing, a school, the Eastern Tool Company, RESCO Energy Systems, several marinas, and about 40 other businesses. A recurring '78 tide would cause $15 million in damages, and a maximum of $38 million, with flooding depths exceeding 8 feet, with an SPN event with one foot of sea level rise. The area was also flooded during coastal storms in 1972, 1979 and January 1987. Frequent flooding of properties is also a problem. Twice in December 1986 the Corps was contacted because of high tides which were flooding basements in homes that border the Pines River marsh.

There are about 300 buildings that are located in the floodplains of the Upper Saugus River and Shute Brook areas. Flooding up to 5 foot flood depths was reported during the '78 Blizzard. Town officials reported that high tides cause drains to back up, flooding buildings in the center of town on higher ground. Shute Brook, especially, backs up, flooding homes with a combination of high tides and runoff such as occurred in 1979.

COASTAL STORM DAMAGES IN REVERE

Approximately one third of the city of Revere (2,650 buildings) is within the study area, including the Revere Beach Backshore — where 1,200 homes and businesses are located behind Revere Beach and along the banks of the Pines River. In the Blizzard of '78, a reported 3,000 people were evacuated to the Revere High School, as flood waters reached depths of 7 feet around homes and businesses. Saltwater flowed into the area from several directions from overtopping of the seawall and banks of the Pines River. The area also

includes the MDC's Revere Beach Reservation and facilities, the Wonderland Dog Track and Park, the Towle Industry Building and Revere High School, many high rise condominiums and retail office buildings. The MBTA Blue Line, Boston & Maine Commuter Rail, Route 107, North Shore Road (1A), numerous marinas and over 100 businesses also lie in this area. Future 1978 tide levels would cause damages of $33 million. The SPN, with depths up to 9 feet, would cause damages of $80 million with sea level rise.

At Point of Pines, which is located just north of Revere Beach along the Saugus River, about 370 homes were flooded with depths to 4 feet during the '78 Blizzard and two houses burned when fire equipment was unable to reach them. The area is one of the most vulnerable to coastal storms and was extremely hard hit by the Blizzard of '78. Severe overtopping also occurred in 1972 and 1979, and in 1987 the ocean flowed in freely by the Yacht Club along the Saugus River. In 1978, residents remained stranded overnight with no heat, electricity or means of evacuation.

Northgate, an area with 180 homes and businesses, including the city's DPW garage, lies along the edge of the Pines River marsh. This area experienced flood waters up to 3 feet deep in 1978 when the estuary rose like a huge lake, flooding these buildings.

COASTAL STORM DAMAGES IN TOWN LINE BROOK (REVERE AND MALDEN)

The Town Line Brook area (including Linden Brook) lies in both Revere and Malden. The estimated SPN (1989 tide levels) floodplain includes about 210 buildings in Malden and another 800 in Revere which are subject to flooding directly from the Pines River and from the backup of drainage in the brooks during high tides. Flooding occurred in this area during the Blizzard of '78, and in 1979 with flood levels reaching El. 7 to 8 feet NGVD on both occasions, with 3 to 4 foot depths of water. In 1987 waters reached the top of the banks of Town Line Brook. As noted earlier, most of the flood problems in this area will be addressed by the MDC Town Line Brook flood control project.

RELEVANT OTHER CONDITIONS IN THE STUDY AREA

Many factors will determine whether vulnerability to coastal flooding will continue at least at current levels in the study area, and whether or not the involved municipalities can address this threat without Federal assistance. These critical factors include:

EMPLOYMENT

The four municipalities in which the study area lies are essentially residential suburbs of Boston. The majority of study area residents work outside the communities in which they live. While the Boston area has recently experienced significant regional growth in employment, this surge has not benefitted the study area significantly. At the same time that total employment increased by 8.6 percent across the state between 1980 and 1984, it decreased by 12.6 percent in Revere and by 4.2 percent in Lynn. Employment in Malden and Saugus has continued to grow (1.4 and 7.2 percent respectively.) Employment within the communities is heavily concentrated on the services, wholesale and retail trade sectors of the economy, sectors which traditionally have low paying jobs. Service employ-

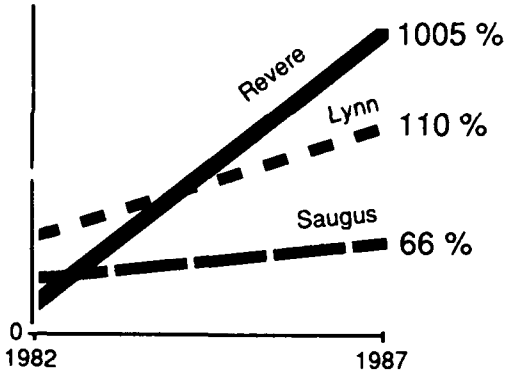
ment in the communities is characterized by personal services, rather than higher paying professional services. Many jobs in Revere are related to entertainment and resort-related industries — seldom high paying jobs. Only Lynn has a substantial number of people employed in manufacturing.

Demands on community services are high in the study area. Local budgets are unlikely to be able to afford the types of flood damage reduction measures that are called for by the extent and nature of the coastal flood threat which is why the communities have turned to the state and Federal governments for assistance.

POPULATION AND COMMUNITY GROWTH

All the communities in which the study area lies have experienced some drop in population from 1980 to 1988. Population within the study area, however, increased by 5.1 percent in this same time period. Although precise population projections are difficult to make, it appears that the population decrease will slow in Revere and Lynn. New residential developments, in Revere in particular, are expected to increase the future population in the community and in the study area.

Building Permits
1982 - 1987



Although total population is decreasing in the communities, the total number of households is increasing. Moreover, each of the four communities in which the study area lies is in the midst of an aggressive effort to attract new development. One measure of their success is that the number of building permits for new residential construction has increased in each community since 1981. The most dramatic increase has been in Revere in which a 1005 percent increase has taken place between 1982 and 1987, while Lynn's total has increased by 110 percent, and Saugus by 66 percent during the same period. There are existing heavy concentrations of population within the four communities in which the study area lies, including substantial sections within the study area itself. The limited amount of additional available land in the study area will not allow for much new development on vacant land; however, more intensive use of existing developed land is likely to continue. There will be a continuing need within the study area for protection from coastal storms.

TRANSPORTATION

The region in which the study area, the SPN floodplain, lies is characterized by densely built up residential centers with numerous local roads that also support through traffic going to and from Boston. The marshlands associated with the Saugus and Pines Rivers have long been affected by transportation planning. Over the years these wetlands have provided wide open lands for rail and road building because they needed only fill, as opposed to routes through existing developments which required expensive acquisitions and costly and time-consuming modifications to other forms of infrastructure. Now, un-

der the most recent public policy, the marshlands have been designated protected natural resources in which vast filling for transportation purposes is much less likely. For this reason, keeping existing arteries as free as possible from disruption and damages due to coastal floods is of both local and regional importance.

Regionally Important Transportation Arteries in the Study Area Include:

- Route 1-A which is primarily a north-south artery to Boston that runs through Revere and along Revere Beach, crosses the Saugus River at the General Edwards Bridge, and continues through Lynn. Route 1-A also services the beach area, the Wonderland Dog Track, and the MBTA Blue Line Station. Within the study area the route has an average daily trip count of 30,500; it suffers from heavy congestion. The road drops to EL. 9 along the marsh, and is flooded frequently, with serious disruption having occurred in 1972, 1978, 1979 and 1987.

- Route 107, which has a daily traffic count of 20,200, runs directly through the middle of the Saugus Marsh. It is a four-lane highway that connects Lynn and East Saugus with arteries in Revere. Route 107 is approximately EL. 9-10. It, too, was flooded during the 1978 Blizzard and the 1972, January 1979 and 1987 storms.

- Two rail systems also cross the study area: the MBTA Blue Line, a commuter rail system which accesses downtown Boston via Logan Airport, and the Boston and Maine Railroad, a commuter rail line that serves Boston's North Shore. Both systems are under consideration for future improvements. There is a possibility that the Blue Line, whose current northern terminus is in Revere, will be extended to serve Lynn and the North Shore. The B&M railroad, which currently serves 4,400 commuters through Revere, is considering the possibility of constructing a station with a 1,000 car parking lot in East Saugus on the existing landfill in the middle of the marsh. The Revere section of the MBTA Blue Line (which serves 8,100 commuters through Revere) was out of commission for six weeks following the '78 Blizzard. Both systems were reported flooded in 1978 and 1987. The B&M drops to EL. 8.4 through the marsh, and the Blue Line dips to EL. 7 in the floodplain behind the shorefront.

The "Revere Beach Connector" and I-95 highway were proposed as far back as the 1950's as four-lane divided highways which would connect U.S. 1 to Route 1-A and link them to I-95. Because their construction was planned in the Saugus-Pines River marsh, a large amount of fill was required. Work on the projects was eventually halted due to concerns over environmental impacts. However, the "I-95 fill" that remains has altered flow factors in the marshland, providing some degree of flood protection to East Saugus, except for severe coastal storms. There is renewed interest in the communities in construction of the Connector highway. If the highway is ever constructed, it is likely to be built in ways that would minimize impacts on wetlands.

PRESSURE TO FILL WETLANDS

The Saugus and Pines Rivers estuary comprises 1,660 acres. Development of the estuary lands was rapid until about 1968. Since then, with enforcement of wetlands protection programs, detailed surveys by the Corps have determined that about 11.5 acres have been filled, 4.7 acres since 1978. Extensive pressures to deposit or dispose of fill in the estuary remain. Recent calls to the Corps and EPA by study participants have resulted in the stopping of 7 illegal fill attempts; 2 of these sites have already been restored.

RECREATION AND OPEN SPACE

Existing recreational facilities within the study area are already pressured by growing demands. In addition, expansion of recreational opportunities and open space are seen as important elements in the current development efforts of each of the four communities in which the study area lies. For example, included in Lynn's neighborhood revitalization strategy is a provision to upgrade local parks and improve open spaces, as well as provide public access along the waterfront. Such goals are seen as methods to help stabilize real property values and encourage economic growth. In Revere, the MDC is preparing to upgrade Revere Beach and has plans for substantial additional improvements. Saugus is currently updating its open space and recreation plan, including coordinating with the MDC to develop a master plan for passive recreation at the I-95 embankment.

EXISTING SHOREFRONT STRUCTURES

The replacement, raising, repair and maintenance costs of the existing 30 miles of shorefront extensively developed with structures (walls and stone protection) are estimated to average $2.6 million per year. Currently, shorefront structures do not provide a continuous or reliable line of protection in any section of the study area. The structures vary in size, type and purpose. They are located intermittently along the shoreline, and suffer from varying degrees of deterioration. The structures, which are a maximum of 20 feet high, were built more for retaining (holding back) embankments that support developed land than for reducing flood damages. These structures would continue to be subject to failure and overtopping from tidal surges as has historically been the case and their useful life remains at 30 to 50 years. The future replacement and maintenance costs of these structures would increase as they are raised the few feet to keep pace with sea level rise. These structures, currently the study area's first line of defense against coastal flooding, make some difference in small storm events. They accomplish little in the face of major storms.

EMERGENCY COSTS

Emergency costs result from special activities that must be undertaken prior to, during and after a flood. These expenses include costs associated with the operation of flood emergency centers and communication facilities not otherwise needed; with temporary evacuation assistance, flood fighting materials and personnel; as well as with additional police and fire protection and public cleanup. During the Blizzard of '78 a total of 20 Federal state and local emergency programs had to be activated. In the study area the cost is estimated at over $2.5 million. Vulnerability to the costs of such programs will remain as long as the coastal flood threat is undiminished.

TIDAL HYDROLOGY

The information on Tidal Hydrology is being presented as part of problem definition because of its important influence on flood vulnerability in this particular study area. The study area experiences a considerable range in astronomical tide levels; minor coastal flood damages can occur from high tides alone without a storm. When meteorological events, particularly coastal storms, coincide even with low tide levels, flood damage can still occur; and when a coastal storm surge coincides with high tides damages can be extensive.

ASTRONOMICAL TIDE LEVELS

Tides, at the study area, are semidiurnal, with two high and two low waters occurring during each lunar day (approximately every 24 hours 50 minutes). The resulting tide range is constantly varying in response to the relative positions of the earth, moon and sun, with the moon having the primary tide-producing effects. Maximum tide ranges occur when the orbital cycles of these bodies are in phase. Known as "spring tides" these occur at the time of the full and of the new moon each month.

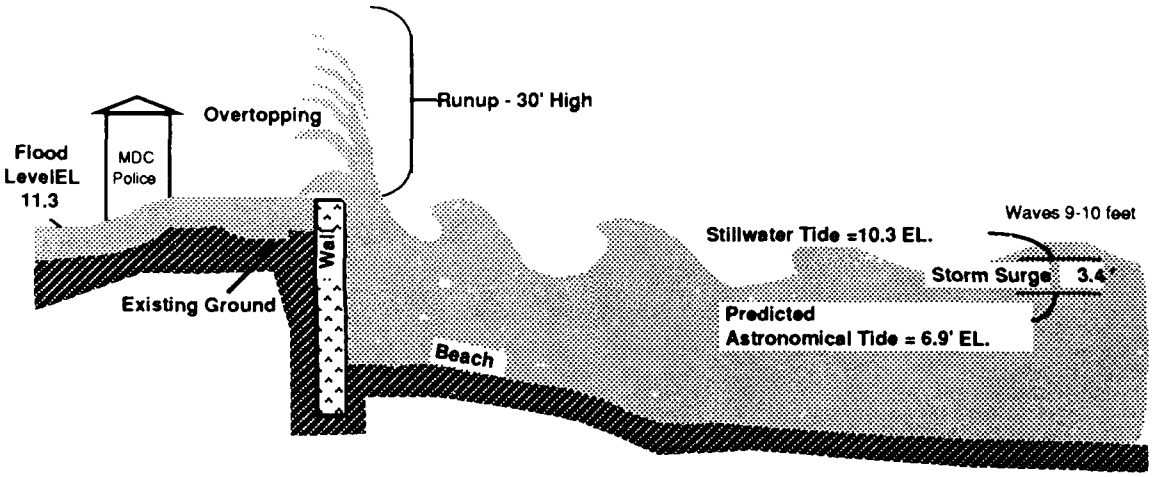
At the National Ocean Survey (NOS) tide gage in Boston, Massachusetts (less than 10 miles from the study area) the mean range of the tide and the mean spring range of tide are 9.5 and 11.0 feet, respectively. However, the Corps of Engineer's Coastal Engineering Research Center (CERC) has estimated the maximum and minimum predicted astronomic tide ranges at Boston at about 14.6 and 5.1 feet. The variability of astronomical tide ranges is a very significant factor in tidal flooding potential in the study area.

TIDAL RANGE IN THE SAUGUS RIVER ESTUARY–Although known to be complex, little recorded data existed on water movement in the Saugus and Pines Rivers. To better define tidal motion within the estuary, tidal stage measurements have been made intermittently over the past three years. What has been learned is that tide levels at the mouth of the Saugus River are nearly identical to those at Boston, while tide levels in the estuary show some slight variance. Measurements taken within the estuary indicate that for normal non-storm tide conditions, the smaller the tide range the less change there is in tide heights at points upstream from the river's mouth. Mean tide range produces nearly the same elevations in the estuary as at the coast. Normal spring high tides on the Saugus River and on the upper Pines River appear to be somewhat lower and low tides somewhat higher than at Boston. On the Saugus River the change seems to be due mostly to frictional impacts of the channel. However, for the upper Pines River, the reduction in tidal elevation is related to the restrictive channel opening in the abandoned I-95 highway embankment and the relatively large storage available in the marsh.

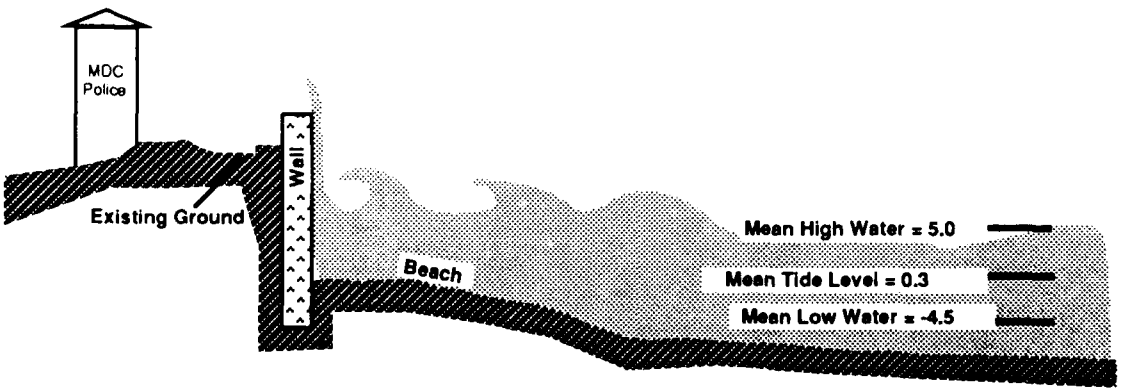
STORM TIDES

During coastal storms, tide gage measurements reflect the tide level resulting from the combination of astronomical tide with the storm surge that is created by wind and wave action and atmospheric pressure. The mix of astronomical tides and storm surge, along with the intensity and wind directions that occur during any given coastal storm event, determines the levels of damage. A wide range of damages can result.

Since the astronomic tide range in the study area is so variable, many severe coastal storms occur during periods of relatively low astronomic tides. In these situations, even though a storm may produce exceptionally high onshore winds, waves and a tidal surge, the resulting tide level may be less than that occurring during a time of high astronomic tide and no meterological influence. A good example of this is the storm event which occurred on November 30, 1945. This storm produced the maximum storm surge of record



February 1978 Storm - Revere Beach

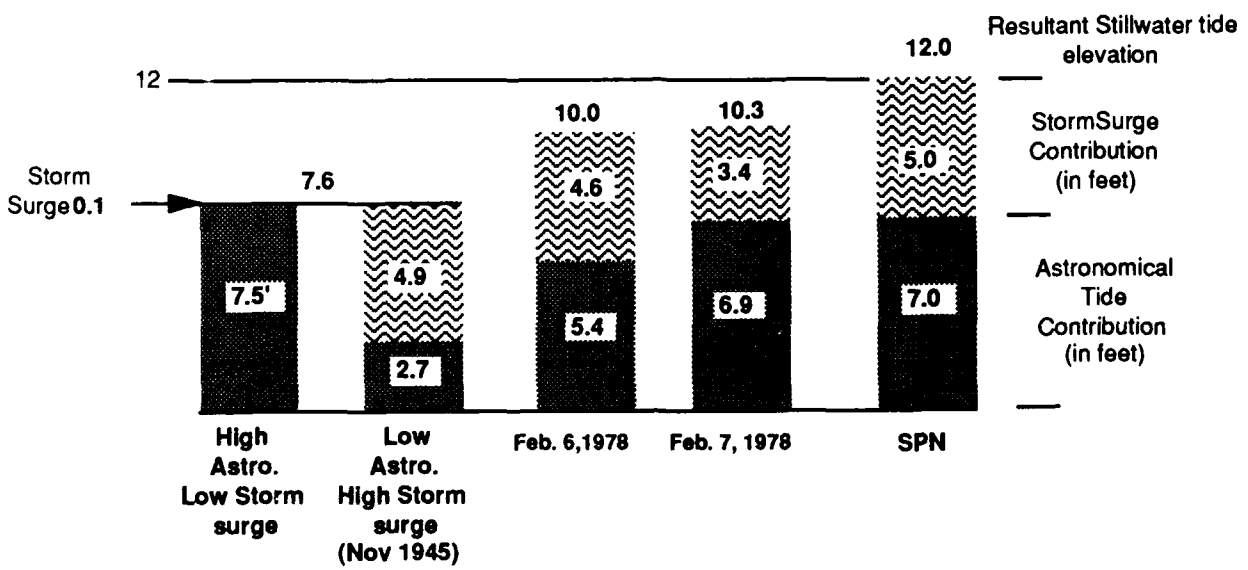


Normal Conditions - Revere Beach

at Boston — 4.9 feet — and extremely high onshore winds. However the event occurred during low astronomic tide and resulted in only a minor tidal flood level (7.6 feet NGVD). Conversely, rather significant tidal flood levels can result when relatively high astronomic tides coincide with only minor meteorological events. Astronomic high tide level, alone, can reach 7.5 feet NGVD in Boston. With such a condition, a coincident storm surge of only 2 to 3 feet can produce major tidal flood levels.

The Blizzard of 1978 provides an excellent example of the interaction among these factors. During the '78 Blizzard, the storm tide **(the maximum observed tide)** at Boston reached 10.3 feet NGVD, the greatest storm tide of record, but this was produced by a combined astronomic tide of 6.9 feet NGVD and a surge of 3.4 feet — a surge of only moderate magnitude. The **maximum surge** recorded during the storm (4.6 feet) had occurred at 10:00 PM on February 6th. By the time the maximum observed tide occurred, at 10:30 AM the following day, the surge was 1.2 feet lower. **Had the maximum surge recorded during the storm coincided with the high astronomic tide that occurred at 10:30 AM on the 7th of February, the observed tide would have been 11.5 feet NGVD, and even more catastrophic flooding would have occurred in the study area.**

STORM TIDES AT THE PROJECT AREA–The NOS has been recording tide heights at Boston, Massachusetts since 1922. Stillwater tide heights are measurements taken in protected areas in which waves are dampened out. The greatest observed stillwater tide level recorded at Boston occurred during the Blizzard of '78. Studies by the Corps Coastal Engineering Research Center (CERC) have indicated that storm tide frequency in the Saugus and Pines Rivers system is at least equal to that at the Boston NOS gage and for severe coastal storms could be up to a half a foot higher. Because of the urban nature of the study area, analyses include storm events up to the standard project storm , which can be compared to the Standard Project Northeastern (SPN), the "most severe combinations of 'meteorological and tidal' conditions that are considered reasonably characteristic of the geographical region involved, excluding extremely rare combinations." Because of the variability of astronomic tides in the study area, and the unpredictability of tidal interaction with storm surges, the SPN stillwater tide level (under 1989 tide conditions) was adopted at 12 feet NGVD for this purpose in this report. In addition to the stillwater



tide level, the SPN event would be accompanied by about 9 foot waves in Broad Sound and up to 30 feet of wave runup on seawalls.

TIDAL VERSUS UPSTREAM RUNOFF INFLUENCES

Because of sluggish flows from the large upstream wetlands and ponding areas, freshwater inflow into the tidally influenced portion of the Saugus and Pines Rivers is a small component of the total estuarine flow. The tidal hydrology of the Saugus/Pines River estuary and its resulting environment are much more a function of the hydraulics of tidewater interchange than of basin runoff.

MOST LIKELY FUTURE CONDITIONS WITHOUT A FEDERAL PROJECT

Without a Federal project the most likely future conditions in the study area include a continued and increasingly serious vulnerability to coastal storms. One project currently planned by the Massachusetts Metropolitan District Commission (MDC) would reduce flood vulnerability in the Town Line Brook sub area of the study area whether or not a Federal project resulting from this study is completed. Several other efforts which are expected to be implemented by others would benefit from a Federal project. Figure 3 and Table 1 summarize future estimated damages for specific events and average annual damages over the full range of flood events. These various situations are summarized below.

FACTORS CONTRIBUTING TO A MAINTAINED OR EXPANDED VULNERABILITY TO COASTAL FLOODING

- The continued growth and intensified development that are expected in the study area will maintain and may add to the existing level of vulnerability to coastal flooding among residential, commercial, industrial and public properties, and to a sustained or increased potential for damages. Local growth is expected to include development during the next few years of the Harborside Landing Condominium Project in Lynn Harbor. The project, which will include shorefront protection between EL. 13 and 18 ft.. NGVD, will provide partial protection to the new facilities but the area will remain vulnerable to severe coastal flooding which circumvents its shorefront. Development of the Lynn South Harbor area within about the next 10 years with a combination of condominiums, retail, hotel and office buildings, marina facilities and shorefront structures for partial protection will increase development in flood vulnerable areas. Condominiums along Revere Beach and new or enlarged marinas next to the General Edwards Bridge, also in Revere, are other planned improvements vulnerable to flooding.

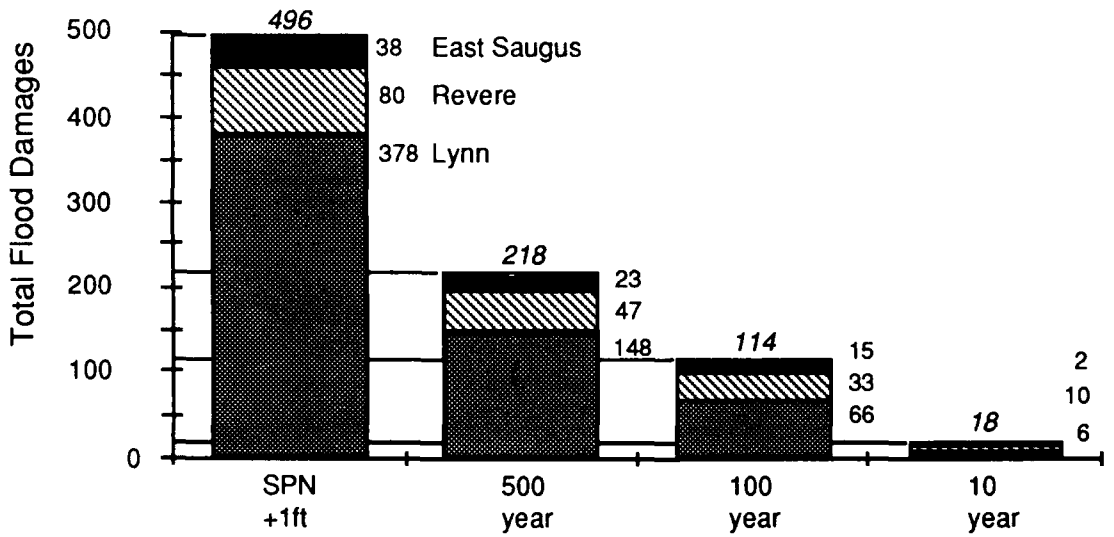
- Vulnerability to disruption of and damages to existing major utilities and transportation arteries will continue. These facilities, which are located in Lynn, Saugus, Revere and Malden, serve the entire North Shore region. Proposed expansions of the MBTA Blue Line, MBTA Commuter Rail Station; and/or construction of the "Revere Connector" would create a further potential for increased disruption and possible damages.

- As sea levels rise, more frequent and more severe coastal flooding is very likely to occur, heightening the threats of and potential for severe damages. Rising sea levels could also lead to higher costs for maintenance, repair, and needed raising or enlarging of existing structures along the 30 miles of shorefront that abuts the Saugus and Pines Rivers and Broad Sound. With the historic rate of sea level rise of about one foot, much of the existing shorefront would likely be raised one foot to protect the area, and the '78 storm (100 year) would occur on about a 15-20 year frequency. SPN damages would approach $500 million. With a four foot rise in sea level (much less likely to occur) the shorefront would gradually be raised between 2 to 4 feet over the next 100 years to protect from frequent flooding the over $2.5 billion investment in the floodplain. Storm tide levels similar to 1978 would occur each year.

Figure 3

Future Flood Inundation Damages

(1988 Price Levels
in $ Millions)



Damages are not included for: the Town Line and Linden Brook areas in Revere and Malden; the upper Saugus River and Shute Brook areas in Saugus; the backing up of drainage systems above the tidal floodplain, underground seepage into basements, loss of revenues for most businesses and General Electric, or for moored vessels in the Saugus and Pines River and in Lynn Harbor.

PLANNED ACTIVITIES WHICH WILL BRING SOME MEASURES OF REDUCED FLOOD VULNERABILITY IN OR NEAR THE STUDY AREA:

- Restoration of Revere Beach within a few years will help stabilize beaches and seawalls at Revere Beach, and should result in a reduction in the overtopping that now occurs in this section in conjunction with yearly storms;

- Construction of the Roughans Point, Revere, Flood Damage Reduction Project, bringing protection to the section of Revere that abuts the southeastern boundary of the study area.

- Construction of the Massachusetts Metropolitan District Commission's (MDC) Town Line and Linden Brook Flood Control Project within 5 to 10 years. This project would alleviate most of the flooding problems from interior runoff in this watershed. There would continue to be a vulnerability during coastal storm events that exceed the MDC project's design capability.

PLANNED ACTIVITIES WHOSE EFFECTIVENESS WOULD BE ENHANCED BY REGIONAL COASTAL STORM PROTECTION:

- The MDC flood control project noted above would benefit from an estimated $800,000 reduction in construction costs with regional protection in place by eliminating the need for walls and dikes (100 year design) along the shorefront. By controlling tide levels in the estuary during coastal storms, a regional plan is expected to provide a higher level of protection from tidal flooding;

- Construction of the Saugus River Navigation Project within 5 years, which would designate the Saugus River as a Federal Navigation Channel. Improved dredging and maintenance of the channel and mooring areas would make the area a better port of refuge during coastal storms, as well as reducing the damages suffered by boats moored behind the tidal floodgates during such events.

- Private or state dredging of the lower Pines River in the distant future would benefit commercial and recreational navigation and could contribute to improved flows and tidal flushing. Vessels using this area would also benefit from the increased protection provided during coastal storms by the tidal floodgates.

- Development within 10 to 20 years of the complete Master Plan for the Revere Beach Reservation, including an expanded linear park, and expanded and improved recreational facilities.

OTHER EXPECTED CHANGES:

- Development within 5 to 10 years of a state linear park along the abandoned I-95 embankment, maintaining the embankment in such a way as to continue to reduce frequent flooding in the upper Pines River estuary, especially in East Saugus.

- Construction within five years of a sewer project to eliminate combined sewer overflows from Lynn's Strawberry Brook into the Saugus River, contributing to improved water quality in the estuary.

- Losses shown in Table 1 for Flood Insurance Administration Expenses are current costs for administering the Flood Insurance Program in the study area. There can be expected to be increased requirements for flood insurance and higher rates in the very near future as a result of refined flood levels that were determined for sections of Lynn, Revere and Saugus as part of this investigation.

TABLE 1

FUTURE AVERAGE ANNUAL LOSSES
(Feb. 1988 Price Level)

	Average Annual Damages/Cost ($1000)
Inundation Damages:	
Lynn	$ 2,970
Revere	3,967
Saugus	1,083
Other Types of Damages/Associated Costs:	
Sea Level Rise of 1 Foot	1,425
Shorefront Structures	2,574
Emergency Costs	195
Affluence	108
Future Development	147
Tide Related Costs Town Line Bk. Project	78
Flood Insurance Administrative Expenses	59
Total	**$ 12,606**

SUMMARY OF PROBLEMS AND OPPORTUNITIES

Existing facilities in the study area do not provide sufficient protection against coastal storm events, as evidenced by the severe flooding that was caused by the February 1978 Blizzard and the flooding-related losses which continue on an annual basis. The communities remain very much concerned about the flood situation. Growth and more intensive development in this already densely built-up area, plus rising sea levels, guarantee the continuation of a dangerous vulnerability to coastal storm events and of increasing costs for the damages and disruption caused by such storms.

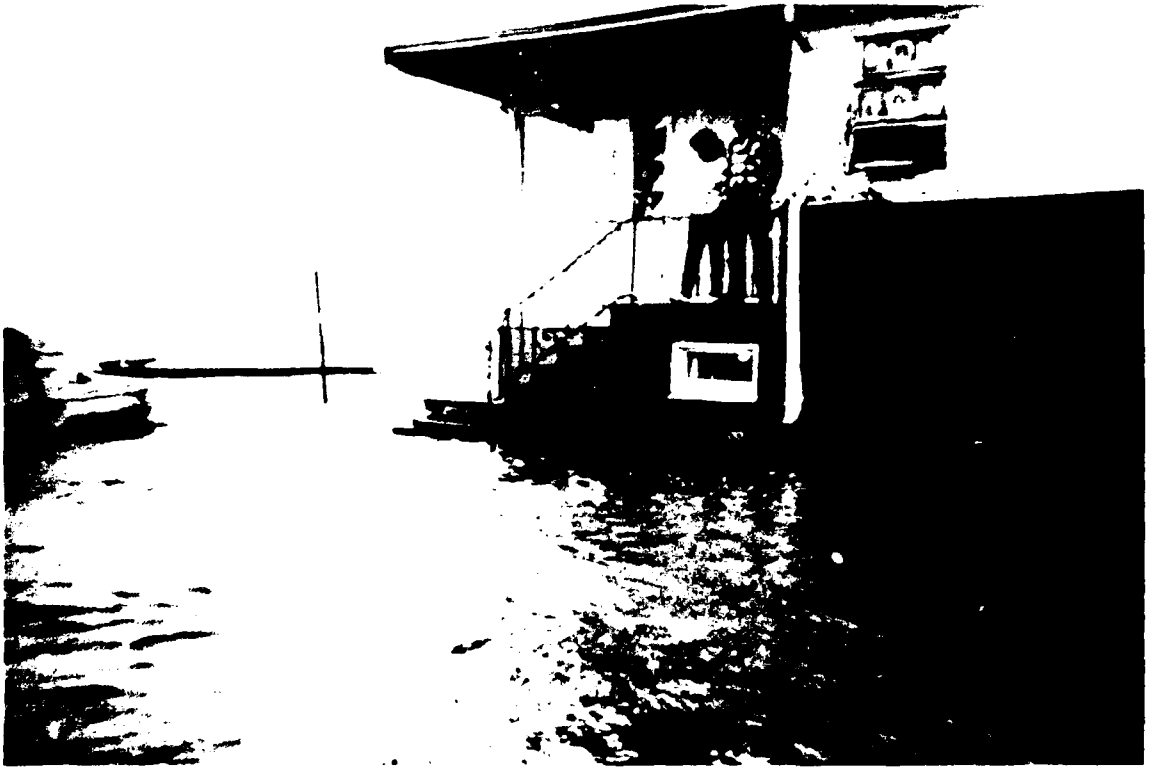
The lowest-lying portions of the study area will continue to be flooded on almost a yearly basis and will be virtually without protection during even more dangerous severe ocean storms. Repeated warnings about coastal flooding in low lying areas are heard on local radios several times a year. Residents and business owners alike are frequently reminded of the threat constantly facing them, and they fear the potential impacts of the next storm. The state-of-the art for coastal flood warning necessary for insuring community wide evacuation is not sufficient to accurately predict the severity of pending flooding. A forecasted surge of about one to three feet, when wind direction, duration and in-

tensity are uncertain, can be the difference between an annual event and a 100 year storm — wet basements or the emergency evacuation of thousands of people from 3,000 buildings, and the disruption of regional transportation systems that serve up to 100,000 people a day.

The technical complexity of this regional flooding problem; the frequency with which coastal flooding strikes the area; the fact that the flooding problem affects four separate communities, and the cost of effective solutions create a need for Federal assistance and strong local and state involvement. Beyond addressing the very serious coastal flooding problem that exists in the study area, a solution offers opportunities: to improve protection of the Saugus and Pines Rivers estuary and associated wetlands; to satisfy and enhance much needed local and state-managed recreation; and to provide improved haven during coastal storm events for vessels which use the Saugus and Pines Rivers as ports of refuge.

February 1978 - About 3,100 Buildings Were Flooded and Saltwater Remained up to Two Weeks

4,000 People Evacuated in 1978



January 1987 - Flooding Experienced in Revere, Lynn and Saugus. Many of Same Areas Were Also Flooded Twice Just One Month Earlier.

INTERAGENCY COORDINATION AND PUBLIC INVOLVEMENT

Coastal flooding problems in the study area pose a severe threat to public safety and to the local economy. However, many other social and environmental concerns also exist in the study area which had to be taken into consideration as the search for solutions proceeded. For this reason, extensive interagency coordination and public involvement were carried out throughout the study process. These interactions had two basic purposes: to provide a continuing two-way dialogue concerning the study, and to begin to build toward the cost-sharing partnership that would be needed to implement a chosen solution.

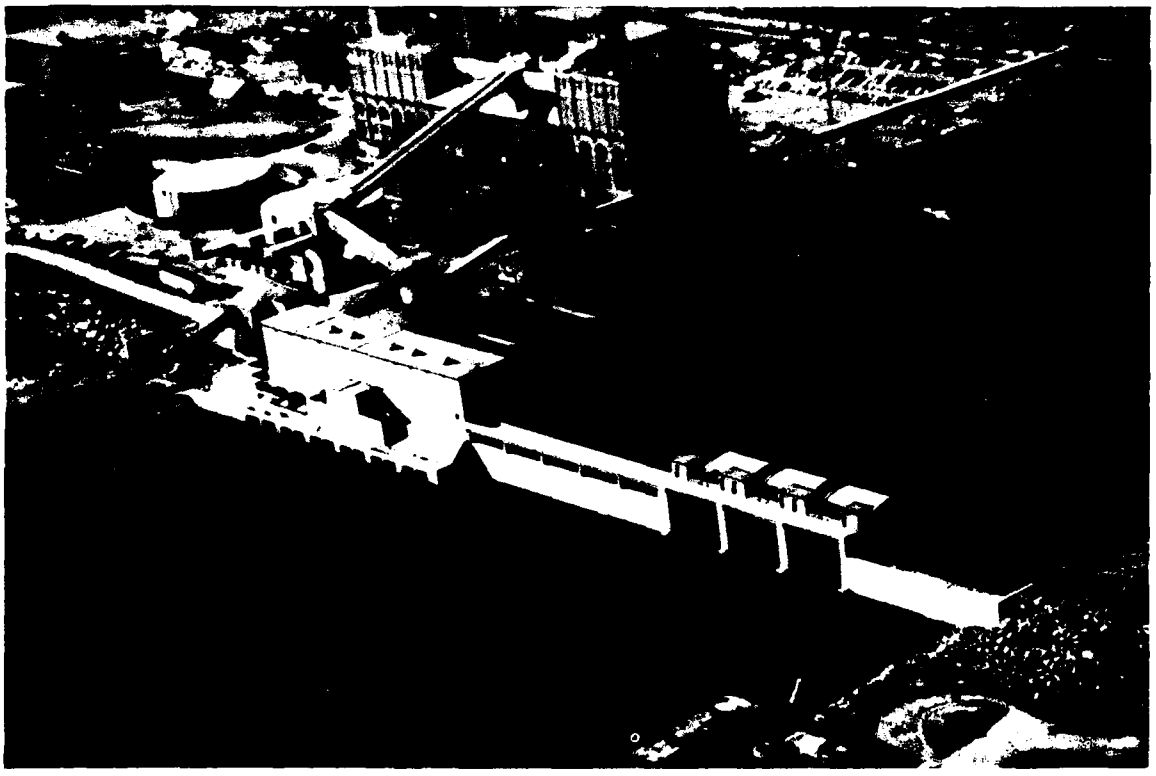
The Corps' earliest contacts were with officials from the four communities which had requested the study. Shortly thereafter, preliminary meetings were held with Federal, state and local agencies to introduce the study and solicit input as to the major environmental and social issues which should be addressed. To assure that the study remained responsive to the needs and concerns of the people who live and work in the study area, four **Citizen Steering Committees** — one from each of the communities requesting the study — were established. The committees included community officials and representatives of commercial, residential, environmental and other interests.

A **Technical Group** was also established to meet periodically with the Corps study team to make sure that the study did not miss any important considerations from the point of view of the agencies and/or organizations the members represented. The Technical Group included James O'Connell of the MA Coastal Zone Management (CZM) office, who had been appointed overall state agency coordinator for the study by the Commonwealth's Secretary of Environmental Affairs. It also included all the other Massachusetts state resource agency representatives who had been appointed to the study process by the Secretary, as well as members from relevant Federal and local agencies and environmental interest groups.

Positive interaction with the Massachusetts Environmental Policy Act (MEPA) Office led to a determination that a combined environmental review process that would meet both state and Federal requirements would be beneficial to all concerned. This has led to the preparation of a combined Environmental Impact Statement/Environmental Impact Report (EIS/EIR). The four communities signed the Environmental Notification Form (ENF) which triggers the MEPA process, thereby becoming project co-proponents. Shortly thereafter the Secretary assigned the Metropolitan District Commission (MDC) as the Commonwealth's agent to serve as a joint proponent with the communities for the study.

In early November 1987, members of the Technical Group, the four Citizens Steering Committees and media representatives were invited to visit two existing hurricane barriers that had been constructed by the Corps of Engineers. The purpose of the field trip was to familiarize study participants with the type of project that was being considered as one of the alternative plans for reducing flood vulnerability in the study area. A total of 54 people joined Corps staff on the all day tour. The group first visited the Fox Point

Project Director at the Fox Point Hurricane Barrier talking with Study Committee Members



Fox Point Hurricane Flood Protection Project - Providence Rhode Island Completed by the Corps of Engineers in 1966

Hurricane barrier in Providence, RI, which is operated and maintained by the City of Providence; and then went to the New Bedford, MA, hurricane barrier, which is operated and maintained by the Corps of Engineers.

As the study effort progressed, meetings were held with the Citizens Steering Committees and the Technical Group; and when the neighborhood of Point of Pines was added to the study, meetings were held to explain the options under investigation to leaders and residents of that area. All participants on all committees were mailed updated reports on the study as these became available; they were also sent copies of all communications the Corps received concerning the study, and invited to provide their comments and input.

The chief concerns expressed by non-Corps participants during the study process were that the selected coastal flood damage reduction alternative should:

- cause minimal or no direct destruction or alteration to vegetated wetlands;
- cause minimal or no impact to the dynamics of the estuarine ecosystem and navigational safety;
- should not cause secondary land development in the floodplain — a result which could have future negative impacts on the estuary and on future flood vulnerability; and
- includes features which are aesthetically harmonious with their surroundings and interfere as little as possible with presently existing views.

The question of who should operate a floodgate project and manage the lands required for natural storage by the project was also seen as critically important to the long term effectiveness of any flood damage reduction plan.

In the Spring of 1988, concerns about protecting the natural resources of the study area led a group of local citizens to nominate portions of Broad Sound, the Saugus and Pines Rivers, and of the cities of Boston, Revere and Lynn and the towns of Saugus and Winthrop to be designated as a Massachusetts Area of Critical Environmental Concern (ACEC.)

ACECs are unique places considered to have natural and human resource values worthy of a high level of concern and protection. In this case, the ACEC was designated primarily for the purpose of protecting natural wetland values. The upland boundary of the ACEC was located along the 100 year floodplain elevation; and any proposed activity which involved altering the ACEC would receive the closest scrutiny and regulation under the various policies and programs of the state.

The Broad Sound nomination was accepted on 1 April 1988, and public information meetings were held to discuss the reasons for the nomination and the ramifications of such a designation. As first proposed, the Broad Sound ACEC included most of the tidal wetlands in the Saugus and Pines Rivers estuary, upland areas in East Saugus, and the

Four Citizen Steering Committees and a Technical Group Helped to Formulate Plans and Identify Impacts

The Estuary Was Designated an "Area of Critical Environmental Concern" in 1988

entire beach in Revere. During the review process the Corps expressed its concerns that the original boundary proposed for the ACEC could affect many ongoing Corps activities in navigation, dredging and erosion control, and could preclude an effective solution to coastal flooding in the study area.

On 22 August 1988, after much consideration including a public hearing at which over half of the speakers explicitly supported Corps programs, the Secretary of Environmental Affairs, the Commonwealth's highest ranking environmental official, designated most of the estuary as an ACEC. Through changes in the boundary and wording in the statement, all Corps projects including what is proposed by this study, were either physically excluded from the ACEC or were exempted from ACEC requirements. As stated in the official document, "The Saugus River Flood Damage Reduction Project is the first project to be exempted from the designation."

The ACEC designation will certainly strengthen local and state efforts to protect resources within the study area, particularly wetlands, from proposed changes in land use that are not consistent with ACEC goals. Concern remains, however, about incremental losses of natural storage capacity in the estuary's saltwater wetlands through illegal disposal of fill and/or activities of landowners whose property abuts the floodplain. There is also a clear recognition of the need to assure the continued availability of appropriate technical experts to operate a floodgate structure. These concerns have resulted in interest on the part of state agencies in having the Corps take on the floodgate/natural storage area management responsibilities. This interest was expressed most recently in a 27 March 1989 letter from the Commissioner of the MDC which noted the magnitude of the project, the sophisticated equipment required for operation and maintenance, and the need for highly skilled engineers of several disciplines.

The Corps will prepare a manual for operation of the floodgates. Other responsibilities that will need to be carried out are given in detail in the section of the report that describes the selected plan. The outline recommends that the project operators, in addition to maintaining and operating the floodgates, establish and maintain close working relationships with Conservation Commissions and other relevant governmental and non-governmental interests to protect against illegal fill operations in the floodplain.

The extensive and constructive interagency coordination and public involvement that has been carried out all during the study has played a vitally important role in shaping a plan that can reduce coastal flood vulnerability while providing improved protection to highly valued local natural resources. The high degree of cooperation has also helped maximize the opportunities for meeting related local and state goals concerning recreation and boating safety, and improved protection for the study area from the impacts of sea level rise. The Corps will continue to work with the MDC, the project sponsor, to define acceptable and effective plans for the long-term operation and maintenance of the floodgate structure and management of the associated lands, and to meet the cost-sharing requirements that will be necessary to achieve implementation.

President Carter's Declaration as a State of Emergency in 1978 provided Federal Assistance for Emergency Services

Governor Dukakis and Mayor Colella of Revere were instrumental in obtaining Federal and State assistance for flood stricken victims

Senator Kennedy briefed on disaster operations in 1978

The Army National Guard assisted with evacuations during the Blizzard of '78

Photos: Revere Journal, February 15,1978

PLAN FORMULATION

The formulation and analysis of alternative plans to reduce coastal flooding is based largely on careful review of the existing and future situations and the problems, needs and opportunities of the study area. In the case of the Saugus River and Tributaries study area it is clear that when future flooding occurs, substantial damage will continue to be sustained by existing homes and businesses. The plan formulation process has evaluated potential methods for reducing future flood damages within this study area to acceptable levels, while taking into consideration the strong state and local interests in protecting the natural values of this coastal floodplain. This section briefly describes the alternatives that were studied, the plans that were developed, and the process that was used to screen the plans. Plan Formulation Appendix A presents this information in more detail.

PLANNING OBJECTIVES AND CONSTRAINTS

THE FEDERAL OBJECTIVE

The Federal objective of water and related land resources project planning is to contribute to National Economic Development (NED) consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements.

The objective of this particular study was to determine ways to reduce coastal flood damages in the Saugus River and Tributaries study area to acceptable levels, with least possible disruption to the natural resources associated with the estuary.

PLANNING OBJECTIVES AND CONSTRAINTS

The limited resources of the Federal government and of cost-sharing partners emphasize the importance of carrying out investigations in the most efficient and effective way possible, while taking into full consideration all relevant Federal, state and local concerns. The geographic scope of the study was limited to the area affected by coastal flooding behind Revere Beach and Lynn Harbor, and areas directly affected by tidal flood levels bordering the Saugus and Pines Rivers. The following constraints defined the precise nature of the study:

- Drainage problems from interior runoff, although also sources of periodic flooding and aggravated by high tides, were not investigated. Drainage problems are considered independent of the coastal flooding concern and will persist with or without coastal flood protection.

- Since much of the study area is comprised of saltwater wetlands, Federal and state wetland policies strongly influenced the study.

PLANNING OBJECTIVES

The planning objectives for the study were based on an assessment of the problems, needs and opportunities in the study area, as determined by Corps investigation and concerns and goals of the affected communities. The degree to which the alternative plans meet these objectives, while complying with required criteria, determines which alternative will ultimately be selected. The objectives of the study are to:

- Reduce the potential coastal flood damage in the study area;
- Reduce the coastal flood threat to public safety in the study area;
- Preserve the valuable resources in the estuary — its vegetated wetlands, mudflats, rivers and creeks, non-storm tide levels, flushing volume, water quality and navigation;
- Preserve and enhance recreational opportunities; and
- Support the objectives of other planning agencies and complement regional long range recreational, environmental protection, and development plans.

DEVELOPMENT OF ALTERNATIVE PLANS

ALTERNATIVES AVAILABLE TO ADDRESS IDENTIFIED PROBLEMS AND OPPORTUNITIES

Measures through which vulnerability to coastal flood damages can be reduced fall into two general categories. Some are designed to protect public safety and reduce the extent of flooding by modifying the hydraulics of the natural environment. Often called "structural" measures, these may include the construction of breakwaters, seawalls, revetments, dikes and walls, and floodgates; and/or restoration of dunes and beaches. Other measures, often called "non-structural", are designed to protect public safety and modify the extent of economic losses through providing early warning systems, regulating floodplain uses, requiring flood insurance, floodproofing or relocating vulnerable structures, and/or controlling further development by public acquisition of floodplain land. Further discussion of these alternatives appears in Plan Formulation Appendix A.

ALTERNATIVE FLOOD DAMAGE PREVENTION MEASURES

MODIFY FLOODS (STRUCTURAL)	REDUCE VULNERABILITY (NON-STRUCTURAL)
Breakwaters	Floodproofing
Seawalls	Flood Warning and Evacuation
Revetments	Flood Plain Regulations
Beach and Dune Restoration	Flood Insurance
Dikes and Walls	Public Acquisition of Floodplain Land
Floodgates	Relocation of Buildings

Various combinations of structural and non-structural alternatives were evaluated as to their capacity to reduce coastal flood damages in the study area. Each measure was investigated to determine: economic and engineering feasibility, associated environmental and social impacts of implementation, and the public attitudes toward it.

PLAN FORMULATION CRITERIA

FEDERAL CRITERIA

Federal water resource planning requires the formulation of a plan which reasonably maximizes net economic benefits, in other words, maximizes contributions to National Economic Development (NED). One plan, called the NED Plan, must be formulated, consistent with Federal objectives. Other plans may be formulated which have less net NED benefits in order to further address other Federal, state, local and international concerns not fully addressed by the NED plan. All alternative plans, including the NED plan, are formulated in consideration of four criteria: completeness, effectiveness, efficiency and acceptability:

- Completeness is the extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects. Each plan must be complete within itself to provide the benefits claimed for that plan.

- Effectiveness is the extent to which the alternative plan alleviates the specified problems and achieves the specified opportunities

- Efficiency is the extent to which an alternative plan is a cost effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the Nation's environment.

- Acceptability is the workability and viability of the alternative plan with respect to acceptance by State and local entities and the public, and compatibility with existing laws, regulations and public policies.

STATE REQUIREMENTS

The Massachusetts Environmental Policy Act (MEPA) process also requires the evaluation of alternatives and display of impacts.

ECONOMIC EVALUATION (based upon the following terms and definitions:)

- Project First Costs include estimated costs for construction, contingencies, engineering, design, supervision and administration, real estate and mitigation , if any.

- Project Investment includes both the Project First Cost and interest during construction on project expenditures until features become operational or begin producing benefits.

- Operation, Maintenance and Replacement costs include all average annual costs estimated for the project after it is constructed to keep it operating and maintained in optimum condition in accordance with provisions prescribed by the Corps. Also included are the average annual costs of major replacements over the project life; these may include such items as operating mechanisms for gates, electrical equipment for the gates, etc.

- Average Annual Costs include the project investment amortized over a 100 year project life at a Federal interest rate of 8 and 7/8 percent plus the estimated project annual operation, maintenance and replacement cost.

- Average Annual Benefits include that portion of the Average Annual Flood Damages prevented by the plans plus any other related NED benefits;

- Benefit-to-Cost Ratio (BCR) is an indicator of the economic feasibility of the plan which is determined by dividing average annual benefits by average annual costs.

- Net Benefits is the difference between average annual benefits and average annual costs.

ENVIRONMENTAL CONSIDERATIONS

In order to enhance the physical and social environment of the study area or to avoid creating unacceptable impacts, the following were kept in mind:

- to avoid wherever possible the direct loss of wetlands;

- to avoid adversely affecting the dynamics and water quality of the estuary;

- to avoid to the fullest extent possible reduction of tide levels and/or flushing in the estuary;

- to avoid creating flows in the navigation channel that exceed 3 knots or 5.1 feet per second to assure safe passage for navigation;

- to reduce or mitigate any significant adverse impacts which cannot easily be avoided; and in general

- to design and develop project features so as to provide opportunities which enhance the environment and recreation in the study area.

DESIGN STORM TIDE

Three design conditions, employing varying storm stillwater tide levels (SWL) in Broad Sound and different interior runoff conditions, were used to formulate alternative plans. These result in different approximate levels of protection. The precise level of protection that is provided in the future will depend on variability in wave overtopping and sea level rise. Reasonable approximations are provided below:

- Design storm tide SWL at EL. 10.3 feet NGVD and 10 year interior runoff. Under 1989 tidal conditions this represents approximately a 100 year level of protection. Over the 100 year project life - based on the historical rate of sea level rise - protection would gradually be reduced to about a 15-20 year level.

- Design storm tide SWL at EL. 11.2 feet NGVD and 50 year interior runoff. Under 1989 tidal conditions this represents approximately a 500 year level of protection. Over the 100 year project life, sea level rise would cause this to be gradually reduced to an 80-90 year level.

- Design storm tide SWL at EL 12.0 feet NGVD and 100 year interior runoff. Under 1989 tidal conditions this represents the Standard Project Northeaster (SPN) level of protection. Over the 100 year project life, sea level rise would cause this to be gradually reduced to a 300-400 year level.

The SPN event was selected as the goal for the level of protection because of the potential for catastrophic damages in this urban area, and uncertainty about the future rate of sea level rise. The 100 yr (1978 storm level) was the minimum considered, since this is an urban area subject to catastrophic flooding; there is only one foot difference between the 10- and 100-year stillwater tide levels; and over a project life of 100 yrs, with a potential rise in sea level of one ft, the storm would eventually represent only about a 15-20 yr level of protection. It should be noted that with sea level rise the storm frequency may not change, but the storm's tide level will change.

For non-structural floodproofing plans for individual buildings, a 100 year design storm was used for comparing this plan to the structural alternatives. Flood insurance rates are reduced when 100 year protection is provided. Lower levels of protection were not considered practical due to the high sensitivity of flood stage and frequency.

Throughout this section on plan formulation, cited levels of protection or storm tides reflect 1989 tidal conditions. Changes that could be expected to occur over time due to rises in sea level have been outlined above.

DEVELOPMENT OF ALTERNATIVE PLANS TO MEET IDENTIFIED PROBLEMS AND OPPORTUNITIES

Three basic plans or options were prepared using combinations of management measures. These included: Option 1: the Local Protection Plan; Option 2: the Non-Structural Plan; and Option 3: the Regional Floodgate Plan. The following section briefly summarizes the evaluation of the three options. More detailed information on the formulation of these plans appears in the Plan Formulation Appendix A.

OPTION 1 - LOCAL PROTECTION PLAN

At the inception of this study, a local protection project (LPP) was already under final design for the Point of Pines subsection of Revere, following a study of coastal flooding problems in that area. The remaining portions of the study area were divided into geographic subsections, each having varying degrees of development. Five subareas appeared to have sufficient damages to justify a local protection project (LPP). These included:

- Revere Beach Backshore, Revere
- City of Lynn
- East Saugus, Saugus
- Town Line (and Linden) Brook, Revere and Malden
- Northgate Area, Revere

In two remaining areas, the Upper Saugus River (including Shute Brook) and the estuary, buildings and damages are too spread out along river banks and roadways to have warranted consideration for a separate local protection plan. On the Upper Saugus River and Shute Brook less than 50 buildings along 2,000 feet of riverbank are in the tidal floodplain. Early in the investigations, the Northgate LPP was not found to be economically justified and was excluded from further consideration. Plate 3 shows the alignments for the remaining four LPPs that were studied further.

REVERE BEACH BACKSHORE LPP – The Revere Beach Backshore LPP included 3.1 miles of new shorefront structures to provide protection to 1,200 buildings located behind Revere Beach. The Plan includes a 3,420 foot long Park Dike at the south end of Revere Beach, raising 1,800 feet of seawall, and a revetment at the north end of Revere Beach, and over 10,180 feet of walls and dikes 4 to 10 feet high and up to 80 feet wide along the shore of the Pines River and estuary. In addition, the plan required maintenance of the existing Revere Beach seawalls, as well as protection of a natural ponding area located behind the homes along the north end of Revere Beach to provide temporary storage for water that overtops the north end of Revere Beach. To contain the water, 900 feet of walls and dikes are needed at the south end of the ponding area. Minimal damages were to be sustained to the homes, even with the overtopping. The Park Dike was optimized at the SPN design level and other features at the 100 year design level of protection. Project economics and impacts are summarized on Table 2 for the preliminary LPP's Plans.

Alternatives: Walls, moving dikes inland, road raising and various alignments were investigated along the Pines River and estuary to reduce the impact of dikes on the wetlands; but costs were at least 15 % higher which would not likely be economically justified. Along Revere Beach, alternatives investigated but also found to have prohibitive costs included replacing and raising seawalls, armor stone revetments, widening the authorized beach, concrete stepped walls, breakwaters offshore, and a wall along Sales Creek. A drainage system at the seaward toe of the Park Dike was considered; however, additional fill to slope the land toward the Boulevard for drainage was more cost effective and also provided recreation parkland benefits.

CITY OF LYNN LPP – The City of Lynn LPP included 4.0 miles of walls and dikes along Lynn Harbor and the Saugus River to protect to the 500 year level about 1,200 residential, commercial, industrial and public buildings. Along Lynn Harbor, 5,100 feet of new

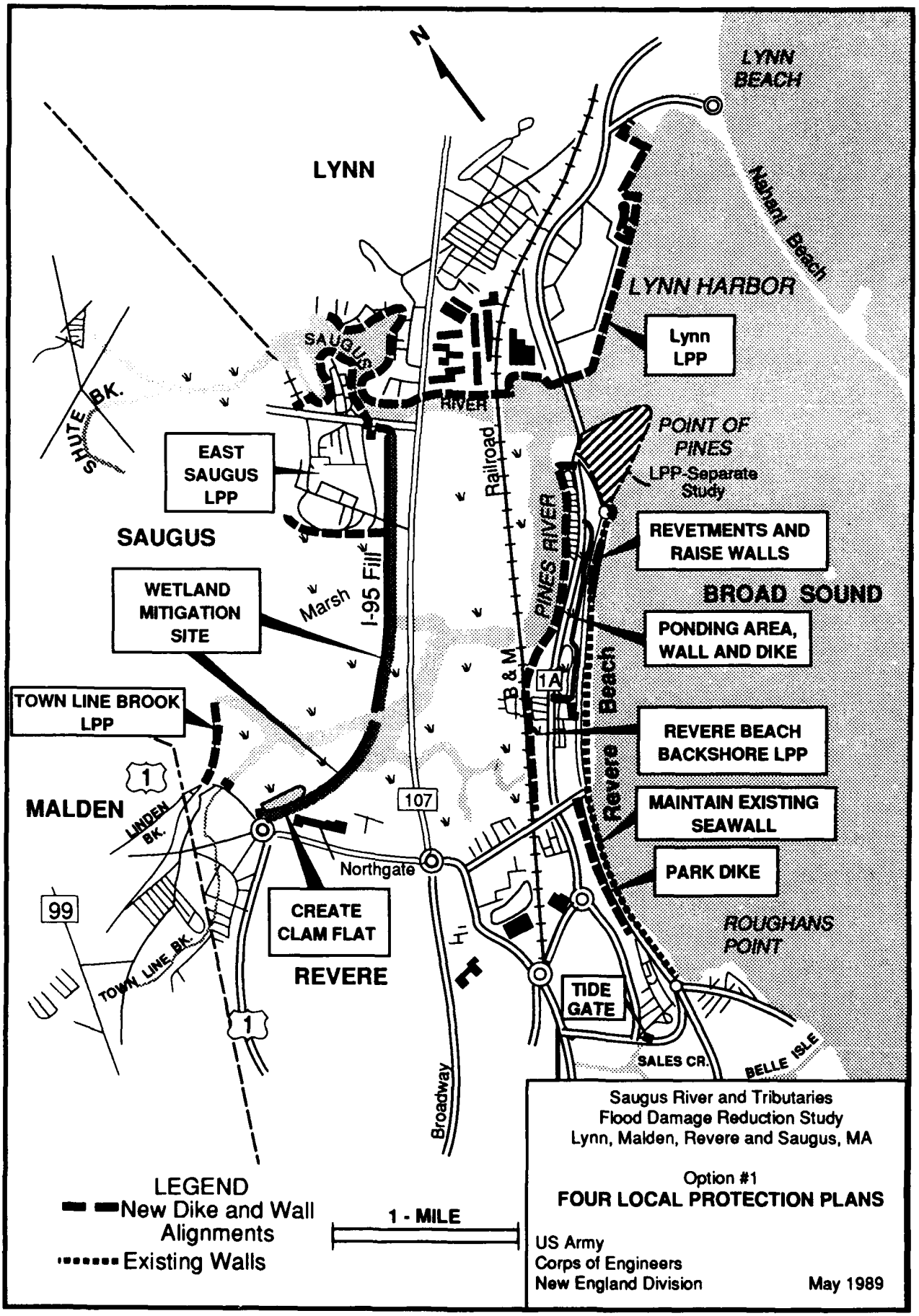

N
LYNN BEACH
LYNN
Nahant Beach
LYNN HARBOR
Lynn LPP
SAUGUS
RIVER
SHUTE BK.
POINT OF PINES
LPP-Separate Study
EAST SAUGUS LPP
Railroad
PINES RIVER
REVETMENTS AND RAISE WALLS
SAUGUS
I-95 Fill
Marsh
WETLAND MITIGATION SITE
BROAD SOUND
PONDING AREA, WALL AND DIKE
B & M
1A
Revere Beach
TOWN LINE BROOK LPP
REVERE BEACH BACKSHORE LPP
1
MALDEN
LINDEN BK.
107
MAINTAIN EXISTING SEAWALL
Northgate
PARK DIKE
99
CREATE CLAM FLAT
ROUGHANS POINT
TOWN LINE BK.
REVERE
TIDE GATE
1
SALES CR.
BELLE ISLE
Broadway
LEGEND
New Dike and Wall Alignments
Existing Walls
1 - MILE
Saugus River and Tributaries
Flood Damage Reduction Study
Lynn, Malden, Revere and Saugus, MA
Option #1
FOUR LOCAL PROTECTION PLANS
US Army
Corps of Engineers
New England Division
May 1989

PLATE 3

stone-faced dikes and 4,500 feet of new or raised existing walls were required. Along the Saugus River 11,625 feet of dikes and walls were to be used to prevent overtopping of the Saugus River bank and estuary. Along the river the dike and wall height would be about 4 to 7 feet above existing ground on the developed side. Along the harbor the walls would be about 4 to 6 feet above existing ground as would the dikes.

Alternatives: Walls were investigated along the Saugus River at several locations to reduce impacts on wetlands; however, the higher costs of the walls (about 6%) would not likely be justified. Along the Saugus River, when the dike location was moved inland, there were significantly higher costs due to real estate impacts. Along Lynn Harbor the assumption was made that the South Harbor developer would have an approved plan to construct dikes inland similar to that proposed by the Corps. This determination resulted from meetings with the developer, Lynn Planning Office, Coastal Zone Management and Corps' Washington Level Review Center. Other options are also open to the developer including a lower dike along the shorefront and raising the ground inland. Without an approved plan, a wall 300 feet inland along the back property line would likely be constructed.

EAST SAUGUS LPP – The East Saugus LPP would have protected 550 residential and commercial buildings from overtopping of the Saugus River banks and the banks along the Pines River marsh against a 500 year tide level. The plan included 1.5 miles of walls and dikes, 4 to 12 feet high and up to 80 feet wide along the shore, which would tie into a section of the abandoned I-95 embankment. No protection would have been afforded to about 50 commercial businesses and homes along the river, or to the Upper Saugus River and Shute Brook areas.

Alternatives: Also investigated were walls along these alignments, and moving dikes inland to reduce impacts on wetlands. However, these alternatives could significantly in crease the cost of the plan and would not likely be economically justified. Various alignments were investigated to protect additional homes and businesses along the Saugus River; but these were not economically justified and were eliminated from the plan. A pumping station was also not economically justified.

TOWN LINE BROOK LPP – The Town Line Brook LPP included 100 year tidal shorefront protection for about 1,000 homes and businesses in the Town Line and Linden Brook watersheds of Revere and Malden. The MDC currently has plans to construct shoreline improvements, a pumping station and interior drainage improvements in the area. Therefore, only shorefront improvements related to high tides were addressed in the LPP. The plan included 1,250 feet of walls and dikes along Rt. #1, the existing MDC dikes and the railroad embankment.

Alternatives: Walls were investigated to reduce impacts on wetlands and the cost would be about 10 percent higher. Moving dikes inland was also investigated, but would have cost significantly more.

MITIGATION: Revere Beach Backshore, Lynn, East Saugus and Town Line Brook LPPs – Project costs include the mitigation of 14.6 acres of intertidal habitat, replacing the loss in-kind by removal of I-95 Fill to create Clam Flats. The 17.7 acres of mitigated wetland loss includes removal of about 20 acres in a strip along the backside of the I-95 Fill to create wetlands. The acreage mitigated is 10 percent higher than the acreage lost in

order to compensate for the time required for the wetlands to approach the ecological value of the wetlands they are replacing.

Table 2 summarizes the results of Option 1, Local Protection Plan studies:

TABLE 2

OPTION 1
LOCAL PROTECTION PLANS

DESCRIPTION	Revere Backshore	Lynn	East Saugus	Town Line Brook	TOTAL
Residences & Businesses protected (bldgs)	1,200	1,200	550	1,000	3,950
Design Level of Protection	100-yr & SPN	500-year	500-year	100-year	100-500-year & SPN
Length of Walls and Dikes (miles)	3.1	4.0	1.5	0.2	8.8
PLAN ECONOMICS					
Project First Cost ($ Millions)	18.4	32.3	10.9	0.8	62.4
Average Annual Benefits ($ Millions)	2.59	3.28	1.21	0.08	7 16
Average Annual Costs ($ Millions)	1.70	3.13	1.07	0.08	5.98
Benefit-to-Cost Ratio	1.5	1.05	1.1	1.0	1.2
Average Annual Net Benefits ($ Millions)	0.89	0.15	0.14	0	1.18
ENVIRONMENTAL CONCERNS					
Vegetated Wetland Lost (Acres)	6.6	2.6	7.4	1.1	17.7
Intertidal Habitat Lost (Acres)	3.9	9.2	1.5	0	14.6

POINT OF PINES LPP – The Detailed Project Report resulting from the Section 205 study had recommended a Federal project. However, the city of Revere advised the Corps on 10 June 1988 that it was unable to provide its share of the project cost. Although the LPP at Point of Pines resulted in a recommended Federal project, it was not included in Option 1 because the project was to be implemented separately. A sensitivity analysis showing potential impacts and project economics if it had been included appears in the section on Evaluation of Alternatives later in this section of the report. A 100 year level of protection would have been provided by the plan. It would have consisted of 5,050 feet of shorefront structures, including revetments and dune restoration along the shorefront; and walls along the Saugus River. About 1,000 feet of walls along the Saugus River that are required in the LPP would not be needed in Option 3.

SUMMARY OF IMPACTS/OPTION 1- LOCAL PROTECTION PLANS – Local Protection Plans were investigated for five of the geographic areas examined. Four potentially implementable plans demonstrate economic feasibility; however, benefits barely exceed costs of implementation. All LPP's could be modified for sea level rise. The cost to raise structures one foot higher for each foot of sea level rise would be about $17million

The LPP plans did provide a significant reduction in average annual damages (or project benefits) to developed areas. The plans also included reduction in flood insurance overhead, and emergency and related costs. However, the plans lacked local acceptability for a variety of reasons:

Environmental Impacts – Option 1 involved the potential loss of 17.7 acres of vegetated wetlands and 14.6 acres of intertidal habitat along mud or sand flats. This potential loss of resources was strongly opposed by resource agencies, environmental groups and many members of the Citizens Steering Committees and Technical Group. The study evaluated the use of walls in lieu of the wider dikes as well as moving dikes inland in the areas in which wetlands or intertidal habitat would be lost; however, the higher cost involved with this approach would jeopardize the option's economic feasibility. Structures constructed bordering the estuary could also impact buried archeological sites.

Social and Economic Impacts – The LPPs were opposed by the Citizens Steering Committees from Lynn, Saugus and Revere, and bordering land owners. Concern was that structures along the edge of the estuary with heights from 4 to 12 feet and widths up to 80 feet would affect views and aesthetics of the estuary and waterfront, as well as real estate values. There was additional concern about the possibility that business operations would have to be shut down during the portions of the construction process relative to construction of tide gates on existing intake or discharge pipes. This related particularly to the General Electric River Works which could likely require shutting down portions of the plant during construction of the close to 30 tide gates or intake and discharge pipes needed along the Saugus River under this option. The confidence level in the plans' functioning properly during a coastal storm event was jeopardized by the need for closure of a large number of access, and intake and discharge tidal gates (about 80). This responsibility was regarded as an added burden on the cities during storm events when local manpower is usually overstressed. Fear also existed that flooding could occur in areas surrounded by walls or dikes if the LPP structures (some of which provide protection only to the 100 year [1978] tidal flood level) were overtopped during an SPN event.

OPTION 2 – NONSTRUCTURAL PLANS

Non-structural plans were prepared as a second option. Alternatives examined included floodwarning and floodproofing and other measures which reduce flood damages to individual buildings. Structural changes included raising homes or constructing utility cells, rooms and/or buildings; closures on doors, windows or other openings; as well as alerting residents to the need to move property above flood levels.

In Revere, Lynn and East Saugus only a very limited number of buildings demonstrated sufficient benefits to equal or exceed the costs of floodproofing. Out of 2,100 homes investigated in the floodplain, only 171 were potential candidates (demonstrating economic feasibility) for raising. Out of 585 commercial and public buildings only an estimated 68 (12 percent) were potential candidates for floodproofing closures. In total, only about 240 buildings could potentially be floodproofed or raised out of 2,685 investigated. In the SPN floodplain, these numbers translate to a total of 7 percent (see Table 3). The 2,685 buildings include only those damage surveyed areas where economic benefits have been taken for structural plans, which excludes the Town Line and Linden Brook (which were evaluated by the MDC project) and the Upper Saugus River and Shute Brook areas. Residents would need to be evacuated for safety, regardless of flood proofing. Predicting the extent of coastal flooding for evacuation purposes is very unreliable and public safety can not be assured. For example, forecasting a tidal surge of 2 to 3 feet, as occurred in January 1987 with a warning that the surge could approach the level of the 1978 Blizzard, makes the difference between the 10-year or 100-year flood - evacuating a few hundred or 40,000 people.

Alternatives: Floodproofing or raising all homes, and ringwalls for commercial properties in the 100 year (plus 1 foot for sea level rise) floodplain was not economically justified at a cost of $148 million and benefit to cost ratio (BCR) of 0.4 to 1. SPN protection would cost $190 million (BCR=0.3). The cost of modifying this alternative one foot higher in the future due to sea level rise is estimated at $100million. Acquisition of floodplain lands, including the relocation or removal of buildings from the floodplain and purchase of the land, was also considered in the investigations; but large scale acquisition in this heavily developed area was eliminated as not feasible. The acquisition costs of residential, commercial and industrial properties in the 100 year coastal floodplain of Revere, Lynn and Saugus would be nearly $1 billion. Floodplain regulations are currently enforced. In 1978 only 10-15 percent of the affected buildings had flood insurance. Today about 40 percent have National Flood Insurance. The insurance does not prevent damages; it partially subsidizes the loss from flooding.

SUMMARY OF IMPACTS/OPTION #2 - NONSTRUCTURAL PLANS – The planning objective of providing a high level of protection to the region would not be met by this option. Only 7 percent of the buildings in the study area are candidates for protection under this plan. Studies also determined that coastal storm forecast systems do not yet exist in a sophisticated enough form to provide effective early warning in this study area. Only a foot or two difference in tide levels lies between a storm that is a minor disturbance and one that poses great threat to human life and/or causes severe damages. At the present time, depending on which circumstances occur, this information is often known only shortly before the event hits the study area.

There are no significant environmental, social or economic impacts associated with implementation of this plan; however, the flooding problem would persist in the study area. Because of insufficient time to provide adequate early warning, and the fact that flood damages would not be significantly reduced by this alternative, local communities indicated no support for Option #2. The State's Executive Office of Environmental Affairs requested the option be completed for comparison to the other options and because of Option 2's negligible impacts on the environment.

TABLE 3
OPTION 2 – NONSTRUCTURAL PLAN
(1988 Price Level)

	REVERE	LYNN	SAUGUS	TOTAL
Number of Buildings Feasible for Raising or Floodproofing in Study Area Flood Plain	88 (5 %)	78 (6 %)	73 (13 %)	240 (7 %)
First Cost ($ Millions)	3.1	1.8	2.5	7.4
Average Annual Benefits ($ Millions)	0.5	0.4	0.5	1.4
Benefit-to-Cost Ratio	1.8	2.4	2.1	2.0
Average Annual Net Benefits ($ Millions)	0.2	0.2	0.3	0.7

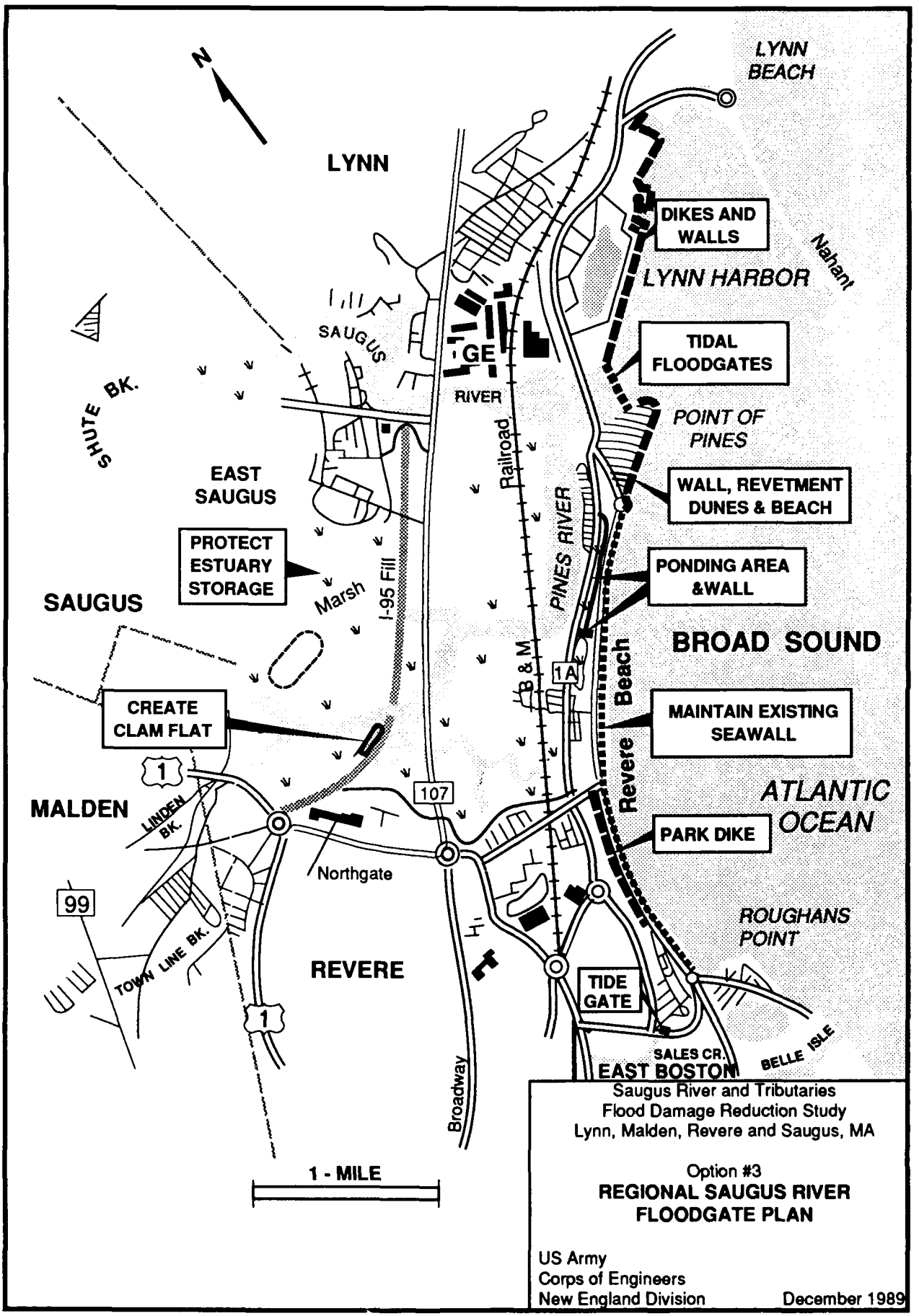
OPTION 3 – REGIONAL SAUGUS RIVER FLOODGATE PLAN

Option 3, the Regional Saugus River Floodgate Plan, examined the effectiveness of a linked series of protection measures (dikes, walls, revetments) along shorefronts in Revere Beach, Point of Pines and Lynn Harbor to reduce overtopping and flooding in the entire study area. It combined these measures with a floodgate structure across the mouth of the Saugus River to prevent tidal surges from flowing up the rivers into nearly the entire study area flood plain. Also, temporary use of the natural flood storage capacity of the estuary would be used to reduce flood damages to the study area.

Key elements of the plan which are explained and shown in greater detail in the next section include (see Plate 4):

- A 3,420 foot long Park Dike behind the south end of Revere Beach is required, as well as maintenance of the existing Revere Beach seawalls so as to prevent additional overtopping of the seawalls. Moreover, an additional 500 foot long wall is needed at the south end of a natural ponding area, which is located between Route #1-A and the Boulevard, to prevent water which overtops the north end of the beach from reaching other developed areas and to direct the water toward the estuary.

- For those floodgate alignments which link to Point of Pines, 1,550 feet of revet-



Saugus River and Tributaries
Flood Damage Reduction Study
Lynn, Malden, Revere and Saugus, MA

Option #3
REGIONAL SAUGUS RIVER FLOODGATE PLAN

US Army
Corps of Engineers
New England Division
December 1989

PLATE 4

ments along the shorefront and 900 feet of new or raised wall along the Saugus River are required. Also, 1,600 feet of revetments under the dunes at Point of Pines are needed to prevent significant overtopping from potential undermining of the dunes, which could threaten the integrity of the Regional Plan and the protection that it offers. Dune restoration and beach protection is also required.

- Along Lynn Harbor the floodgates would tie into to about 8,900 feet of new stone-faced dikes and new or raised walls largely along commercial property.

- The floodgates, which would be located at the mouth of the Saugus River, would be closed initially two or three times a year and generally for only a few hours each time. During more severe storms, such as the Blizzard of '78 (100 year event), the gates would be closed for a longer period of time and possibly on several consecutive high tides. The gates would be reopened as soon as the ocean tide level dropped below the level of the estuary water confined behind the floodgate.

The interior storage available behind the floodgates to handle runoff from the watershed and tidal overtopping when the gates are closed are important to project operations and the prevention of damages. Meeting this storage requirement and providing for safe project operations would be accomplished by protecting the natural storage in the estuary through acquisition in fee or easement of the estuary storage area.

INVESTIGATION OF THE FLOODGATE ALTERNATIVE – The study's Technical Group and Citizens Steering Committees generally felt that use of tidal floodgates in an environmentally sensitive and navigationally active estuary could be acceptable providing certain conditions could be met.

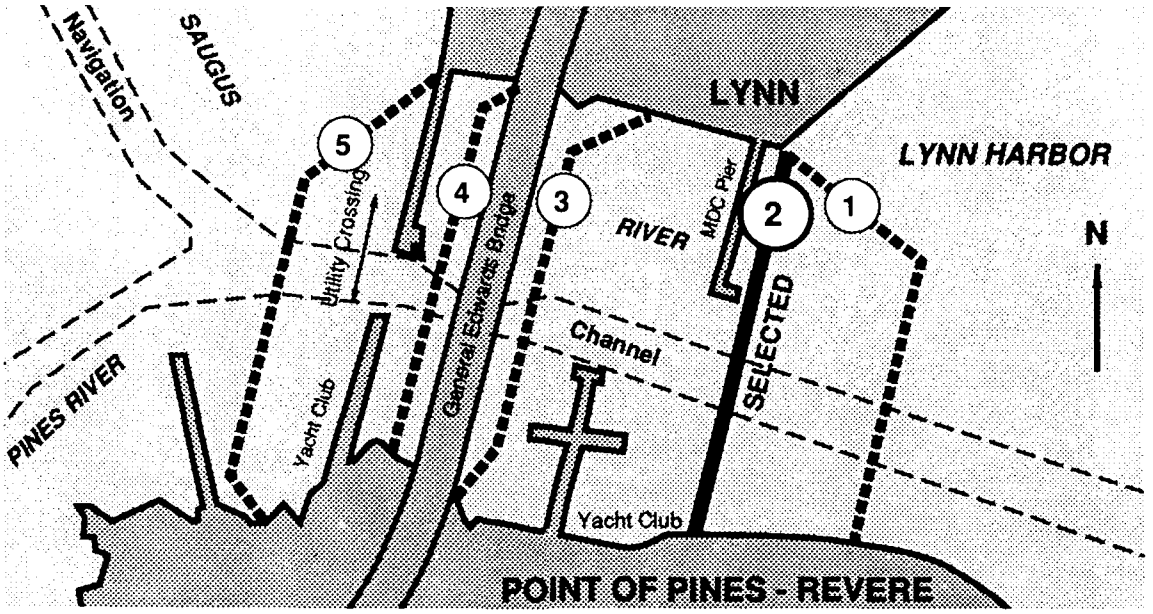
Design Criteria – In the "open" position, natural flushing and tide levels in the estuary, as well as safe passage for navigation were to be maintained. With the floodgates in the "closed" position, concern focused on the need to maintain natural inundation of the estuary's vegetated wetlands, and to avoid detrimental impacts on the quality of the temporarily impounded water.

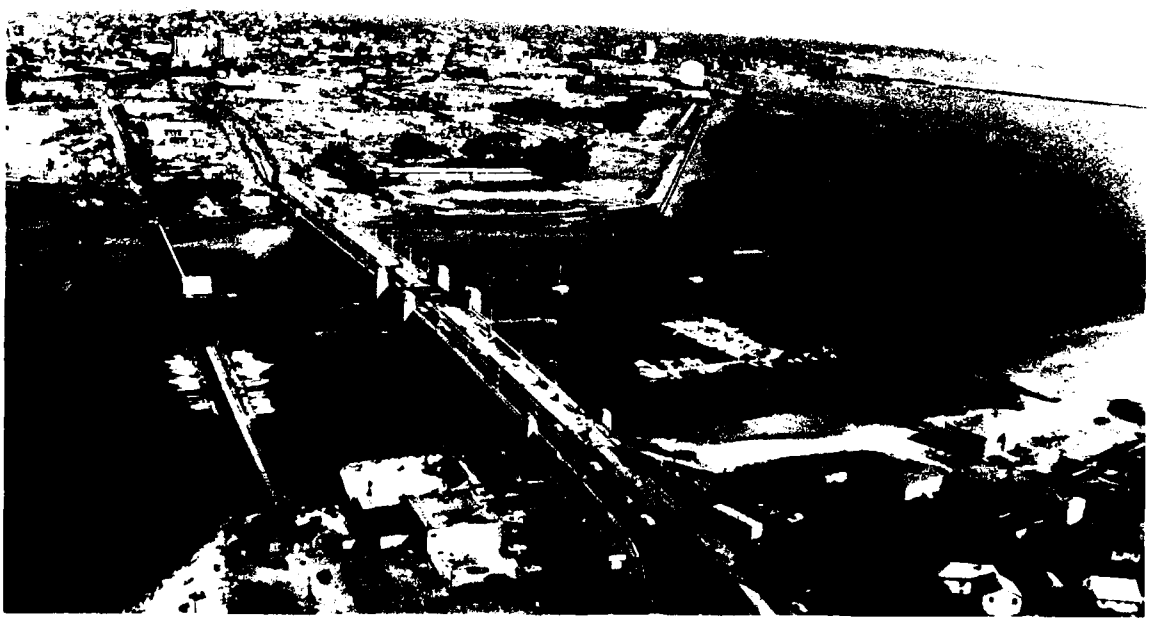
Studies were carried out to determine whether and how these conditions could be met. With extensive help from the committees, through meetings and letters, alternative floodgate schemes were evaluated for their impacts on wetlands, navigation currents and safety, future conditions, and other social and environmental concerns. These studies included determining existing river flow area and currents; investigating gate designs and placements that would meet the outlined conditions for the open gate position; and investigating the impacts of floodgate closure not only on flooding conditions, but on water quality and the resources of the estuary and associated marshlands. Floodgate alignments at five locations at the mouth of the Saugus River were evaluated for costs and impacts. See Figure 4 .

Currents measured at the General Edwards Bridge were used to calibrate a tidal flow, flushing, and tide level model of the currents and estuary. This information was used to estimate the impacts of various floodgate structure openings or gated openings. The major criteria used in evaluating gate designs was previous studies for other floodgate structures by the Corps Waterways Experiment Station (WES) which recommended that

Figure 4 **Saugus River Floodgate Alignments and Economic Comparison**

	FLOODGATE ALIGNMENTS				
Regional Plan (1988 Price Level)	**5**	**4**	**3**	**2**	**1**
First Cost ($M)	94	96	90	85	90
Average Annual Benefits ($M)	8.9	8.9	8.9	10.9	10.9
Average Annual Costs ($M)	9.3	9.5	8.9	8.6	9.0
Net Benefits ($M)	-0.4	-0.6	0	2.3	1.9
BCR	0.9	0.9	1.0	1.3	1.2





The Mouth of the Saugus River (As Viewed from the South) -- Several Floodgate Alignments Investigated

peak flows not exceed 5 feet per second (3 knots) in the navigation channel. This flow was considered by WES as the maximum safe flow velocity for vessels, a figure that was supported by local mariners who were already concerned about swift currents and eddys in the vicinity of the bridge. A number of options were investigated, including gates of different types and sizes. As the studies progressed, it was determined that the recommended number and type of gates were critical to assuring navigational safety and to maintaining natural flushing patterns in the estuary.

After intensive study it was determined that a floodgate located at alignment 2 at the mouth of the Saugus River, 700 feet east of the General Edwards bridge, and Gate Scheme N4 which matched the peak flow area in the river at that location, met all of the criteria for inclusion in the Regional Plan. This is explained in more detail in the Plan Formulation Appendix A.

The other floodgate alignments investigated (1, 3, 4 and 5) would cost at least $4 million more to construct, due to an increase in the length of the floodgate structure and shorefront features; and to significant impacts on the navigation fleet, commercial real estate, bridge footings, underground cables, drainage systems, nearby marinas, and General Electric's fuel supply. Alignments 3, 4 and 5 would not protect Point of Pines and thus would prevent less flood damages than Alignments 1 or 2. Alignments 1, 3, 4 and 5, with either less benefits and/or higher costs than Alignment 2, are either marginally or not justified economically. Alignment 2 does not have these problems.

Gate Scheme N4 included a 100 foot wide navigation gate and a total of 600 feet of openings which would be closed off during storms. By matching the existing opening of the river at peak flows (mid tide) it was possible for the gates to nearly match existing currents. Even for likely future conditions of sea level rise currents are not expected to exceed 3 knots or 5 feet per second. Other gate schemes considered would either not meet the navigation criteria, or would cost more to construct, yet would not provide any significant additional benefits to meeting environmental criteria.

Major changes in the design of the openings are not expected. The gates will be further evaluated in the final design phase if the project is approved. More detailed modeling of the existing river mouth, floodgates, size of openings, location of openings, affect of sea level rise and exact alignment will establish the optimum design to meet navigation and environmental criteria. A workshop and social survey for Point of Pines residents showed the majority supported the plan, although a vocal minority opposed it. Opposition was principally due to fear that the beach and dunes, important elements of flood protection at Point of Pines, could be damaged by overuse if the beach was made public following financial involvement by the Commonwealth. Further details on the sensitivity analyses appears in Plan Formulation Appendix A.

Floodgate Operations – The floodgates would be closed whenever the tide is projected to rise to or above EL. 8 feet NGVD, which is considered to be about the start of damage around the tidal estuary. This water level is normally reached about once a year. Due to the uncertainty of anticipating the level at which storm tides peak, a factor that is affected by wind direction and velocity among other factors, there will be occasional closures when tides have not yet reached this elevation. The number of closures each year would average about 2 to 3 initially, including 1 or 2 that may turn out to be false alarms.

Closure would normally occur when tides reach EL 7.0 to provide one foot of storage below the start of damage. Because of the normal mixing due to wave action and wind that is expected to continue in the estuary even after gate closure, water quality of the temporarily impounded waters is not expected to be negatively affected.

Over time, floodgate closure would become more frequent if sea level rise continues. The gates would continue to be closed if tides were predicted to reach the start of damages, EL. 8. By the time the rise in sea level approaches one foot, gate closure could be averaging 35 to 45 times a year, for an average of 2-3 hours each time and the SPN level of protection would change to a 350 year level.

If sea level rise approaches two feet, closure would become more frequent. If these conditions do come to pass, closures would occur about 200 times per year or on about 25 to 30 percent of the tides. Closures would occur only on the high tide portion of the tides, typically for a period of 3 to 4 hours out of the 12 hour tidal cycle. The level of protection would drop to about a 50-year level. The gates, nevertheless, would remain open about 90 percent of the time even with an accelerated two foot rise in sea level which is twice the historical rate. The impacts associated with project operations from a 2 foot sea level rise, if it should occur over the project life, is unacceptable to Federal and state agencies. If sea level rise exceeds the historical rate during the 100-year economic life, the non-Federal sponsors could request an investigation to evaluate modifying the project as sea level rise approaches 1 foot. Modifications could be accomplished to raise the level of protection back to SPN and reduce the number of closures to 2 to 3 per year.

IDENTIFICATION OF THE NED PLAN

The Regional Plan, using alignment #2 of the floodgate scheme, produced the highest average annual net economic benefits of any alternative studied. To establish the NED Plan — the plan that provides the greatest contribution to National Economic Development — further optimization analyses were conducted. Three areas of the Regional Plan were analyzed as separable elements: South Half of Revere Beach area; Point of Pines, and the North End of Revere Beach.

THE SOUTH HALF OF REVERE BEACH AREA

This section is nearly hydrologically separate from the study area. Located behind the south end of Revere Beach, high ground cuts it off from the rest of the study area floodplain (except for MBTA tracks and a culvert which pass under the local sections of Beach and Revere Streets). The areas behind the Park Dike were optimized at the SPN level of protection with provisions for a temporary closure at Beach Street. However, south of Beach Street tidal flooding in the Garfield area is also caused by high tides in the Belle Isle Inlet which overtop Bennington Street into Sales Creek. Construction of the Roughan's Point flood damage reduction project would prevent 100 year (1978) flooding from entering the area by way of the Eliot Circle intersection. In addition, construction of a tide gate on Sales Creek is also needed to provide 100 year protection for the Garfield School area. The gate is justified, based on damages prevented in the area.

A 500 year flood with a tide level one foot higher than 1978 would flood Suffolk Downs to about EL. 11 feet NGVD and would overtop the Revere Beach Parkway, the MBTA

tracks under the Parkway, and the Eliot Circle intersection. However, preventing flooding from a 500 year event in the Garfield School area would require 1,200 feet of walls, dikes and road raising. The cost significantly exceeds the additional economic benefits that would be gained. The Garfield School area can only be justified for protection to the 100 year level, for which the highest net benefits are produced by use of a tidegate on Sales Creek.

POINT OF PINES

Point of Pines is an area that, during most of the study, was assumed would be protected by the separate local protection project to be implemented under the Corps Continuing Authority Program. The project included revetments, walls, dune and beach replacement along the shorefront to protect the area at the optimized 100 year level. The Regional Plan was initially formulated assuming the project would be built prior to the Regional Plan. The Regional Plan also assumed that during events which exceeded the 100 year level of protection at Point of Pines, floodwaters overtopping its shorefront would be stored in the estuary. Late in the study process, the city of Revere advised the Corps that the project could not be built because the city could not meet cost sharing requirements. Since Floodgate Alignments 1 and 2 must tie into shorefront improvements at Point of Pines, these improvements were added to the Regional Plans. Point of Pines features were checked again to see if a higher level of protection could be justified as part of the Regional Plan. The analysis showed that Point of Pines remains optimized at the 100 year level — the level recommended for it in the Regional Plan. The floodgates will also aid in further reducing damages in this area by allowing waters which overtop the shorefront to flow out of the neighborhood and into the estuary storage area. If the Regional Plan proceeds into final design, a recently developed dune/beach model would be used to assess the feasibility of using additional sand for a dune/beach system possibly in lieu of all or part of the revetments. The results may show an acceptable alternative to the need for revetments.

NORTH END/REVERE BEACH

In this section of the study area, basements of some thirty homes were flooded in 1978 from overtopping of the north end of Revere Beach. Control of floodwaters in the estuary and protection of the wetland ponding area behind the homes will reduce these damages for the full range of flood events. But to provide total protection would require raising an existing 1,800 foot seawall, at a cost of over $2 million. The increased level of protection was not found to be economically justified as part of the Regional Plan.

OPTIMIZATION OF THE REGIONAL PLAN

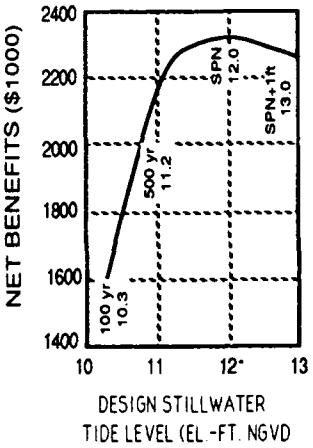
Integrating shorefront protection measures, tidal floodgates and the use of interior marshland for temporary storage of floodwaters was found to produce the highest average annual net economic benefits of any option or combination of options that was studied. The Regional Plan accomplishes optimization by varying the height of shoreline structures and adding features where needed to test four different levels of protection for the Ponding Area Wall behind Revere Beach, the Floodgates and shorefront protection along Lynn Harbor. These non-separable measures must be used in conjunction with nat-

ural storage in the estuary. The cost of the Sales Creek Tide Gate, Park Dike and Point of Pines features, which are separable, were held constant during optimization of the other features.

The effectiveness of the Regional Plan depends upon all of these individual flood damage reduction measures functioning in conjunction with each other. Table 4 includes an evaluation of the 100 year, 500 year and SPN levels of protection (at 1989 tidal conditions for design stillwater tide levels of El. 10.3, 11.2 and 12.0 feet NGVD, respectively). It shows that the Regional Plan achieves its maximum net benefits at the design SPN level which significantly reduces damages with sea level rise. A sensitivity analysis of a plan designed for a stillwater tide level of 13 feet NGVD was also conducted. This alternative would further reduce damages against sea level rise including the SPN level (1989 tide conditions) with one foot of sea level rise, as explained further in Plan Formulation Appendix A. The sensitivity analysis showed that raising project features one foot above the SPN plan would not be justified by the small amount of additional benefits that would accrue at this time. If accelerated rates of sea level rise occur, damages would increase benefits in the future and likely justify further raising the shorefront protective features.

TABLE 4
REGIONAL PLAN OPTIMIZATION
1988 Price Level

Level of Protection	First Cost ($million)	Annual Cost ($1000)	Annual Benefits ($1000)	Net Benefits ($1000)
100 year	$82	$8,320	$9,915	$1,595
500 year	$83	$8,420	$10,666	$2,246
SPN	$85	$8,640	$10,956	$2,316
SPN+1 foot	$86	$8,730	$10,979	$2,249



SUMMARY OF IMPACTS/OPTION #3 - REGIONAL FLOODGATE PLAN - This plan provides a very high degree of coastal flood protection to nearly the entire study area. The plan was optimized to provide full SPN level of protection to most areas. In Point of Pines and at the Garfield School area behind the south end of Revere Beach, 100 year protection would be provided. At the north end of Revere Beach overtopping would continue during severe events. However, partial reduction in flood damages would occur, with flood depths reduced by several feet for severe storms up to and including the SPN event. This option provides the highest net economic benefits of any plan and is designated as the National Economic Development (NED) plan. The plan would have the beneficial impact of eliminating the future need for raising or widening existing shorefront structures around the estuary for likely rates of sea level rise. Other beneficial and potentially adverse impacts include:

Environmental Impacts/Potentially Beneficial – include the protection of the estuary storage area and its associated biological, aesthetic and recreational resources through acquisition of the estuary storage area.

Environmental Impacts/Potentially Adverse – include:

- the loss of 2.0 acres of intertidal and 1.0 acre of subtidal habitat along the coastal shorefront and at the floodgate location due to construction of walls, revetments and the floodgate structure. To compensate for this loss, the plan includes the creation of 2 acres of clam flats and 1 acre of subtidal habitat. Also, through development of the mitigation site, a 0.5 acre vegetated wetland and a 0.7 acre intertidal transition area are also created.

- There was concern that the location, design, construction and operation of the floodgate structure not result in changes in the dynamics, tide levels, flushing patterns, salinity and water quality in the estuary; or have an impact on passage of fish and related resources through the floodgates. In the open position, the floodgate structure has been formulated to maintain the natural dynamics of the estuary, causing about 0.1 percent reduction in estuary flushing and less than 0.05 foot reduction in tide levels -- changes that are not significant. In the closed position, the floodgate structure is not expected to have a negative impact on water quality due to the infrequency and short duration of closure, only on rare occasions will there be a high amount of freshwater runoff coinciding with a significant storm tide, the mixing of the estuary waters that would continue to occur during storm conditions, and there are no significant source of wastewater discharges into the estuary which would cause harm to the estuary before the gates would be open again and normal tidal flushing resumed. This remains true for even a 1 foot rise in sea level (with gates closed about 1 percent of the time) when the project would likely be modified to return the number of closures back to 2 to 3 per year.

- Further, there was concern that the regional plan could induce unwanted filling of wetlands and unwise development within the study area. It was determined that acquisition of the estuary storage area, plus limited land availability (about 140 acres developable), as well as environmental protection statutes, will control future development patterns. Acquisition of the estuary storage area that is required by Option #3 would strengthen local, state and Federal efforts to minimize illegal wetland activities.

Social and Economic Impacts – For most of the region, the project would eliminate the frequent threat from coastal flooding and sea level rise, as well as the trauma that follows flooding, and the economic and aesthetic impacts of damages. Navigational interests will benefit from the improved port of refuge that would be created behind the floodgate, but wanted to make sure that the floodgate structure would not create unsafe navigation conditions. The floodgates have been formulated to meet navigation criteria (of currents no more than 3 knots/ 5 feet per second) by matching river flows at the location of the floodgate structure. The final design of the floodgates would assure safe passage for navigation. Another concern of the public and of the Metropolitan District Commission (MDC) is that the floodgate structure be aesthetically pleasing and minimize the obstruction of views. During design the floodgate structure would be evaluated for architectural treatments, and for a separate walkway spanning the navigation opening. At Point of Pines, the project structures would restrict views of Broad Sound for 15-20 homes when combined with new and raised walls.

Funding Concerns – Option #3 would protect not only the communities, but also facilities that serve regional transportation, utilities and other needs. Moreover, the environmental, social, economic and recreational benefits that would accrue from Option #3 would extend well beyond the study area. For these reasons, local decision-makers hope that the state will be receptive to requests for assistance with funding requirements at the appropriate time.

EVALUATION OF ALTERNATIVES — SELECTION OF A PLAN

This section summarizes the major concerns that were considered in evaluating whether Option 1, 2 or 3 met the Federal criteria for selection of a plan that is complete, effective, efficient and acceptable. In addition, effects of sea level rise for Options 1, 2, and 3 were considered. The findings regarding sea level rise are discussed in the Environmental Impact Statement/Environmental Impact Report that accompanies this Main Report.

OPTION 1 – LOCAL PROTECTION PLANS

SENSITIVITY OF OPTION 1 – The Local Protection Plans (LPPs) were initially formulated between 1983 (Revere Beach Backshore) and 1986 (East Saugus, Lynn and Town Line Brook). Since then several factors have required revisions in the formulation and features. These include public comments, the evaluation of historical and accelerated sea level rise, plans of others, additional technical data and more refined analysis. The project costs shown in Table 6 on Plan Comparison reflect revisions from this updated information. Contingencies have been included for unknown variables such as subsurface data, costs of materials, refinements for design stability, hydraulic freeboard, and coastal analysis of beach and dunes. If final design were accomplished for these LPP plans, several remaining unknowns could further increase the costs. For example, there is growing public concern with losses of vegetated wetlands. This may spur public opinion to require the use of walls instead of dikes to reduce this impact in many locations, assuming it is feasible to do so, even though mitigation of the impact would be less costly.

The East Saugus LPP ties into and assumes the I-95 fill directly bordering the residential area would be retained, due to the insistence by the community for keeping this barrier to reduce the noise on Route 107, and other reasons. The possibility exists in this reach that the state's land could be returned to the original property owners, with removal of this fill. If this occurs, the East Saugus LPP would need up to 40 percent additional length of work to protect the area. Such a change would result in a significant increase in cost, possibly rendering the plan infeasible.

The dikes and walls currently included for the East Saugus LPP have not been coordinated in detail with bordering property owners or Town Officials due to their opposition to the LPP and their support for Option 3, the Regional Plan. If detailed coordination for this particular LPP were accomplished, support could be contingent on revisions to the plan which could further increase the cost. This is also true for those features in the Lynn, Revere Beach Backshore and Town Line Brook LPPs which border the estuary or which are not included among features incorporated into and coordinated during development of the Regional Plan.

For Lynn's LPP, additional costs were included to reduce impacts on General Electric to help assure the overall facility's uninterrupted operation during construction affecting the numerous cooling water and other pipes along GE's shorefront. Extensive investiga-

new development or are changing their land use along the shorefront of the Saugus and Pines Rivers. These changes would affect LPP alignments. Along Lynn Harbor there are several possibilities where detailed design may show lower costs, as discussed under Option 3 sensitivity. Although contingencies have been added in the costs to account for some revisions, detailed examination of the new developments or plans could significantly increase the LPPs' costs.

The Revere Beach Backshore LPP also must assure that there would be no failure of the existing project-dependent shorefront structures, especially at the north end of the beach, otherwise the consequences could be catastrophic, since waves overtopping the shorefront could no longer flow back to the estuary. Instead, storage is required in existing ponding areas, and if storage is significantly exceeded due to seawall failure or accelerated sea level rise, the LPP areas that are bounded on all sides by walls or dikes would retain water at levels higher than without a project. This should be avoided; therefore costs have included some contingency to assure the structural stability of the shorefront. Additional features and costs could be realized if detailed design were accomplished. Due to the extensive length (almost ten miles) of shorefront affected, the dynamic ongoing land use changes, the importance of assuring no accelerated overtopping of protective features, and the potential for unacceptability of wetland impacts, the costs displayed in Table 6 for Option 1 could significantly increase if detailed design were accomplished.

EVALUATION OF OPTION 1 – This plan is partially effective in providing a high level of protection for Revere Beach Backshore and Town Line Brook against a storm similar to the Blizzard of '78, about a 100 year event. Damages are likely to be substantially reduced in protected areas of Lynn and East Saugus for a tidal storm with a 0.2 percent chance of occurrence each year - about a 500 year event. However, the plan excludes protection for Northgate, part of East Saugus, and other areas as well as several transportation arteries of regional importance. And severe damages are still likely to occur in the study area during an SPN event. Concerns exists as well with the manpower required to assure closure of up to 80 access and intake and discharge tidal gates during all coastal storms, and with the possibility of flooding caused by overtopping of the structures during the SPN event. An evaluation of the potential effectiveness of the Revere Beach Erosion Control Project to prevent damages from waves overtopping the seawall showed that only the Park Dike and sluice gate features of the Revere Beach Backshore LPP may remain feasible if further analysis was accomplished.

The plan is economically efficient in that the benefits exceed the costs of implementation; however, there is only a slight margin between the two.

Option 1 had environmental, social and economic impacts that were unacceptable to the members of the public and agency representatives who participated in the study process. Environmental concerns related to loss of nearly 30 acres of vegetated wetlands and intertidal habitat. Social-Economic concerns reflected the serious impacts that walls up to 12 feet in height and wide dikes could have on aesthetics, views and real estate values. Disruption of economic activities, particularly at the General Electric River Works, was also a concern.

POINT OF PINES SENSITIVITY ANALYSIS

The Point of Pines Sensitivity Analysis is provided to show how Option 1 would compare to the Regional Plan if the Point of Pines LPP was made an element of Option 1. It should be noted that most of the Point of Pines LPP features and costs are also found in the Regional Plan (Option 3), and are reflected in that option's cost estimate. The following summary is based on the Detailed Project Report (DPR) that was prepared for Point of Pines. It also includes updated costs and information that was developed as part of the Regional Plan investigation. There is a feature and cost included in the LPP plan which is not needed in the Regional Plan. It consists of 1,000 feet of additional wall along the Saugus River from Witherbee Avenue around the Point of Pines Yacht Club to high ground at the General Edwards Bridge abutment.

In the costs cited below, the single departure from the DPR plan (for which the design level of protection was the 1978/100 year level) is the inclusion of a revetment under the sand dunes. During the Regional Plan investigation it was determined that the sand dunes along Point of Pines shorefront would not be likely to withstand severe coastal storms, and would again be partially breached as occurred during the Blizzard of 1978. Also, based on historic sea level rise, over the life of the project the '78 event would come to occur more frequently (approximate recurrence interval of 15 to 20 years). Based on current design assumptions, of not depending solely on sand dunes for protection until a detailed dune-beach model is accomplished, the sand dunes should be augmented with a revetment to assure continued protection for this highly developed area. If either the LPP or Regional Plan options move forward, more detailed analysis would be accomplished to conclude whether revetments under properly restored dunes are needed to prevent washing away of the dunes allowing the free flowing of the ocean water into the community. In the Regional Plan the revetment not only provides local protection, but also prevents ocean waters from breaching the dunes and circumventing the floodgate and causing flood damages in areas behind the floodgate. In summary, in order to assure the high level of protection for Point of Pines and realize the benefits previously claimed for the LPP plan, and to make the LPP comparable to the Regional Plan, revetments have been included in the revised LPP. The costs for the revetment are reflected in the costs shown in Table 5.

TABLE 5
SENSITIVITY ANALYSIS - POINT OF PINES LPP

	POINT OF PINES LPP	OPTION 1 PLUS POINT OF PINES
Buildings Protected	370 @ 100 year level	4,320
Reduction of Inundation Damages	90 %	82 %
Length of Dikes, Walls & Revetments	1 mile	9.8 miles
Project First Cost	$8.7 million	$71.1 million
Average Annual Benefits	$1.90 million	$9.06 million
Average Annual Costs	$0.92 million	$6.90 million
Benefit-to-Cost Ratio	2.1	1.3
Average Annual Net Benefits	$0.98 million	$2.16 million
Intertidal Habitat Lost	1.4 acres	16 acres
Vegetated Wetland Lost	0	17.7 acres

OPTION 2 – NON-STRUCTURAL PLAN

SENSITIVITY OF OPTION 2 – The Revere Beach Backshore area was evaluated based on a building by building analysis of floodproofing or raising costs and individual benefits for buildings. In Saugus and Lynn, home-raising costs were developed on a building by building basis, however, benefits were based on values determined in Revere for similar types of homes. Since the average depth of flooding in Revere is deeper than the other communities, the benefits and number of buildings for which raising is feasible are probably somewhat overstated in these two communities. The number of commercial buildings feasible for floodproofing in Lynn and Saugus are also based on similar results of the more detailed studies of Revere. Therefore, although Option 2 offers a fairly accurate assessment of the costs, benefits and numbers of buildings in Revere that are potentially feasible for non-structural measures, the evaluations for Lynn and Saugus are somewhat overstated in terms of benefits and numbers of potentially feasible buildings.

EVALUATION OF OPTION 2 – The plan does not provide a high level of flood protection to the study area. Investigations indicate that only about 7 percent of the buildings in the study area would be economically feasible and could potentially be raised or floodproofed. A plan to floodproof all buildings in the floodplain was not economically justified and would cost twice as much as Options 1 and 3.

The non-structural plan is ineffective in accomplishing the planning objective because, while it provides protection to the buildings which could feasibly be raised or floodproofed, these represent only a small proportion of the buildings in the study area. There are also significant problems in developing an effective flood warning and evacuation plan. Only a foot or two difference in tide levels lies between a minor storm and one that poses great threat to human life and/or causes severe damages. The high degree of unpredictability of coastal storm characteristics could result in warnings which turn out to be false alarms and which could diminish public response when most needed. Public safety can not be assured. This option does not reduce the actual geographic extent of potential flooding. The effectiveness of Option #2 is also affected by the large number of water and sewer valve and pipe closures which would need to occur to prevent flood damages. The plan is efficient in that for buildings that are candidates for floodproofing measures, the benefits exceed the cost of protection. The plan was not acceptable to any of the communities.

OPTION 3 – REGIONAL FLOODGATE PLAN

SENSITIVITY OF OPTION 3 – Extensive investigations have been carried out for the Regional Plan to eliminate as many unknowns as reasonably feasible which could significantly increase project costs. Generally all features have been examined to assure the cost would not significantly increase during design. The most significant costs involved are in the design of the floodgate structure which accounts for about 65 percent of the Regional Plan costs. The cost estimates for the gates are quotes from distributors or based on recent estimates of similar gates. Costs of other materials are either from quotes by suppliers or from similar construction. Although detailed design has not been accomplished on the concrete structures, costs of similar designs from other projects were used.

Adding or deleting flushing gates would result in a significant change in costs. The ten flushing gates in the current design represent the maximum number likely needed to achieve safe navigation flows (not to exceed 3 knots) on over 95 percent of tides for the highest local gate flow velocities through the gates considered. If local velocities are found to be less than the maximum used, up to two gates might be eliminated at a savings of almost $6 million and the intertidal area dredged may be reduced. If two gates were eliminated there would be no measurable change to tide levels in the estuary. There would also be no significant change to flushing volumes. Even under maximum astronomical tide conditions (less than 0.01 percent of tides) volumes would decrease about 1 percent. The navigation gate currently matches the existing opening of the General Edwards Bridge. Modeling would help determine whether a wider opening may be needed to provide safer passage. A 20 foot wider gate, for example, would likely increase costs less than 20 percent, a number that would be well within the average 32% contingency for the gate. An increase in the navigation gate flow area would also decrease the width of the flow area needed for the flushing gates.

Other features which have assumed near worst case conditions because of limited data on foundations conditions or design information are: the design of bearing piles and a 12 foot wide road surface access along the floodgates, which affects the width of the tainter gate and cofferdam structure. Additional savings may result from the re-design of the revetments at Point of Pines due to both lower wave heights expected in the area than wave heights used for the current analysis, and the potential stability of a dune/beach system in lieu of revetments.

Along Lynn Harbor, real estate and construction costs could be lowered up to $1 million each for: possibly closing off and filling in the Gas Wharf Inlet, and deleting a gravity wall at the north end of the project alignment at the proposed Harbor Side Landing Project where the developer may raise the existing ground above the needed elevation. An analysis of the Revere Beach erosion control project to reduce overtopping and flood damage showed that, even if it reduced flooding up to a 20 year event, all features remain economically justified. The regional project could be modified for sea level rise at a cost of between $15 and $20million per foot of sea level rise to raise the level of protection and limit the number of gate closures per year. The project is also economically justified over a 35 year life when a one foot rise would occur under the NRC high rate-- if policy decisions at that time dictate retreating from the floodplain. See "Sensitivity and Modifications for Sea Level Rise" section.

EVALUATION OF OPTION 3 – Of the three plans investigated, this plan is the most effective since it reduces damages for all of the 5,000 residences and buildings in the study area. The plan effectively protects nearly the entire study area against catastrophic flooding from an SPN coastal storm accompanied by sea level rise. The plan produces the highest net economic benefits of any plan and is thus designated the National Economic Development (NED) plan.

The Regional Saugus River Floodgate Plan is the most acceptable of any plan since it is supported by Steering Committee representatives from the four communities in which the study area lies, and has been endorsed in letters from the mayors of Revere, Malden and Lynn and Board of Selectmen and Town Manager from the town of Saugus. Letters supporting regional flood protection have been received from both U.S. Congressmen, the Metropolitan District Commission, homeowners associations, local and regional organizations and others.

State legislators have also expressed support for regional flood protection. With the help of the Citizens Steering Committees, the Technical Group (which includes most relevant Federal, state and local agencies and environmental and other interest groups) and the general public the plan has been formulated to provide a high level of flood protection to the entire region while meeting the state and local goals of minimizing unacceptable impacts on the estuary or on navigation. **Because it meets Federal criteria (i.e., is the NED plan), is consistent with local and state goals, and enjoys wide support, Option 3, the Regional Floodgate Plan is the Selected Plan.**

TABLE 6
PLAN COMPARISON

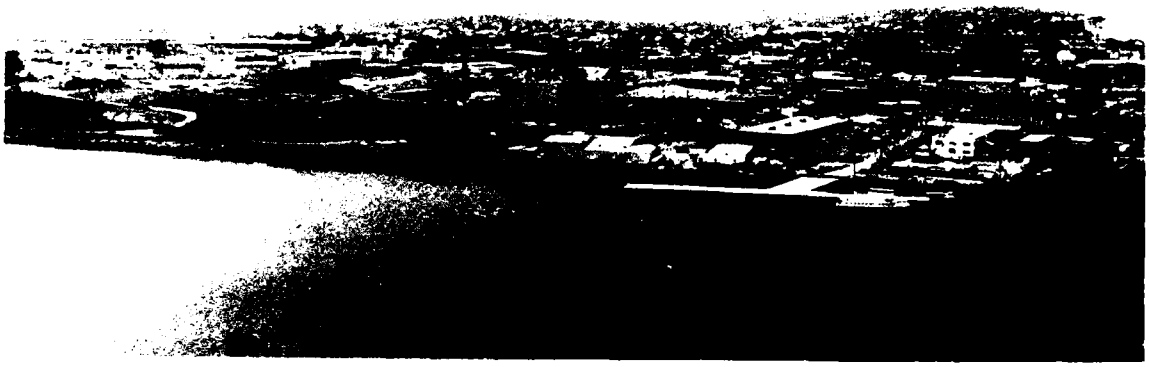
	Option 1 4 LPP's**	Option 2 Nonstructural	Option 3 Regional Plan
Buildings Protected	3,950	240	5,000
Percent Protected	80%	7%	100%
Reduction of Inundation Damages	65 %	17 %	88 %
Length of New Structures	8.8 Miles	n/a	3.5 miles
Level of Coastal Flood Protection (at1989 tidal conditions):			
City of Lynn	500 Yr.	0-100 Yr.	SPN
Revere Beach Backshore	SPN&100 Yr.	0-100 Yr.	SPN
Crescent Beach	100 Yr.	0-100 Yr.	100 Yr.
East Saugus	500 Yr.	0-100 Yr.	SPN
Town Line Bk.	100 Yr.	n/a	SPN
Point of Pines	--**	0-100 Yr.	100 Yr.
Northgate & Outer Oak Is.	no	0-100 Yr.	SPN
Rt. 107, B&M R.R.	no	no	SPN
Upper Saugus River	no	no	SPN
Environmental Considerations			
• Estuary Protection Feature	no	no	yes
• Vegetated Wetlands Lost (to be mitigated)	17.7 acres	none	none
• Intertidal and/or Subtidal Habitat Lost (to be mitigated)	14.6 acres	none	3 acres
• Effect on Water Quality	minor	none	minor
• Loss of Views & Aesthetic Impact	high throughout area	negligible	15-20 homes at Pt. of Pines
Plan Economics (1988 Price Level)			
First Cost (Millions)	$ 62.4	$ 7.4	$ 85.1
Average Annual Benefits (Millions)	$7.16	$1.4	$10.96
Aver. Ann. Costs (Millions)	$ 5.98	$ 0.7	$ 8.64
Aver. Ann. Net Benefits (Millions)	$1.18	$0.7	$2.32
Benefit-to Cost Ratio	1.2	2.0	1.3
Evaluation Criteria			
Complete	Yes	Yes	Yes
Effective	Partial	No	Highest
Efficient	Yes	Yes	Yes
Acceptability to Sponsor	Minimal	Minimal	High

** The four LPPs include Lynn, Revere Beach Backshore, East Saugus and Town Line Brook. Point of Pines was covered under a separate Section 205 study which recommended 100-year level of protection.

In East Saugus 600 Buildings Are Vulnerable to Flooding from the Saugus River (on the Right) and the Pines River Estuary (on the Left)

THESE REGIONALLY IMPORTANT FACILITIES WOULD ALL BE PROTECTED BY THE SELECTED PLAN

In 1978 Waves Overtopped the Lynn Bulkhead and Flowed into the Business District



Lynn's New EDIC Pier Serves Many Businesses and Fishermen. Gloucester Fish Corp. and Regional WastewaterTreatment Facility are Located in the Flood Plain

Mass. Electric, Boston Gas and Phillips Lighting (Norelco) are Major North Shore Businesses

DESCRIPTION OF SELECTED PLAN

REGIONAL SAUGUS RIVER FLOODGATE PLAN

NON-STRUCTURAL AND STRUCTURAL FEATURES

This section describes in detail the non-structural and structural features of the Regional Saugus River Floodgate Plan, and outlines the design, construction and operation and maintenance requirements associated with each feature. All references to cited **levels of protection or storm tides for 100 year, 500 year or SPN events** reflect 1989 tidal conditions.

NON-STRUCTURAL FEATURES - Non-structural features of the NED plan will play an important role in reducing damages from major coastal storms in the study area, through the **protection of natural storage in the estuary, maintenance of existing seawalls, beaches and tide gates**, and through the development of a **comprehensive flood preparedness plan.** These features are briefly described below, with further details given under the subtopic of Operations and Maintenance which appears later in this section.

Protection Of Natural Storage In The Estuary -- The selected plan requires protection of 5,400 acre-feet of storage capacity between +2 and +8 feet NGVD in the estuary. The storage is required to assure that an adequate area exists behind the tidal floodgates for storage of interior runoff and wind-driven ocean waters which overtop shoreline protective structures. The total storage capacity needed is based on the design condition of an SPN tidal storm coincident with 100 year interior runoff. These combined events would require nearly all of the available storage in the 1,650 acre estuary. Although the occurrence of this combination is extremely rare at this time, sea level rise would increase the number of closures and the importance of protecting the estuary storage area. The only viable option to protecting the storage would be an extremely high expense somewhere in the future for major interior drainage improvements, including pumps. Therefore,two methods to protect the storage area were evaluated including acquisition or enforcement of existing laws and regulations to protect wetlands. Following review of existing laws and regulations by the Corps' Washington Level Review Center, legal counsel and real estate office, it was determined that the only sure and sound way to protect and control the storage area was through a real estate interest. The reasons cited were that regulatory measures were ever changing and risky to depend on over the next 100 years. Also, the laws and regulations all allow variances which could reduce the storage capacity. Protection of the storage area is necessary and fundamental to the flood control function provided by the Regional Plan. Acquisition of the 1650-acre estuary storage area in fee or easement which includes both private and publicly owned lands is therefore included as a project feature. Operation and maintenence costs include an environmental manager and facility costs to oversee protection of the estuary storage area. The limits of the storage area are shown on plates in Appendix D.

The local communities would be required, to the extent legally empowered, to implement floodplain management programs to ensure wise use of the floodplains in, as well as adjacent to, the project area. To effectively operate the project and protect the required storage area, the selected plan calls for acquisition of the estuary storage area in fee or easement up to elevation 7 feet NGVD.

Maintaining Existing Beaches, Seawalls, Tide Gates And Ponding Area – As part of the overall coastal flood protection effort, local assurances of this project must require that existing project-dependent non-Federally constructed seawalls and associated protective work along the shorefront in Revere, Lynn and Saugus are maintained.

The design of the selected plan assumes continued long term maintenance of the authorized Revere Beach Project and the Point of Pines beach. The Revere Beach Project would restore Revere Beach and cause waves associated with smaller coastal storms to make their landfall and break more than 100 feet from existing seawalls. The selected plan assumes that the beach could erode to pre-Revere Beach authorized project conditions during severe coastal storms. The existing Point of Pines beach breaks the waves fronting the dunes and is important for survival of the dunes. The existing seawalls along Revere Beach must be maintained to continue to provide reduction in tidal overtopping.

In addition to, but separate from the Saugus and Pines River estuary, there are localized low areas in Revere and Saugus where local drainage is presently dependent on localized ponds and gated drains to the estuary. It is noted that the Regional Plan cannot be operated to provide continuous gravity drainage for these low areas and some residual local drainage problems, in the absence of tidal flooding, may persist. Local assurances will need to stipulate that all gated structures to the estuary be maintained in good operating condition, and that any and all proposed new developments be reviewed with regard to their potential impact on existing drainage problems or needs.

FEMA Flood Insurance Program –The selected plan also calls for any new development around this tidal estuary to comply with established FEMA flood insurance and floodplain management programs. If after completion of the Regional Floodgate Project, FEMA considers revising the base flood level for flood insurance purposes within the protected area, *this study should be done in coordination with the New England Division, Corps of Engineers.* This provision is necessary to ensure there will be no adverse impacts on the project's flood control operations and that proper flood levels are identified for zoning purposes. This study should also consider the impacts of sea level rise.

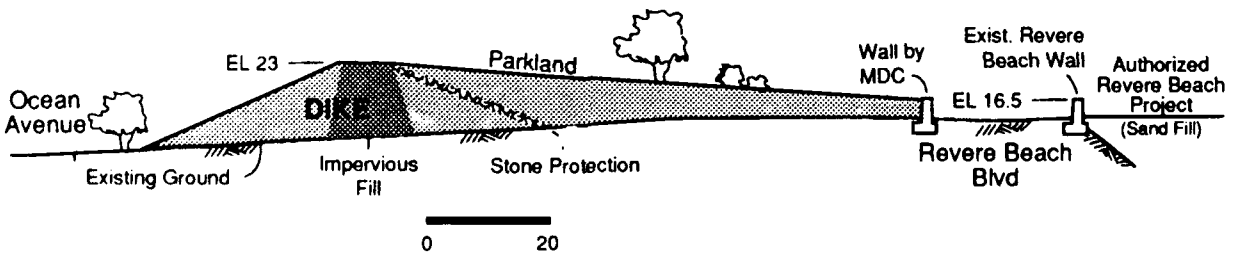
Development Of A Flood Preparedness Plan – The selected plan also requires the development of a comprehensive Flood Preparedness Plan by the project sponsor. The Corps would prepare an Operation and Maintenance Manual describing how and under what conditions the project would be operated and maintained. This information would also assist in the development of the Flood Preparedness Plan.

STRUCTURAL FEATURES – The selected plan includes the following structural features. For any features that would affect the environment, the impacts are noted. In the study area, developing coastal storm conditions can require extremely rapid local action. For this reason, all proposed closures would be further evaluated during design to determine the most efficient type of closure in achieving the needed levels of protection.

Sales Creek Tide Gate – A tide gate is required on the Sales Creek culvert passing under Revere Beach Parkway. The tide gate or sluice gate would be closed only when tide waters begin to back up Sales Creek threatening to flood homes in the Garfield School area. This area would be protected to the 1978 -100 year level. Sales Creek can be expected to back up when tide levels exceed EL. 9, about a 10 year event. Tides overtop Bennington Street from Belle Isle Inlet into Sales Creek, as occurred in January 1987.

Park Dike - A dike would be constructed behind the Revere Beach seawall on the MDC land located between the Boulevard and Ocean Avenue running 3,420 feet from Beach Street to the Revere Street intersection. (See Plate 5). The Park Dike would consist of an impervious earth core to reduce seepage through the dike, and a stone protection layer which would reduce wave erosion during major storms. The highest section of the dike would be EL. 23. This height includes three feet of freeboard above the water ponding level (EL. 20) behind the seawall caused by wave overtopping during the Standard Project Northeaster. To contain the water, a ramp or raised road surface would be needed at the south end of the dike. The ramp would rise to EL. 20 with provisions for a closure in the three foot freeboard range. It would start immediately north of the Beach Street Pavilion and be wide enough for the MDC's proposed boardwalk along the seawall. Emergency access over the Park Dike would be provided immediately north of the MDC Police Station. The Park Dike would tie into the south side of the Police Station with a concrete floodwall. North of the Police Station the ramp and dike would likewise join together using floodwalls. A temporary closure would be needed across the MBTA tracks under Beach Street for events exceeding the 1978 (100 year level) to prevent floodwaters in the Garfield School area from flooding behind the Park Dike.

The Park Dike would prevent water from flowing back onto Ocean Avenue, Wonderland Park, nearby residential areas, the Garfield School area, or into the County Ditch and Kelley's Meadow, as well as from overtopping the B&M tracks and flooding the Towle and Revere High School areas or flowing into the estuary. Plate 5 shows the north end of the dike at Revere Street and the south end at Beach Street where beyond these streets, the existing beaches and seawalls prevent SPN overtopping.



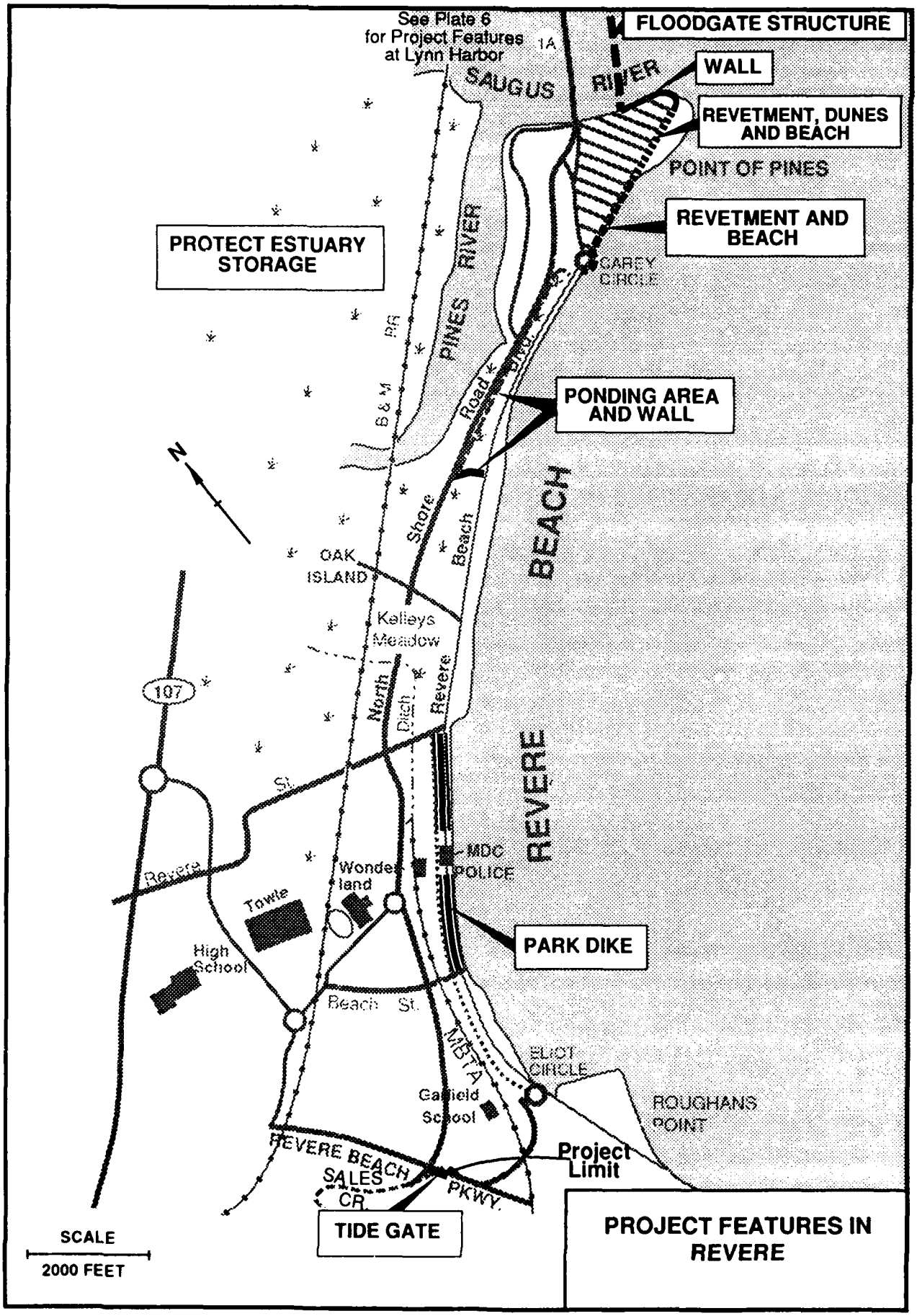
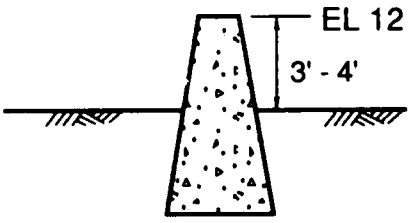

See Plate 6
for Project Features
at Lynn Harbor
1A
FLOODGATE STRUCTURE
WALL
SAUGUS RIVER
REVETMENT, DUNES AND BEACH
POINT OF PINES
REVETMENT AND BEACH
PROTECT ESTUARY STORAGE
CAREY CIRCLE
PINES RIVER
B & M RR
Road
PONDING AREA AND WALL
N
Shore
Beach
BEACH
OAK ISLAND
Kelleys Meadow
107
North
Dich
Revere
REVERE
St.
Revere
MDC POLICE
Wonderland
Towle
High School
PARK DIKE
Beach St.
MBTA
ELIOT CIRCLE
Garfield School
ROUGHANS POINT
REVERE BEACH PKWY.
Project Limit
SALES CR.
TIDE GATE
SCALE
2000 FEET
PROJECT FEATURES IN REVERE

Plate 5

Environmental Effects of the Park Dike – The Park Dike would largely improve the vacant land that now lies between Ocean Avenue and the Boulevard. Constructing the dike as proposed is in conformance with the MDC's Master Plan for the Reservation. The land was previously acquired by the MDC for use as park land. The sloping ground along the dike would create a free and accessible area for passive recreation with a pleasant easterly exposure. Extensive use of the parkland would occur throughout the year. The only known impact is a partial loss of ocean view from the lobbies of the high rise condominiums that border Ocean Avenue. A dike for flood control only, if built adjacent to the Boulevard, would be smaller; however, the larger dike and parkland embankment, at an additional cost of $1.2 million, is justified on recreational benefits.

Ponding Area And Wall - Protection of an existing 20 acre ponding area and construction of a wall are needed behind homes along the north end of Revere Beach. The potential overtopping of the Revere Beach wall, following the restoration of Revere Beach, will be reevaluated in final design. For this report we have assumed that the beach condition would erode to pre-Revere Beach authorized project conditions during severe coastal storm events. Under this worst case condition, wave action accompanying severe storms would overtop the seawall at the north end of the beach. Waters would flow down the embankment behind the homes along the Boulevard. The water would be stored in the existing ponding area along North Shore Road, Route 1A. For tide levels exceeding the ponding area's capacity, water would flow over North Shore Road and into the estuary where levels are controlled by the Floodgates. The damages from overtopping alone were insufficient to justify raising of the Revere Beach seawall or other measures to further reduce overtopping. Damages would be lowered in this area by a 1 to 2 foot reduction in flood levels attributable to the floodgates controlling water levels in the estuary. Protection of the storage capacity in the ponding area is required. Most of the land is in the Eastern Mass. Electric Company Right-of-Way in this wetland. A 500 foot long wall at the south end of the ponding area would prevent water from flowing south toward Oak Island Street. The 3-4 foot high gravity wall would be located along the top of the old narrow gage railroad embankment running between Rt. 1A and the Seaview Condos on the Boulevard. The wall would connect to Seaview's existing retaining wall along their driveway, the retaining wall raised about 2 feet, and end at the Boulevard sidewalk.

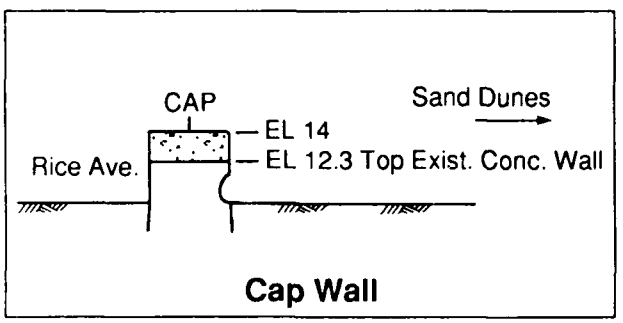
During severe storms and overtopping of the Revere Beach seawall, a closure of the Boulevard connecting to the Ponding Area Wall may be required. This would prevent waters from flowing down the Boulevard and flooding homes in the area of Oak Island Street. Also closures may be required at the north end of the Boulevard connecting to the Carey Circle seawall to contain and direct waters toward the ponding area and estuary. Depending on the potential rate of overtopping, determined during future design studies with Revere Beach restored, ramps or a gradual rise in the Boulevard surface at each end should be considered to reduce the need for the closures and provide emergency access.

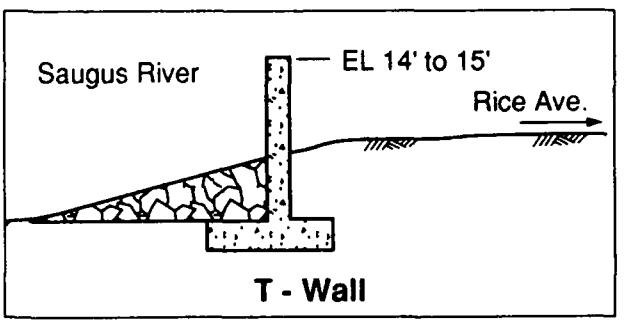


Ponding Area Wall

Walls, Revetments, Dunes And Beach/Point Of Pines – Reducing overtopping along Point of Pines shorefront from Carey Circle to the floodgate structure requires 4,290 feet of improvements. The height of new structures varies depending on the height of wave runup and wave overtopping which needs to be prevented. At the north end of Revere Beach waves overtop the Carey Circle seawall and flow down the Lynnway contributing to flooding in Point of Pines and other areas behind Revere Beach. To reduce the overtopping, an armor stone revetment would be constructed sloping toward the beach to break the waves. The 1,550 foot long revetment would also help support the 80 year old seawall. The revetment would continue along Point of Pines shorefront with a top elevation of 16.0 feet NGVD — nearly the same height as existing riprap and precast walls; however its' slope is designed to reduce runup and overtopping. Starting at Chamberlain Avenue and fronting the existing solid cast-in-place wall (top elevation of 15.4) the revetment would continue for 450 feet with a top elevation of 14.0.

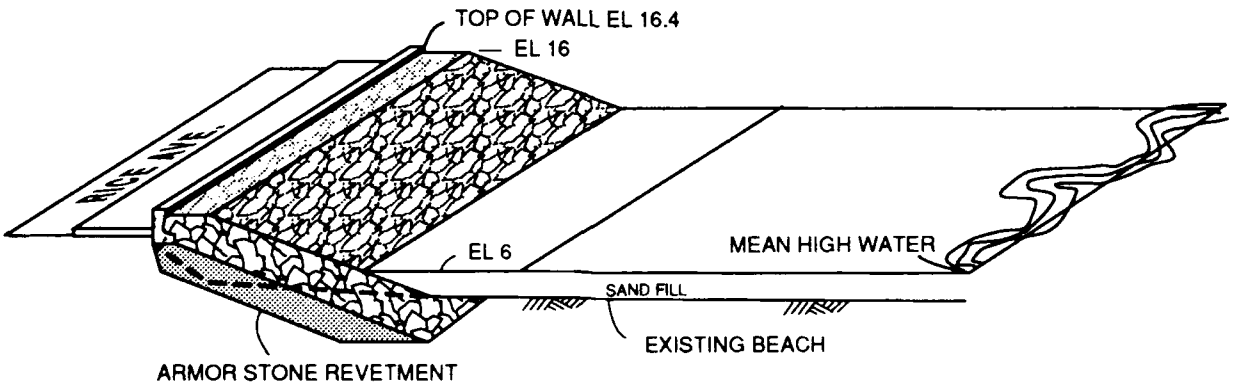
The existing sand dunes along the north half of the shorefront vary in their width and top elevation. The armor stone revetment would continue for 1,600 feet with a top elevation of 14.0 and would be constructed under the dunes. The dunes would be replaced and restored with dune grass and shrubs and protected from erosion. A curb along the land side of Rice Avenue, replacement of the existing fence, and sand fences at the top of the dunes would help prevent the dunes from being damaged by pedestrians or automobiles. Protection of the dunes and beach are important to reduce wave heights and overtopping of the revetments. The revetment would tie into the existing cast-in-place wall at Rice Avenue fronting Wadsworth Avenue. The wall would be raised 1.7 feet to elevation 14.0 for a distance of 200 feet. The existing precast block wall (top EL. 12.3 to 12.9) which runs along Rice Avenue paralleling the Saugus River is not stable. It would be replaced for 940 feet with a cast-in-place T-Wall for greater stability and protection. The top elevation would transition from elevation 14 to 15 and meet the floodgate structure at the end of Bateman Avenue. The beach fronting the revetment and dunes would be built up to about elevation 6 feet NGVD for 6 acres of new beach using surplus sand excavated dur-



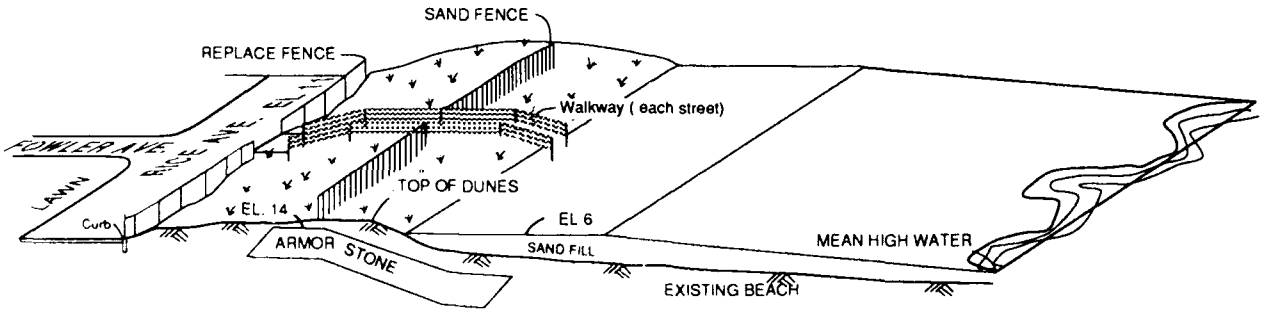


ing construction of revetments under the dunes. Use of the sand for this purpose would more than replace the beach displaced (0.2 acres) by construction of the revetment built south of the dunes as well as to the north by the floodgate dike. Placement on the beach would also save the cost of hauling the sand away. The additional natural sand in the vicinity of the dunes would help to assure the dunes' longevity. Preservation and protection of the dunes and beach are important for the project and to the residents of Point of Pines and a goal of the Point of Pines Beach and Conservation Association. Existing shoreline access along the shorefront will be replaced. To protect the grasses and stability of the dunes, new crossovers would be provided at the end of the streets. A new vehicular gate would be provided for access to the beach near Witherbee Avenue to permit maintenance.

A New Revetment at Point of Pines Would Reduce Overtopping Which Floods the Neighborhood and Flows into the Saugus River.



Restored Sand Dunes Over a Revetment Would Reduce Flooding at Point of Pines



Environmental Effects at Point of Pines – The revetments and dunes along the shorefront would be constructed to about the same height as existing shorefront structures. Along 1140 feet of the Saugus River the wall level would be raised about one to three feet. This would affect views from a few houses. The revetments would cause the loss of about 0.7 acres of intertidal habitat which would be mitigated by creating clam flats. Construction would take about ten months to complete. Every effort would be made to avoid impacts on the community by using access from Carey Circle along the beach, and temporary two-way haul along the Rice Avenue stretch of the Saugus River. The Corps would minimize construction interference with beach use periods as much as possible, as concern for public safety is paramount.

Tidal Floodgates – The floodgate structure would span the mouth of the Saugus River from the Point of Pines seawall opposite Bateman Avenue to the corner of the Lynn bulkhead adjacent to the existing MDC public fishing pier. The structure would prevent tidal surges from flowing up the river and flooding the communities of Lynn, Malden, Revere and Saugus. The eleven gates would remain open except when coastal storms threaten to cause damages. The gates would be closed initially about 2 to 3 times a year for generally one to two hours during the peak of the tides, then opened as the tides recede to the level of the estuary. With the historical rate of sea level rise, one foot in 100 years, the gates would likely be closed 40 times a year, for 2-3 hours each time, and remain open about 99 percent of the time. The floodgate structure would have a total length of 1,290 feet. It would include a navigation "miter" gate, ten flushing "tainter" gates, and two concrete gravity wall sections (See Figure 6).

Miter Gate – The navigation "miter" gate would be centered on the existing navigation channel and the Federal navigation channel that is being considered for the Saugus River. The miter gate includes two hinged gates, like hinged doors, which close by a hydraulic control. The doors close on a miter or bevel, so that the force of the water from the ocean side serves to force the two gate leaves tighter together. The bottom or sill of the 100 foot wide navigation gate rests near the bottom of the river at EL.-18. The top of the gate is at the design top elevation of the floodgates, EL. 15, which would prevent tides from the Standard Project Northeaster from entering the estuary. The gate would be a total of 33 feet high and when normally open allow unlimited clearance for all vessels. The 100 foot width of the opening is the same as the existing width of the navigation opening under the General Edwards Bridge. Wider openings in the gates would be considered in final design. The estuary side of the gate sill would be inclined to facilitate lobster passage. On the ocean side, the vertical edge of the 1.5 foot high sill provides a positive water tight seal for the gates. In final design, an inclined edge on the ocean side would be evaluated for easier lobster passage.

The bottom elevation of the sill would be about 5.5 feet deeper than the proposed Federal navigation channel for the Saugus River, and would rest at the same elevation as the existing river bottom, thus there should be no problem of interference with vessels. The gates were needed at this low an elevation to assure no significant change in the draining of the estuary at low tide while at the same time providing needed flow area. As with the other gates, closure could be made in less than 30 minutes to seal off storm tides. The housing and bottom slab of the gates would be constructed of reinforced concrete. Concrete reinforced piles would be driven into the riverbottom to bedrock or refusal at about EL.-95 to support the gates. All concrete structures making up the floodgate structure sit on bearing piles.

Flushing "Tainter" Gates – In addition to the navigation gate, ten (10) flushing "tainter" gates each with a 50 foot wide and fourteen foot high opening would be needed to maintain safe velocities for navigation and the natural tide levels and flushing in the estuary. The tainter gates would continually be in a raised (open) position and during coastal storms could be lowered to a closed position. The bottom of the gates would be located at the floor of the river at EL.-14 with a top elevation 0.0, so they are totally submerged during mid tide or peak flows to make maximum use of their openings.

Nine flushing gates would be located on the Lynn side of the navigation gate and one on the Revere side. This configuration is necessary to reduce the amount of dredging required to align the river bottom with the bottom of the gates. The configuration also helps reduce the loss of beach at Point of Pines.

The concrete gated structure for the navigation and flushing gates would be 730 feet long with 8,800 square feet of gated openings at El. 0.0 NGVD, mid-tide. A 30 foot wide stone apron to prevent scour at the edge of the gate slab would run the full length of the gates on both sides of the structure. The apron would be at the surface of the floor of the river and level with the bottom of the gate opening. The design top elevation of the concrete structure is 15.0 feet NGVD for preventing SPN tides from overtopping the floodgates. Running along the top of the tainter gates is a 12 foot wide roadway for access to the mechanical control units of the gates and control rooms for the operators at the navigation gate. All gates would be electrically operated and have a backup power generator if local electricity should fail. The operating control rooms would be self contained for operators to weather a storm. In addition to radios, telephones, weather and tide gages, the floodgate would be equipped with a security system and cameras. Security fences would prevent unauthorized access to the gates and control rooms. Police surveillance would also be required. Other measures for personnel safety will also be designed into the project.

The navigation and flushing gate openings are designed to match as closely as possible the existing flow patterns in the river. This was accomplished by making the total openings nearly equal to the minimum flow area near the mouth of the river. Peak flow occurs at mid tide about EL. 0 when the flow area at the gate location is 8,700 square feet. By comparison, the minimum flow area at the mouth of the river is 8,200 square feet up to El. 0. The floodgates would therefore nearly match the flow characteristics in the mouth of the river and would provide sufficient openings to maintain a flow rate not to exceed about 3 knots or 5.1 feet per second which is considered acceptable for vessels in the estuary. This rate would rarely be exceeded even for most likely future conditions with higher flows caused by sea level rise .

Environmental Effects of Gates – Environmental effects of the gates in the open position should be minor on passage of fish and other organisms, since there would be no significant change in the velocities and all gated openings would have rounded edges to reduce eddys and shear forces. The gates would allow nearly the same volume of water (reduced less than 0.1percent) to flush in and out of the estuary without measurably changing tide levels (reduced less than 0.05 feet). Thus there should be no significant impacts on resources of the estuary, including wetlands, and no measurable change in the water quality of the estuary during the large percent of time 99.9 percent the gates are open.

Gate closures would cause no significant change in the estuary. The gates would only be closed if tides are projected to reach or exceed EL. 8 ft. NGVD, the start of flood damages around the estuary. Closure would generally be made if tides are expected to reach or exceed EL. 8.0 ft. NGVD. Gates would generally be closed at EL. 7.0 ft. in order to provide needed flood water storage. With typical closure at El. 7.0 ft. (except in rare circumstances, when closure could be at a lower elevation) gate operations would still allow complete inundation of the vegetated wetlands. On several occasions, Corps biologists field checked the wetlands when tides approached EL. 7.0, and found complete inundation of

Figure 5

Floodgate Structure/ Navigation And Flushing Gates

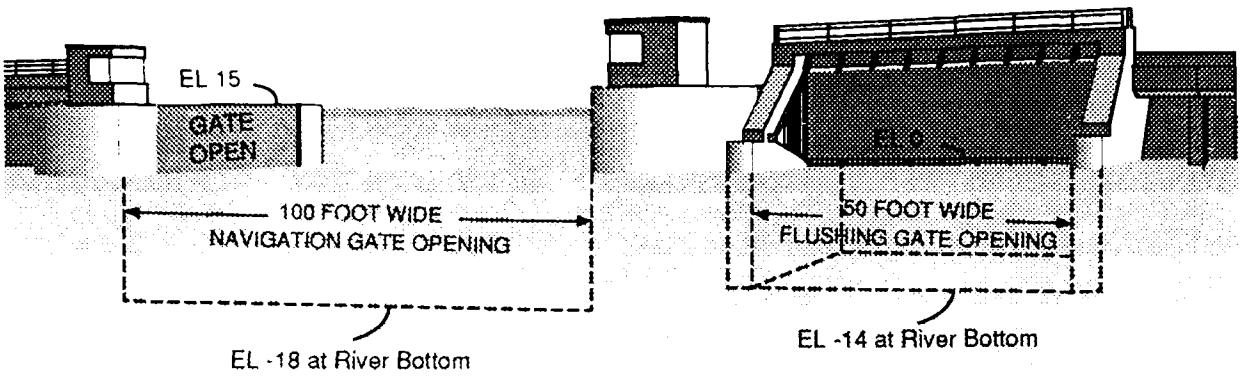
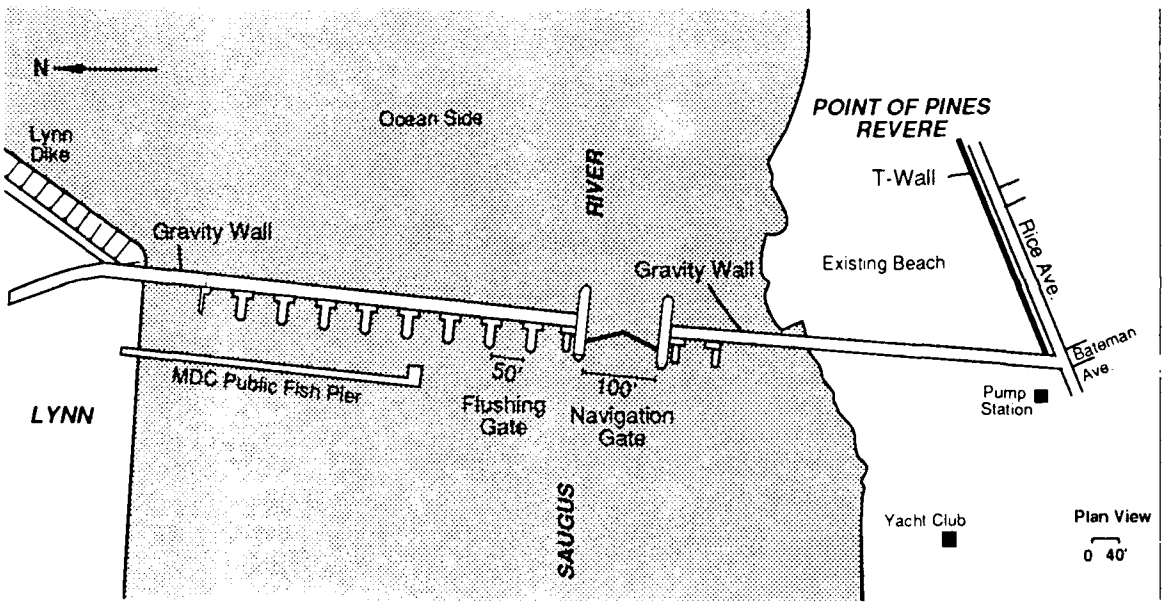
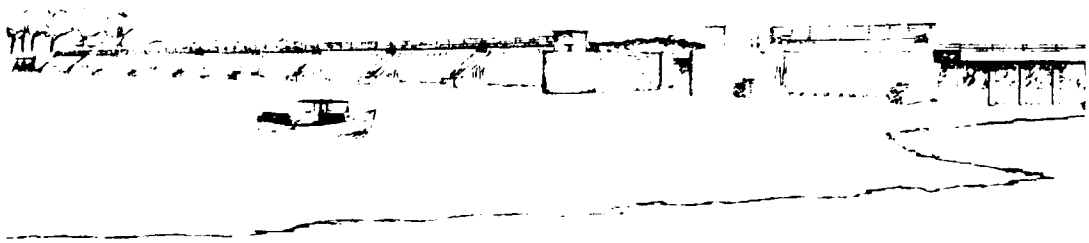


Figure 6

Floodgate Structure/ Plan View





View of Floodgate Structure From Point of Pines Yacht Club

wetlands at that elevation. Water quality would not be significantly impacted because gate closures will happen infrequently and be of short duration. Salinity levels would rarely be affected during closure because of the infrequent occurrence of high freshwater runoff coincident with coastal storms approaching a 100-year tide. Moreover, the momentum of the tides and wind-driven waves would continue to mix water in the estuary during closure. Water quality should be improved with protection of the estuary storage area by elimination of flooding around the estuary which would otherwise carry undesirable elements from buildings, warehouses, gas and oil lines, debris, and other pollutant sources back into the estuary. If accelerated rates of sea level rise of 1.6 to 4.2 feet in 100 years should occur, the project would need to be evaluated to determine if project features should be raised or modified to assure a high level of protection and no significant impact on the estuary or navigation. For example, raising the start of damage around the estuary and the addition of low level walls and dikes to maintain estuary storage capacity and infrequent gate closures, would likely be preferred over increasing gate closures and construction of a Saugus River pump station and navigation locks. The effects of a 1.6 foot rise would not be felt for 60-100 years.

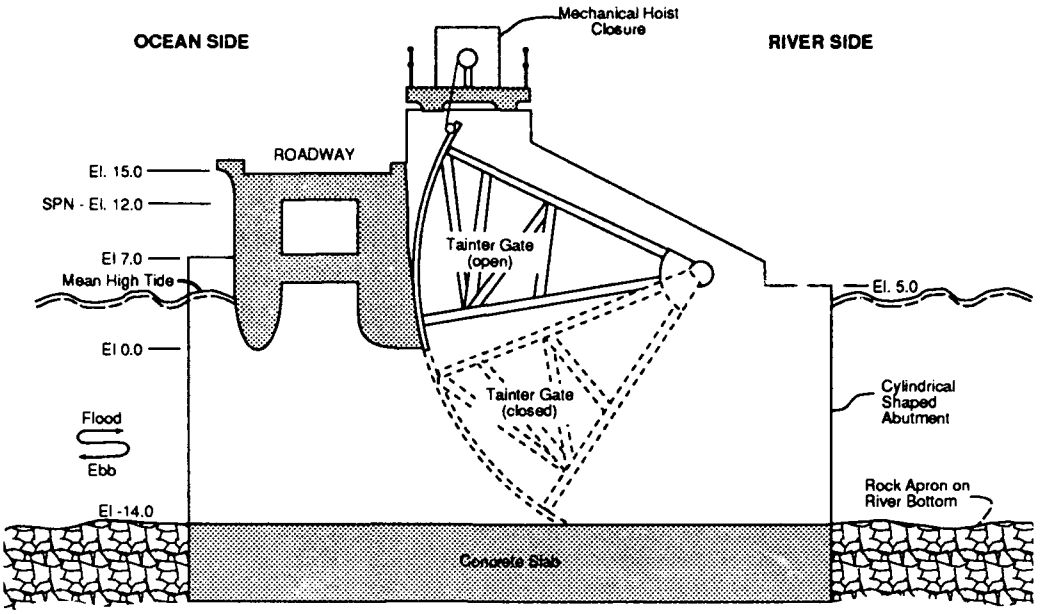
- Gravity Walls – Connected to each end of the floodgate structure would be a concrete gravity wall with access ramps. On the Lynn side a 140-foot long wall would end beyond the bulkhead. On the Revere side, a 420-foot long wall would end near Bateman Avenue. The concrete gravity walls would sit on piles and include a 12 foot wide roadway with a design top at EL. 15.0. (See Figure 6).

Architectural treatment of the floodgate structure, shrubbery at the approaches, and a walkway spanning the navigational opening, all concerns of the MDC, would be addressed during design.

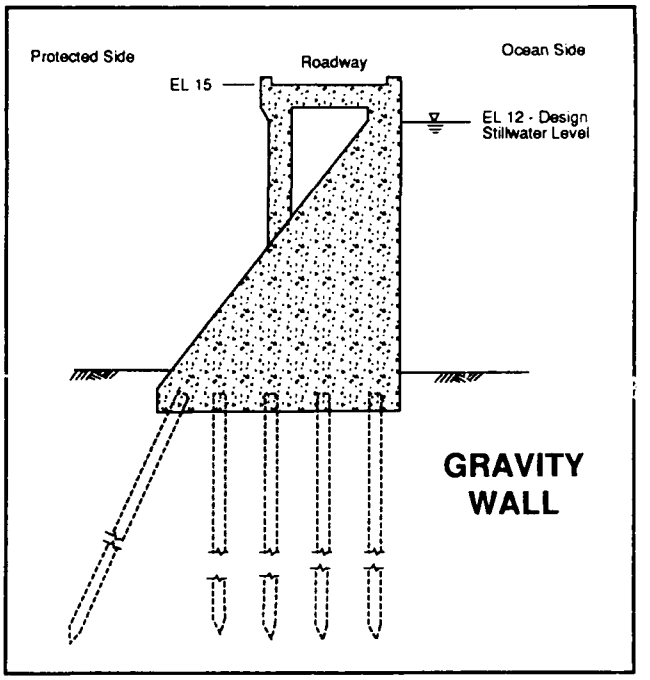
The beach cross over of the floodgate structure would include the ramp for reaching the top of the gravity wall and a walkway down the opposite side of the wall to the beach.

- MDC Public Fishing Pier – The existing MDC Public Fishing Pier, where the floodgate ties into the Lynn bulkhead, may need to be removed. Final design will determine whether the pier interferes with construction of or currents through the gates.

- Cofferdams – The navigation gate would be constructed within a circular cofferdam braced with ring beams. The tainter gates and gravity walls would be constructed within a narrow rectangular cofferdam braced with steel beams. Construction sequence and duration is explained later.

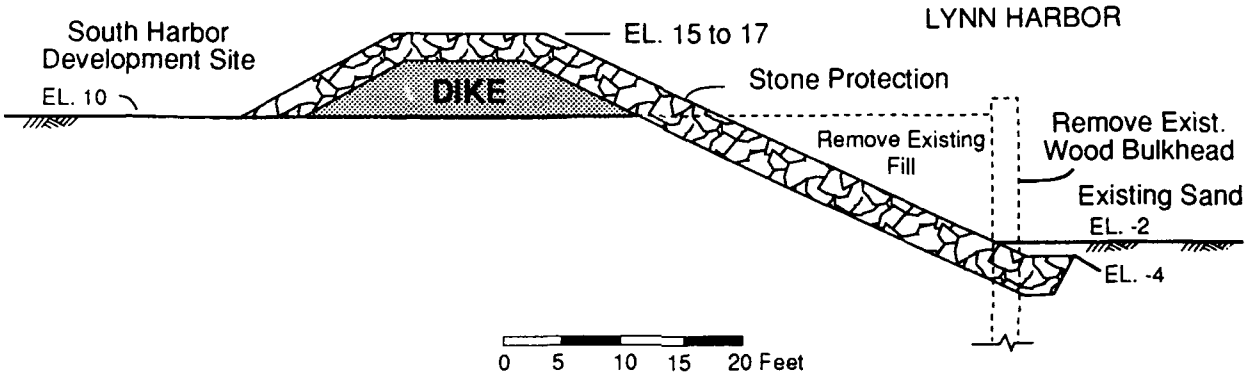


FLUSHING GATE

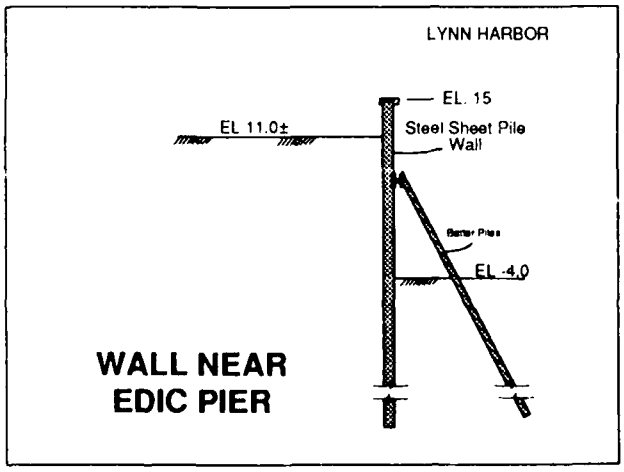


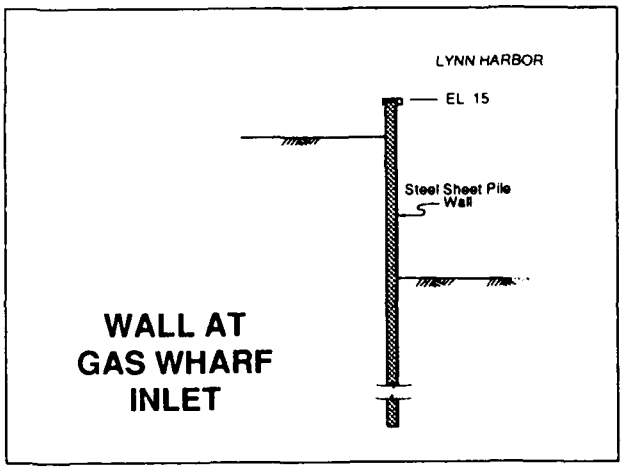
Environmental Effects of Floodgate Structure – In addition to the environmental effects in the estuary from operating the floodgates, which have been discussed, the physical location of the structure and associated dredging causes the loss of 1.3 acres of intertidal habitat of clams and other benthic organisms, and 0.9 acres of subtidal habitat which would be mitigated. The structure and raising of walls along the Saugus River would also partially block the view of 15 to 20 homes in Point of Pines, all of which benefit from flood reduction. The structure would not be readily visible from most of the neighborhood, due to its relatively low profile. The construction impact is minor in the neighborhoods as the structure would be built from barges or from the Lynn side, except for the few months during construction of the floodgate gravity wall on the Revere side. Noise impacts would result from occasional use of compressors and pile driving equipment. Although there would be some loss of beach along the Saugus River at Point of Pines, there would be a net gain of almost 6 acres of beach overall.. In Lynn the land where the floodgates tie into the bulkhead is currently vacant. The large parcel of land would eventually be developed. One developer was interested in building a marina between the Fishing Pier and the General Edwards Bridge. However, he intended to delay his plans, pending a final determination on the implementation of the Regional Plan, the exact location of the Floodgates and effects on currents.

Dikes and Walls - Lynn Harbor – The floodgates would tie into 8,900 feet of dikes and walls along Lynn Harbor. Along the first reach of the Lynn bulkhead, starting near the existing fishing pier and running 1,800 feet along the bulkhead, would be an earth filled dike with stone slope protection. The dike would overlap the floodgates' concrete gravity wall to prevent seepage past the dike. The dike's top elevation would rise quickly to elevation 17 ft. NGVD to prevent any overtopping of SPN waves. It would have a top width of 12 feet and slope toward existing sand flats with a 2 on 1 slope. Under the rock it would have a compacted impervious fill to prevent seepage. The next 1,500 feet of the bulkhead is subject to lower wave action with the result that a top elevation of 15 feet NGVD is required for SPN protection. The dike would end just beyond the sewer outfall adjacent to the Gloucester Fish Corporation property. The existing road drains would be collected into a single line with a gated outlet. The existing timber bulkhead would be removed before the dike is built. The developer would need to have a similar plan approved by the state or the sponsor would need to contribute the additional cost of the plan (about $3million in real estate) at no cost to the Government before the dike could

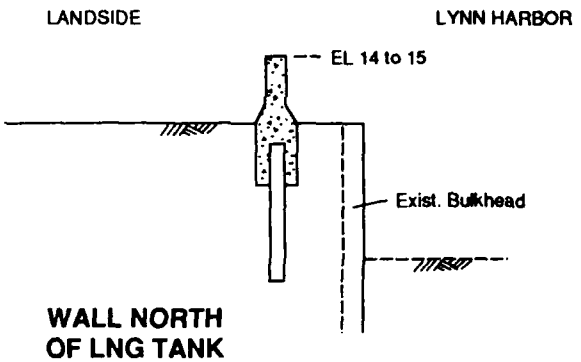


be built. An approved plan would lower the real estate cost to the project by about $3.7million, thus making the dike the most cost effective alternative. Otherwise the most cost effective alternative would be a wall built about 3 to 4 feet high and 300 feet inland from the bulkhead along the back property line. In this case, the wall could be removed once the developer has constructed comparable protection approved by the Corps. The undeveloped property along Lynn Harbor is subject to Massachusetts Chapter 91 regulations for filled tide lands which requires developers to provide public access along the waterfront and other public uses.



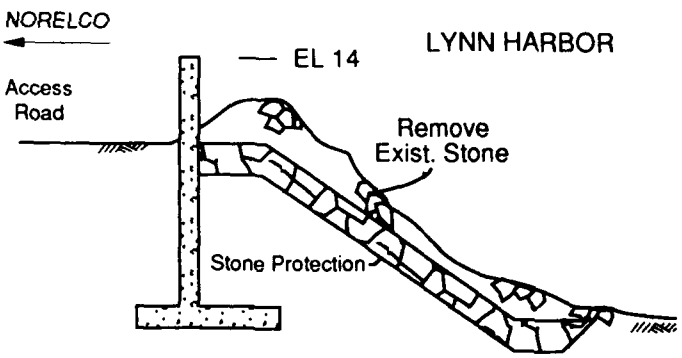


New or raised steel sheet pile walls with a top EL. 15.0 would run along about 3,100 feet of Lynn Harbor. Walls are used instead of dikes to avoid interference with mooring and movement of navigation vessels. Along the EDIC pier and Gloucester Fish Corporation shorefront, steel piling from the floodgate cofferdams would be reused to reduce costs. The wall continues to the south wall of the Gas Wharf Inlet, with a vehicular gate provided for access to the city of Lynn's existing EDIC commercial pier. At the Gas Wharf Inlet, steel sheet pile is currently used along the south wall. The existing wall would need to be raised by welding extensions onto the wall.



WALL NORTH OF LNG TANK AT LYNN HARBOR MARINE

Due to reported ground currents corroding steel walls in this area, new steel sheet pile walls would require cathodic protection to prevent corrosion. Along the south wall, a timber platform is needed for Bay Marine's operators to see to unload vessels on the opposite side of the wall. Steel sheet pile walls are needed along the west wall connecting to the concrete foundations of new buildings. And a hinged drop gate or stoplog closure is needed so Bay Marine can continue to lower boats into the w. .er. The wall continues along the north side of the inlet to join with the existing wall fronting Boston Gas's reserve LNG tank. The wall would need to be raised to EL. 15.



CONCRETE T-WALL

Beyond Boston Gas, a steel sheet pile I-Wall would be used fronting the city's Lynn Harbor Marine. A vehicular gate is required across the boat ramp, and a tide gate on the drain pipe to the south side of the ramp. The I-wall would end along the north side of the property. An 1,100 foot long concrete T-wall with stone protection would then run along the shoreline of Eastern Smelting and Refining and, continuing along the same alignment, past Philips Lighting Norelco Building to the north property line.

The T-wall would be constructed to EL. 14 with stone slope protection. The next reach of the shoreline is currently under proposed development into the Harborside Landing with condominiums. The shoreline is scheduled to be raised to EL. 13 and possibly EL. 18, depending on final plans, and the shorefront protected with stone. To provide SPN protection, a gravity wall may be needed to EL. 14 landside of a proposed public walkway. If the developer raises his property to EL. 18 the wall would likely not be needed and would reduce the project cost. The property to be raised is about 1,100 feet long. At

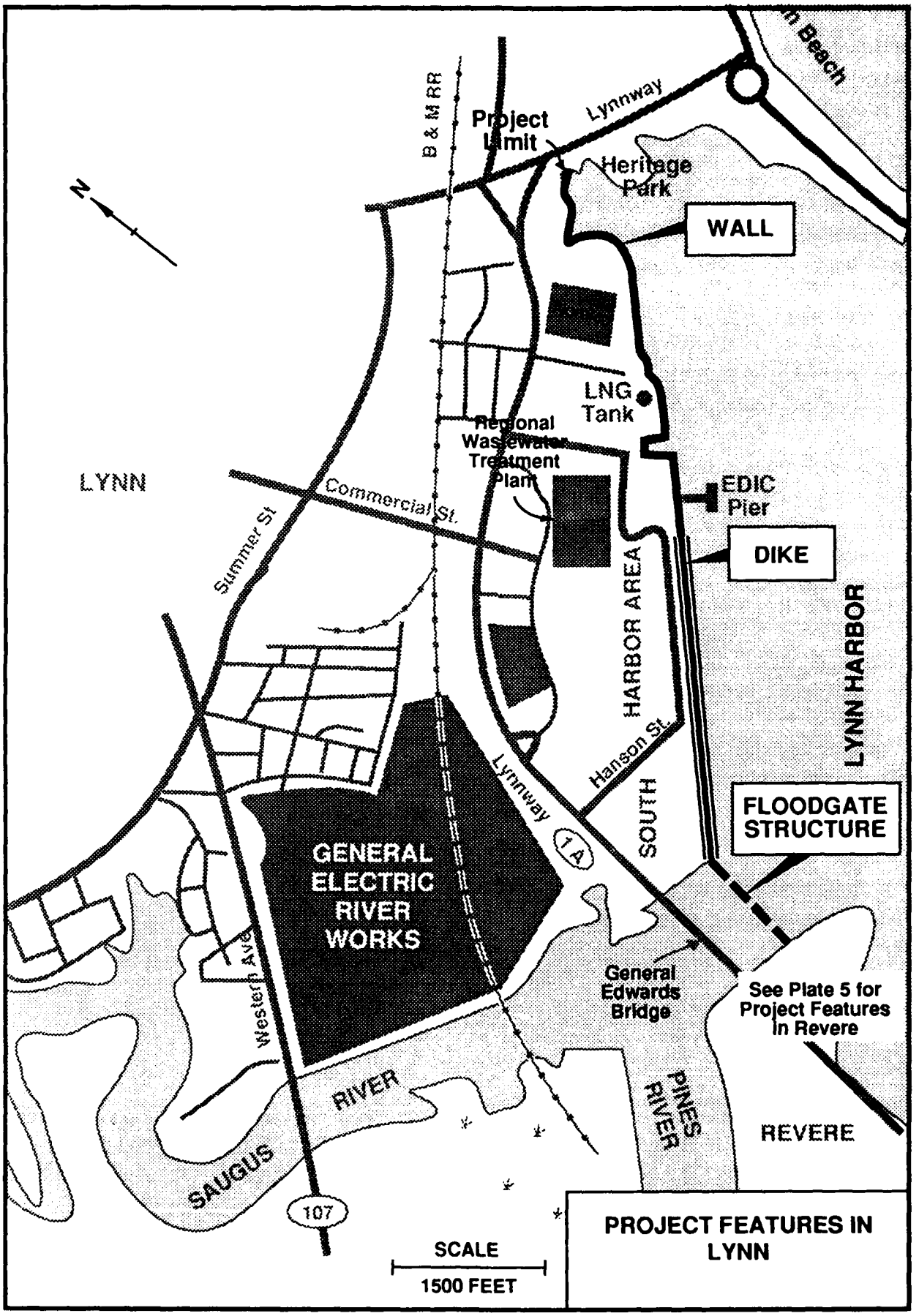
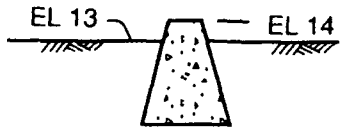
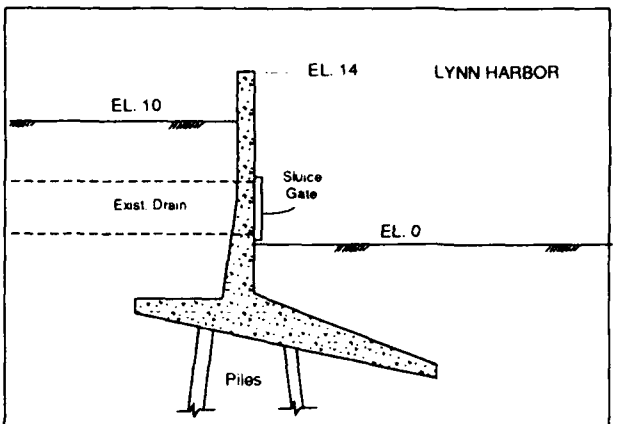

N
B & M RR
Project Limit
Lynnway
Heritage Park
WALL
LNG Tank
Regional Wastewater Treatment Plant
LYNN
Commercial St.
Summer St
EDIC Pier
DIKE
HARBOR AREA
LYNN HARBOR
Hanson St.
SOUTH
Lynnway
1A
FLOODGATE STRUCTURE
GENERAL ELECTRIC RIVER WORKS
Western Ave
General Edwards Bridge
See Plate 5 for Project Features in Revere
RIVER
SAUGUS
PINES RIVER
REVERE
107
SCALE
1500 FEET
PROJECT FEATURES IN LYNN

Plate 6



WALL AT HARBORSIDE LANDING



WALL AT PROJECT LIMIT

its north end, an additional 300 feet of city owned property exists with several drainage outfalls. The Regional Plan includes replacing the existing deteriorating walls with concrete T-Walls and steel I-Walls. Drainage requirements, including gated outfalls, would be evaluated during design.

The wall along Harborside Landing connects to the wall near Norelco and to an existing retaining floodwall (top EL 13.1) adjacent to Heritage Park. The point of high ground (above the El. 12 design tide level) and the end of improvements needed in Lynn Harbor is the El. 13 ground level at the Park, retained by the floodwall. The El. 14 contour is located 100 feet away on the eastbound lane of the Lynnway. The need for a temporary closure across the Lynnway to reach ground El. 14 will be evaluated during design.

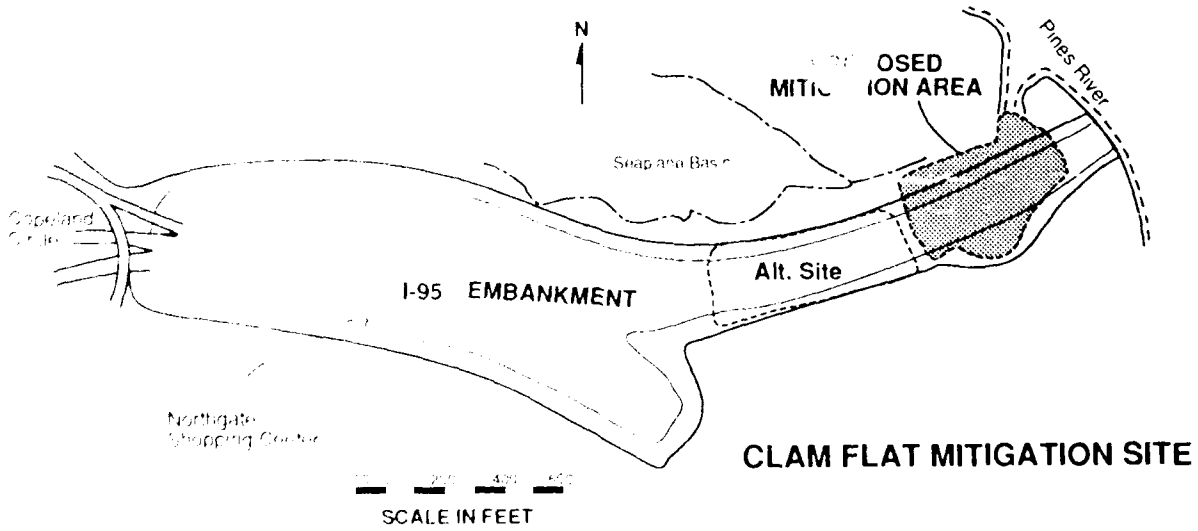
Environmental Effects in Lynn Harbor – The sheet steel pile wall proposed for Lynn Harbor near the EDIC pier would cause the loss of 0.1 acres of subtidal habitat. Plans are to mitigate for this loss by the creation of subtidal habitat. The proposed dikes are not expected to cause a significant impact on future development, as similar structures are planned by the developer. No other significant impacts are known to exist along the waterfront. Plans will continue to be coordinated with appropriate decision-makers and property owners.

Create Clam Flat -- Mitigation – The Regional Project causes the loss of 2.0 acres of intertidal and 1.0 acre of subtidal habitat. For loss of this habitat, the plan includes creating 2.0 acres of intertidal clam flat and 1.0 acres of subtidal habitat. This would be accomplished by removing the west side of the abandoned I-95 fill near the Pines River to create a mostly intertidal basin. A 6.5 acre site would be used in total. Clams would be transplanted into two acres within the basin to form the clam flat. The created basin would be edged by a 0.5 acre fringe of marsh grass, a 2.3 acre buffer zone and protective dike and include an additional 0.7 acres of intertidal transition area. About 70,000 cy of sand would be excavated in total. The sand would be used to create the protective berm; used elsewhere in the project to the extent practicable, or stockpiled for later use by others.

The Sea Plane Basin (center) - a Productive Clam Flat near the Mitigation Site. Town Line Brook (center left) is location of the MDC's Flood Control Project. (I-95 Fill not shown.)

Mitigation Site Includes Removal of I-95 Fill (top). Northgate area (center) Is Flooded From the Pines River (top right)

Figure 7



CLAM FLAT MITIGATION SITE

DESIGN CONSIDERATIONS

The following summarizes many of the design and construction methods and procedures considered for developing and implementing the plan for each major structural feature: the Floodgates, Lynn Harbor shorefront, Revere Beach Park Dike, Point of Pines Shorefront, and the mitigation area. For all features subsurface investigations, land and hydrographic surveys and detailed structural design will be required over about a four year design period.

Preceding any detailed structural designs on the floodgates would be mapping for the estuary storage area and hydrodynamic modeling of currents and flushing requirements at the mouth of the river for evaluating and optimizing the gate structures, reducing the effects of eddys and improving flow. The model studies which may include a physical model would be completed over a one-to two year period. Beach and dune erosion models are scheduled to precede design along Revere Beach and Point of Pines.

• **FLOODGATES** - The initial design of the floodgates involved investigations and data collection to define and evaluate the tidal characteristics in the area using gauging stations, tide level modeling, land surveys and future conditions of rising sea level and navigation dredging. This information was used to determine the affects various sizes of gated openings would have on hydraulic conditions in the estuary and currents for navigation.

The initial design of the gates was based on the selected flow area and investigations of various types of gates available and estimates of those warranting consideration. The "miter" navigation gate and "tainter" flushing gates yielded the lowest cost and were most acceptable for the limited space available. The 50 foot wide tainter gates were also preferred over numerous small (e.g. 10' x 10') gates by fisheries biologists. The biologists also preferred gates close to the shore, along the bottom of the river and openings near the water surface. The size, location, type and openings of the gates will undergo more detailed design to reduce any remaining impacts on localized currents and sedimentation, beach erosion or other potential impacts near the gates.

Construction of the floodgates is an important issue, due to the sensitivity of the estuary and navigation needs. Two types of cofferdams were investigated, the braced and cellular, for constructing the gates on a dry river bed. The braced cofferdam using a ring wall around the miter gate and parallel walls for the tainter gates was found to be less expensive than the cellular type. Also the braced takes up less room, has less impact on the river bottom and flow area and should be faster to construct. Investigations during design will also address effects during construction.

The sequence for constructing the floodgates would maintain sufficient flow area in the river during construction so as to cause no measurable change in tide levels in the estuary. Safe passage for navigation would be provided using a temporary navigation channel around the cofferdams. The following sequences in construction would complete the floodgates in about three years. The first year and a half would include dredging the temporary channel and bottom approaches for the gates and cofferdam locations; con-

structing the ring cofferdam and navigation gate, simultaneously with constructing the first four tainter gates and gravity wall on the Lynn side and initiating the gravity wall on the Revere side. The following year and a half, with the above gates open, would include the construction of the remaining five Lynn tainter gates, the Revere tainter gate and gravity wall.

During design additional information would be collected on subsurface and soil conditions. To assure safe passage for navigation, extensive hydrodynamic modeling and possibly physical modeling during final design may widen the navigation gate openings, and raise the tainter gate opening upwards a few feet to reduce friction in the flows. Also, possible widening of the navigation gate may result in a reduction in one or two tainter gates. The project would be designed so that it could be modified to accomodate the worst case (NRC high rate) of sea level rise. This is expected to affect the foundation design of the floodgates and raising the top opening of the taintor gates. Minor adjustments in the overall structure dimensions can be expected. Significant changes are not expected. Both the miter and tainter gates are extensively used throughout the country and information on their design, operation and maintenance was used in this study.

Other considerations in design of the gates to reduce impacts on fish, plankton and lobsters are requested by agencies and the public. These include raising the top of the gates to high tide level, keeping gates as large as possible, reducing eddys and shear forces through the gates and keeping the bottom of gates on the river bottom.

The construction of the navigation and tainter gates and cofferdams would be accomplished in part from barges loaded in Lynn, possibly at the EDIC commercial pier or Bay Marine, both facilities capable for this type of work. Access to the Lynn gates, and concrete and material delivery would also be from land on the Lynn side. The Revere dike, however, would be constructed from Point of Pines over two periods of about a month or two each, possibly using two-way haul on the river stretch of Rice Ave. The noise at Point of Pines would be similar to the ongoing rehabilitation of the bridge where compressors can be heard. Occasionally noise from pile driving would be audible.

• **LYNN HARBOR** – The design of the dikes and walls in Lynn Harbor would be based on studies of waves to reduce overtopping, and investigations of foundation conditions and structural stability of dikes and walls. Construction of the dikes and most of the walls could take as little as a year. Work can start at several locations. The remaining walls near the EDIC Pier would be completed last since the steel sheet piling needed for over 1,000 feet of the wall would initially be used to construct the cofferdams for the floodgates. The haul routes to the EDIC pier for the floodgate material, and to Lynn Harbor for the Lynn Harbor features, would be along North Shore Road (Route #1A), possibly through Revere from Rt #1.

• **REVERE BEACH PARK DIKE** – The design of the park dike would be based on studies similar to those in Lynn Harbor, including the overtopping estimated for the wall fronting it. Below the park surface, stone would likely be needed to protect the facing of the dike. The project will be closely coordinated with the MDC since they have planned to construct the new bath house, an addition to the police station, a sitting wall, and re-

move the old and install a new drainage system prior to start of the dike. The dike will take about nine months to complete. Construction interference with the peak beach use days and commuter hours would be avoided to the extent possible through coordination of traffic routes, public safety, and construction sequencing.

• **POINT OF PINES** – Estimates of overtopping and the design of revetments, walls and dunes would be based on model studies, design manuals and borings along the shore. Construction is expected to be concurrent with other work and require most of a construction season (at least nine months). Two haul routes are being considered in the neighborhood, one along the water side of the walls and revetment from Carey Circle and the other along Rice Ave. Work schedules would be coordinated to provide for beach use, public safety, work during regular hours and other concerns.

Dune sand surplused by excavation for revetments would be used to replace the beach. Also, sampling and testing of the sand dredged from the Saugus River for potential beach use at Point of Pines will be considered in design. At the start of design a recently developed beach erosion model that was not available during planning would be used to analyze the feasibility of a dune and beach system in lieu of all or part of the revetments along the Point of Pines shorefront.

• **MITIGATION AREA** – The mitigation basin area would be excavated to a minimum of -6 ft. NGVD to assure frequent inundation of the clam flats within the intertidal area. Much of the excavated sand would be used in the construction of the project. The marsh grass and clams would be transplanted from nearby flats and marsh.

REAL ESTATE CONSIDERATIONS

• **FLOODGATES** – Temporary construction easements (0.5 acres) will be required at each abutment of the floodgates for access and stock piling materials. The majority of stock piled materials will be located on a one acre permanent easement on the vacant Lynn South Harbor area. The one acre (for the structure, parking and access) permanent easement will also be required for visitors and operators. The existing MDC fishing pier parking and access easement could be used for this purpose.

• **REVERE BEACH PARK DIKE** – Construction and maintenance of the park dike and related features will require an 8.5 acre permanent easement. The Sales Creek tide gate requires a 0.02 acre permanent easement for access and maintenance.

• **PONDING AREA WALL** – A permanent easement of about 0.04 acres would be needed to construct and maintain the ponding area wall along the old narrow gauge railroad embankment between North Shore Road to and including the existing retaining wall along the north driveway of Sea View Towers.

• **POINT OF PINES** – Construction temporary easements (4.9 acres) will be required along the shorefront for constructing the protective features. Permanent easements (4 acres) are required at the location of the revetments and Saugus River wall after construction for future maintenance.

• **LYNN HARBOR** – Temporary construction easements (9.7 acres) would be required on both sides of the dikes and walls. Inspection and repairs can be accomplished after construction from the top of the dike and from the waterside of the dikes and walls rather than acquire expensive 15 foot wide permanent easements on the land side. Temporary easements could be obtained, as well, for some maintenance work. Along the Lynn Harbor waterfront actions are also planned by the city which would facilitate public access in the future.

• **MITIGATION SITE** – The site requires a 6.5 acre permanent easement and a 2 acre temporary easement for construction access, maintenance and stock piling of surplus excavated materials.

• **ESTUARY STORAGE AREA** – Protection of the estuary storage area and ponding area at the north end of Revere Beach includes the acquisition in fee or permanent easement of 1650 acres, nearly all coastal wetlands. A guide taking elevation of 7 ft. NGVD would be used for acquisition purposes of the estuary storage area. Generally, the EL. 7 acquisition boundary would lie halfway up the embankment between a mean spring high water level (or high marsh) at about EL. 6 and the top of the embankment which is usually at or above a one year tide frequency of elevation 8 ft. NGVD. Flexibility will be used to establish the exact alignment, and property owners will be coordinated with individually. For example, the limit of the wetlands will be used in those areas where an impact may occur through acquisition of part of a parcel above the wetland limit. If a significant cost would result from fee acquisition of a wetland parcel which would impact the upland parcel, then an easement for storage purposes would likely be required.

CONSTRUCTION CONSIDERATIONS

Construction will require a moderate size work force with varied construction skills, largely in the heavy equipment and semiskilled and skilled labor trades. Within the greater Boston area, there is a sufficient number of workers who could commute to work and not require housing near the project. A field office for Corps of Engineers' inspectors would be required in the vicinity of the proposed project. Construction of the project would be accomplished under multiple contracts. Completion of the Park Dike, Ponding Wall, Point of Pines, and the mitigation area in the first year would provide partial reduction in overtopping to these areas, and initiate colonization of the clam flats. Upon completion of their design, these features precede the start of the floodgates. Once the floodgates are started, construction and acquisition of the estuary storage area would be completed in about 3 years, subject to many externalities, including environmental factors, timing of the awarding of contracts, etc. Plans for construction phasing of the floodgates are provided in Appendix J.

OPERATION AND MAINTENANCE REQUIREMENTS

NON-STRUCTURAL FEATURES OF THE SELECTED PLAN

The plan requires protection of 5,400 acre-feet of natural storage in the estuary through real estate acquisition, semi-annual inspections of project features and continued monitoring to protect the storage area. The storage is required for interior runoff and potential tidal overtopping. In order to protect the extensive investment required for this plan and the protection it affords, monitoring and enforcement of the real estate boundaries is required by the non-Federal sponsor. To achieve this, an improved monitoring, education and enforcement program is being recommend as a measure to accomplish necessary estuary storage protection. Estuary storage protection will require participation of the general public, Conservation Commissions, Community Officials, and State and Federal agencies. Much of the responsibility for successful implementation will lie with local and State officials.

Estuary storage protection will require:

- Enforcement Activities: State, Local Responsibilities:

  The state sponsor would maintain single points of contact for Conservation Commissions and the public to provide assistance on estuary real estate boundary limits, be responsive to calls on fill activities, initiate stop orders and follow up action.

- Monitoring: Sponsor Responsibility:

  The project sponsor would perform semiannual inspections of the entire estuary perimeter, and would, in addition, frequently tour the perimeter to assure no filling activities are underway. Any potential violations would be reported immediately for appropriate action. The sponsor would also maintain a single point of contact available for public inquiries concerning filling activities and wetland/storage requirements. Any illegal activities and follow up actions would be reported in local newspapers and media as a deterrent measure. The operation and maintenance costs include an Environmental Manager to oversee the monitoring and protection of the estuary.

- Community Education: Sponsor Responsibility:

  Recording the estuary real estate boundaries on the deed of each property and the maps developed during design of the project would serve as the basis for the Community Education effort. The project sponsor would meet with Conservation Commission chairmen on a semiannual basis to review progress on efforts to protect the perimeter of the storage area; to reiterate the importance of this protection; and to discuss how legal action may be taken to remove fills.

  Once a year the state sponsor would provide a local news release explaining the importance of the storage area and reviewing the measures governing its protection, and noting points of contact for the public's questions.

  The state sponsor would prepare and keep up to date a brochure giving the same information as the news release. Copies of the brochure would be available to Conservation Commissions and other appropriate local leaders for distribution to interested members of the public. Every few years the brochure would be mailed directly to all land owners whose property abuts the storage area.

- Preparati of a Flood Preparedness Plan: Federal, State and Local Responsibility

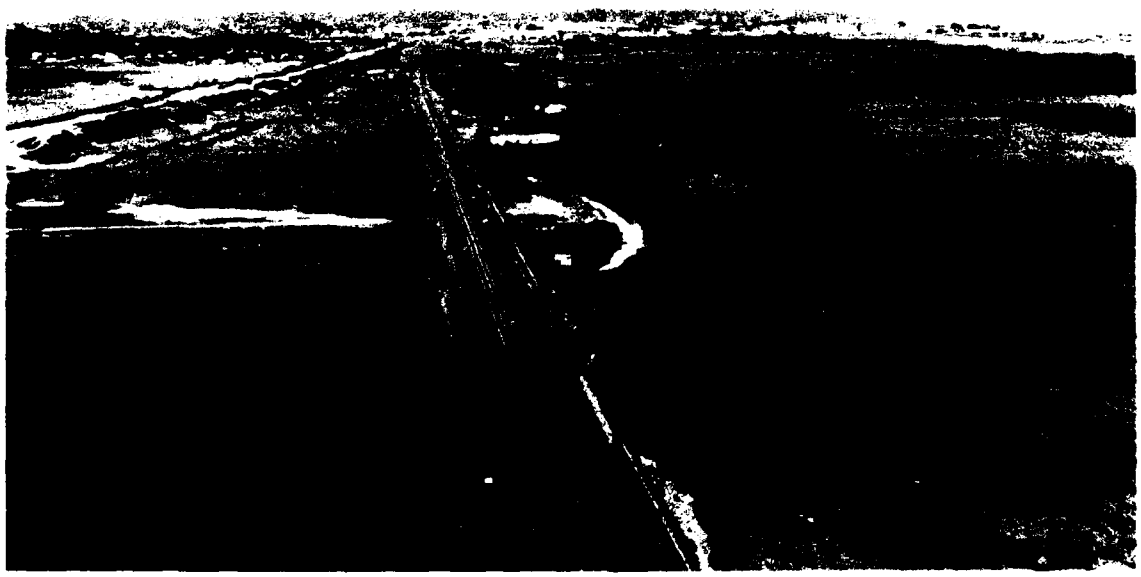
At a minimum, the Flood Preparedness Plan developed by the non-Federal sponsor in coordination with the Corps would direct when all tide gates along the Revere and Lynn Harbor shorefronts would be closed; when mariners would be alerted to a possible floodgate closure; and when residents and business owners in flood prone areas would be alerted.

For residents and employers in the area, the preliminary warnings must indicate the seriousness of the expected flooding; the actions that are currently being undertaken by appropriate officials; what actions the residents should take at that time (relocation of belongings, goods, etc.); and what the process will be if evacuation becomes necessary.

Community officials will have had to agree on specific routes for evacuation, and designate shelters that have adequate space and are easily accessible along routes which are safe from flooding. Plans must be in place that will assure the continuous provision of vital services especially to the three areas in Revere which are vulnerable to flooding that exceeds the 100 year level — Garfield School, Point of Pines and the north end of Revere Beach.

Periodically the Flood Preparedness Plan will need to be reviewed in light of sea level rise, and plans adjusted if necessary. It will also be important for residents and officials of the study area to maintain familiarity with the Flood Preparedness Plan, particularly if there is a long interval between flooding episodes in the study area and, especially, in Revere's three vulnerable areas.

Another Beneficiary of the Regional Plan



Route 107 is One of Four Major North Shore Arteries in the Flood Plain

STRUCTURAL FEATURES OF THE SELECTED PLAN

• **FLOODGATE OPERATION AND MAINTENANCE** – The operation, maintenance and replacement features and costs of the plan are quite extensive for the floodgates to ensure that gates will operate when needed, will operate so as not to harm the estuary and will provide sufficient warning to mariners prior to gate closure.

The operation of the gates will occur when a coastal storm threatens to cause coastal flooding. Around the estuary the start of damage is about EL. 8 ft. NGVD. Historical tides in the estuary reach this level a little less than once a year. Initially the tide gates would be closed about 2 to 3 times a year if it appears significant damages would occur. Usually this would occur in the late fall, winter or early spring months.

Closure would occur about one to two hours each time during the peak of the tide. Most gate closures would be made when the rising tide reaches EL.7 ft. NGVD, as shown in Figure 8. The one foot differential below EL. 8 ft. NGVD normally provides enough storage to contain the interior runoff when the gates are closed.

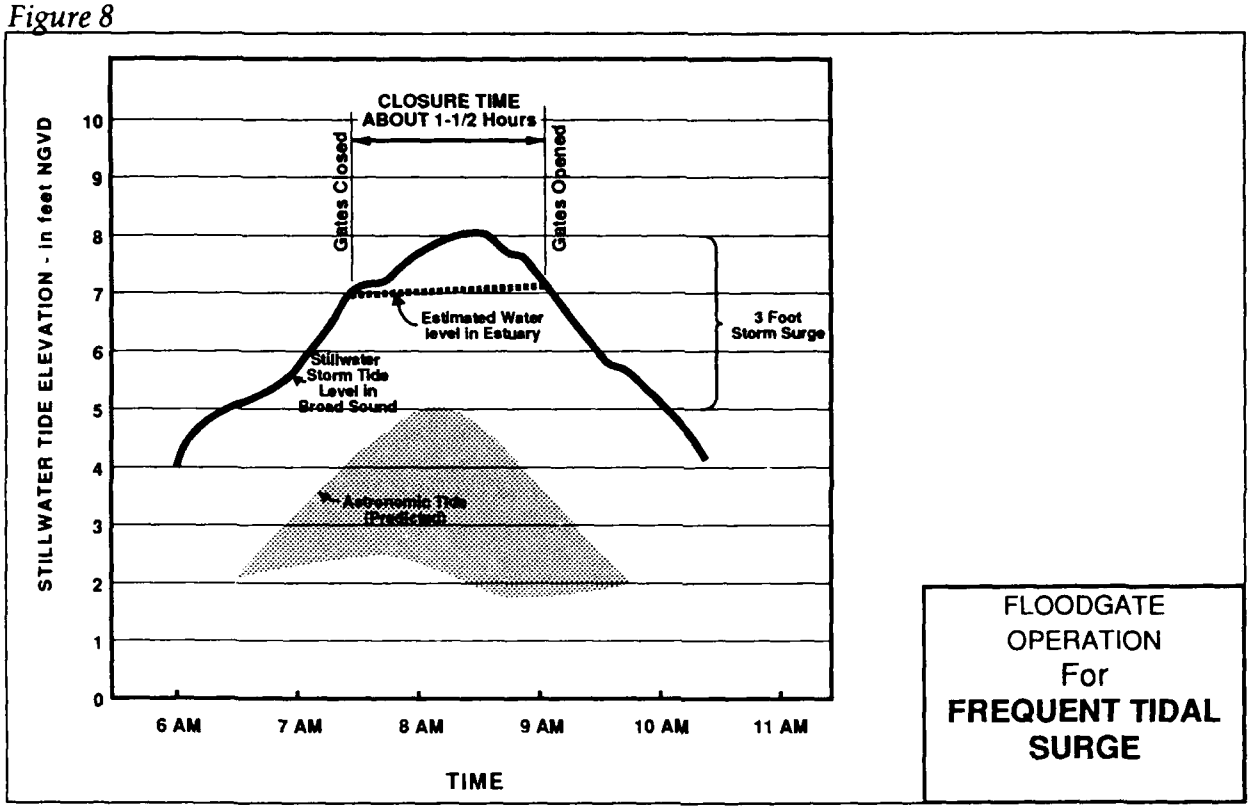
For example, during the 1972, 1979 and 1987 storms with frequencies of about a 10 to 17 percent chance of occurrence each year, gates would have closed at EL.7. For the '78 storm there was no significant runoff, with the snow, but the stronger 60 mile an hour winds produced waves about two feet high in the estuary, so closure would have been made as shown in Figure 9. Steps leading toward closure are accomplished in phases to alert mariners in ample time that gates may be closing. Notices are sent out to mariners hours in advance, followed by periodic updates of the degree of the alert, until the decision is finally made. Warnings go out on the Coast Guard radio, lights will signal, and possibly a siren will sound minutes before closure is started. The gates would be reopened when the receding tide in Broad Sound reaches the same level as water in the estuary.

• **FLOODGATE OPERATION** – Competent operators, one assiged to the floodgates, will be required for floodgate operation. Their primary responsibility will be manning the gates during the anticipated two to three closings, per year including "close calls". Certain contingencies require two people to assure uninterrupted operation during these critical periods. For example, a lengthy event may necessitate rotating shifts between the two operators. A major event usually requires full time participation of all available trained personnel. In fact, many employees find it necessary to work multiple shifts to keep pace with the emergency.

Other operator duties include normal maintenance, interfacing with the public and agency officials, data collection, managing rehabilitation and repair work, and security.

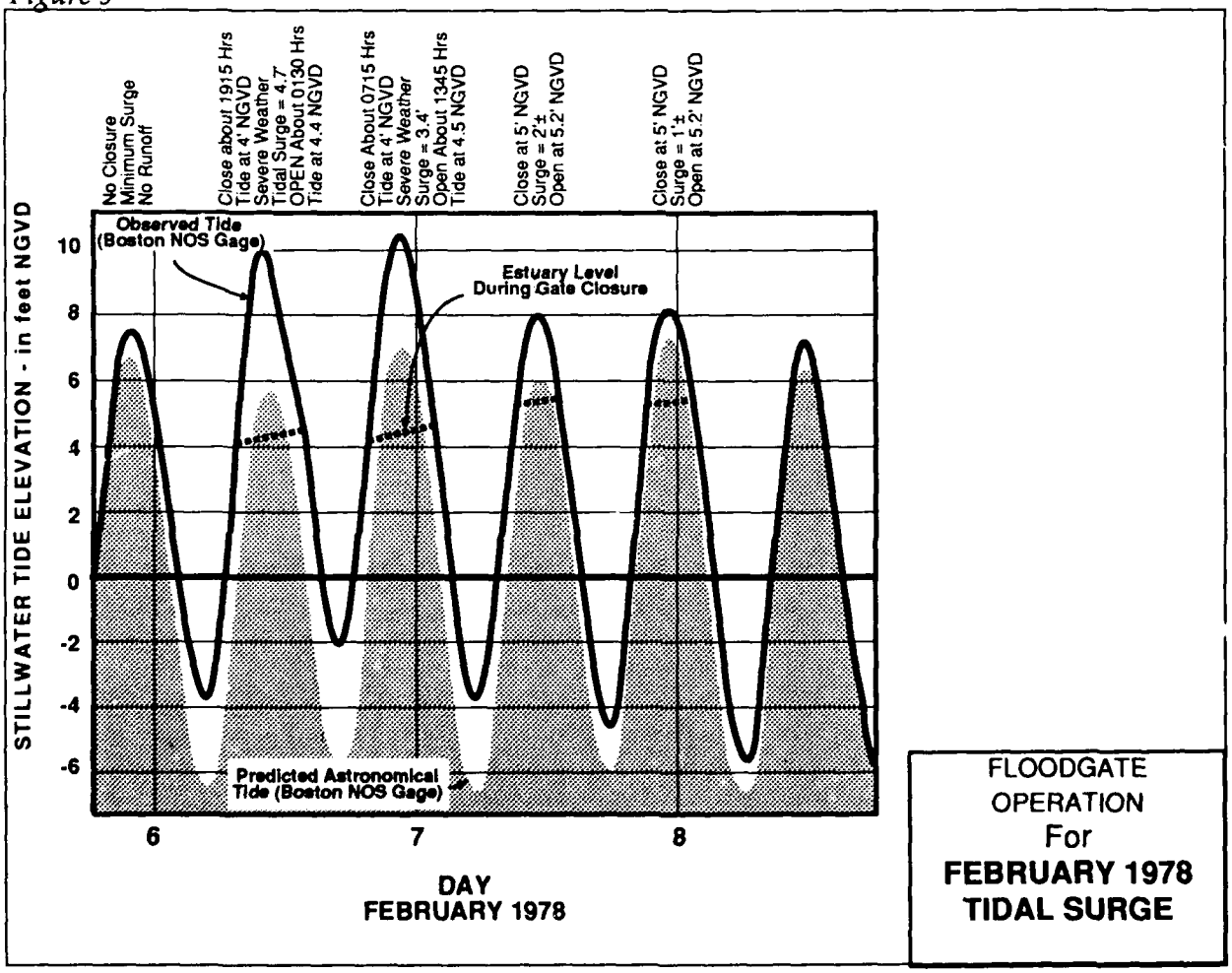
During the construction phase, the Reservoir Control Center at the New England Division (NED) of the Corps of Engineers would prepare a complete **regulation manual** for the entire Regional Floodgate Plan. This manual would discuss all aspects of flood control activities and be comparable in scope to procedures and format used by the Corps over the past 20 years for similar coastal structures in southern New England.

Figure 8



FLOODGATE OPERATION For **FREQUENT TIDAL SURGE**

Figure 9



FLOODGATE OPERATION For **FEBRUARY 1978 TIDAL SURGE**

• **FLOODGATE MAINTENANCE AND SECURITY** – Experience at other Corps projects with Miter and Tainter gates has historically determined them to be very reliable and relatively maintenance-free gates. Both require painting about every 15 years and rewiring of motors every 40 years or so. Both will require cathodic protection to prevent corrosion. The equipment is not used that often, so wearing out is not a major problem. The gates are tested at least twice a year and any other major project features are checked out. Cleaning of concrete walls, painting, replacing road surfaces and the like is done about every five years. Any fence security repairs or other safety problems are taken care of immediately. Trimming of shrubs and grass mowing is accomplished as needed. The final design for security, personal safety and preventing vandalism will be given careful consideration.

• **REVERE BEACH PARK DIKE** – The park dike requires very little maintenance to assure its integrity as a flood control structure.

• **POINT OF PINES** – Maintenance of Point of Pines features would be accomplished several times a year including repairing crossovers, cleaning any debris off of the revetments or walls or replacing fencing. Grooming and shaping the existing beach fronting the dunes should continue to assure that the beach maintains at least its existing profile. The only operation required would be the opening and closing of the vehicular gate which would provide access for cleaning the beach in the summer time.

• **LYNN HARBOR** – Operations required at Lynn Harbor during the threat of a storm will be to assure that the gated access points along the shorefront are closed. These gates are closed and inspected yearly. The Operation and Maintenance Manual prepared during the construction phase will define the responsibilities for individual closures. The dikes, walls and gates are solidly built, and little maintenance is expected other than routine repair of weather and storm damage to cement walls, replacement of dislodged stones, periodic clearing of debris off dikes and walls, and infrequent replacement of gates and cathodic protection materials.

• **ESTUARY PROTECTION** – The estuary flood storage area will be monitored to assure that no illegal encroachment of the wetlands/storage area occurs. Other educational and technical assistant provisions were previously explained.

• **MITIGATION SITE** – The mitigation site would be frequently inspected and maintained to assure the continued flushing and viability of the clam flats. The protective berm and buffer zone would also be maintained to provide protection of the mitigation site.

SENSITIVITY AND MODIFICATIONS FOR SEA LEVEL RISE

The sensitivity of the Regional Plan to future rates of sea level rise was evaluated using two assumptions: 1) If in the future policy decisions are made to abandon the floodplain, is the Regional Plan economically justified at a 50 year evaluation period at the historical rate (one foot in 100 years); or, when one foot rise would occur for the National Research Council Case 3 at a 35 year evaluation period; and 2) Can the project be feasibly modified for sea level rise?

(1) The Regional Plan is economically feasible when evaluated for both a 50 year evaluation period with a historic sea level rise; and a 35 year life, assuming a one foot rise under the Case 3 (worst case at 4.2 foot rise in 100 years) sea level rise scenerio, as shown below, compared to the 100 year evaluation period at the historical rate. As shown with Case 3, damages would occur more frequently and thus projects benefits increase.

Project Economic Evaluation Period — (1989 Price Level in $1000)	Historical Rate 50 Years	Case 3 35 Years	Historical Rate 100 Years
Average Annual Cost	$ 9,050	$9,400	$ 8,990
Average Annual Benefits	$11,050	$12,460	$11,390
Net Benefits	$ 2,000	$3,060	$ 2,400
Benefit to Cost Ratio	1.2	1.3	1.3

(2) The Regional Plan could be modified for all cases of sea level rise. Modifications could include measures to maintain a high level of protection, and limiting the number of gate closures to range between 3 and 40 per year. Modifications for the level of protection could return the project to an SPN level after each foot of sea level rise has reduced that level to about a 350 year level of protection. Costs were estimated for raising by one foot the floodgate structure and shorefront protective structures along Lynn Harbor, Revere Beach and Point of Pines (and assuming the top opening of the gates would be raised roughly one foot) for each foot of sea level rise. In order to limit the number of closures to about 40 per year where no significant water quality impacts would occur, the start of damage around the estuary would be raised one foot for each foot of sea level rise. The cost reflects raising low areas along the riverbank with walls or dikes on upland, just as would have occurred without the project to keep pace with sea level rise. Assuming these changes were being made today and the project had experienced one foot of sea level rise, the potential feasibility is reflected in the following analyses for each foot of sea level rise.

Benefits and Costs per Foot of Sea Level Rise ($ Millions 1989 P.L.)	Maintain Level of Protection Between SPN and 350 yr.		Limit Gate Closures Between 3 to 40 per year		Maintain Level & Limit Gate Closures	
	Case 2*	Case 3*	Case 2	Case 3	Case 2	Case 3
First Costs:						
Raise Ocean Shorefront & Floodgates	$ 5.0	$ 4.5	—	—	$5.0	$ 4.5
Raise Estuary Rivers Banks**	—	—	$13.9	$11.1	13.9	11.1
TOTAL FIRST COST	$5.0	$4.5	$13.9	$11.1	$18.9	$15.6
Average Annual Cost	$ 0.5	$ 0.4	$ 1.4	$ 1.1	$ 1.9	$ 1.5
Average Annual Benefits	$ 1.0	$1.0	$1.4	$ 1.1	$ 2.4	$ 2.1

*Case 2 reflects a 2.9 foot rise in 100 years and Case 3 a 4.2 foot rise.
**Approximately 40% of the first cost is for permanent easements.

Displaying the average costs per foot of sea level rise facilitates the analysis of Benefits. Raising the level of protection appears justified based on the assumption that Benefits for each foot of sea level rise would be at least equal to the $1.1 million of benefits presented in the report for one foot of sea level rise.

Constructing or raising walls or dikes around the estuary for each foot of sea level rise was found nearly equal to the savings in operation and maintenance costs, thus the benefits are shown equal to the annual cost of raising.

In order to initiate project modifications for sea level rise, the non-Federal sponsor would need to request the Corps to conduct an investigation under the Corps Section 216 authority for modifications to authorized projects. A reconnaissance study would be accomplished, followed by (if approved by the Corps and sponsors) a cost shared feasibility study. The modifications recommended by the study would also be cost shared. The current project would be designed so that it could be modified for the worst Case 3 sea level rise.

SUMMARY OF PROJECT COSTS, ACCOMPLISHMENTS AND BENEFITS

Project first costs are shown in Table 7. Costs include the direct cost and contingency for major features. Other costs include Lands, Easements, Rights of Way and Relocations, Engineering and Design, and Supervision and Administration costs during design and construction. Operation and Maintenance costs are shown in Table 8. Costs at the 1988 price level were increased 4 percent to reflect inflation for the 1989 price level. The detailed cost estimate is included in Appendix J.

TABLE 7
NED PLAN
PROJECT COSTS
Regional Saugus River Floodgate Plan

FEATURE	DIRECT COST (in $1,000, incl. Contingency) 1988 Price Level	1989 Price Level
Floodgate Structure -		
Navigation Gate (Code 5, Locks)	$14,105	14,670
Flushing Gates & Gravity Walls (Code 11, Levees & Floodwalls)	34,170	35,540
Total Floodgate Structure	$48,275	$50,210
Dikes, Walls, Revetments and Dune Restoration -		
Lynn Harbor, Park Dike & Point of Pines (Code 11)	$15,843	16,475
Buildings, Grounds & Utilities (Code 19)	284	295
Beach Replenishment (Code 17)	202	210
Total Dikes, Walls, Revetments and Dune Restoration	$16,329	16,980
Fish and Wildlife- Clam Flat Mitigation (Code 6)	$212	220
Lands, Easements, and Rights of Way (LE&R) (Code 1, Lands & Damages)	$8,142	8,470
Relocations (R) (Code 2, incl. Alterations of Existing Utilities)	$ 695	730
Total LERR	$ 8,837	9,200
Engineering and Design (Code 30)	$ 6,930	7,200
Supervision and Administration (Code 31)	$ 4,510	4,690
TOTAL FIRST COST	**$85,093**	**$88,500**

TABLE 8

ESTIMATED OPERATION, MAINTENENCE AND REPLACEMENT COSTS

Feature	Aveage Annual O,M&R Cost 1988 Price Level	1989 Price Level
Floodgates	$120,000	$125,000
Environmental Manager & Mitigation Site	70,000	73,000
Revere: Park Dike, Wall & Sluice Gate	11,000	12,000
Revere: Point of Pines	9,000	9,000
Lynn Harbor	10,000	11,000
TOTAL O,M&R COST	**$220,000**	**$230,000**

PLAN ACCOMPLISHMENTS

The Regional Saugus River Floodgate Plan offers extensive flood damage reduction benefits to the region, State and Nation. It also offers benefits to recreation and the environment. The plan was optimized at the highest level of protection recommended against coastal flooding, the Standard Project Northeaster (SPN), which protects against the worst combination of conditions likely to occur over the life of the project, including most damages due to sea level rise. Throughout this section on plan accomplishments, cited levels of protection or storm tides reflect 1989 tidal conditions.

ECONOMIC BENEFITS

The Selected Plan would accomplish many positive objectives. It would eliminate nearly $500 million of damages for an SPN event, including most damages due to a one foot sea level rise. Table 9 reflects the range in estimated reductions in depths of tidal flooding. The lower limits for each area reflect reductions in coastal flooding (with residual flooding from significant interior runoff) and were used to compute project benefits. The higher levels of flood reduction reflect potential reductions in coastal flooding without significant interior runoff. Similar reductions in flooding are shown for the SPN event if the event is associated with one foot of sea level rise.

TABLE 9

SELECTED PLAN
REDUCTION IN FLOOD DEPTHS

Flood Event	SPN + 1ft Sea Level Rise	SPN	100 Year	10 Year
REVERE				
Ocean Ave and Wonderland Park Areas	8-10.5	7-9.5	5-7	1.5-3
Towle and Revere High School	3-8	2.5-6	0.5-2	--
Kelley's Meadow & Diamond Cr.	7-9	6-8	3.5-5	1.5-2
Revere House Area	5-8	5-7	2-4	0.5-2
Riverside, Pines River & Oak Island	4-6	4-5	3	2
North Revere Beach	0.5-2	1-2	1-2	2
Point of Pines	--	0-2	2.5-4	1-2
Northgate	5-7	5-6	3.5	2
Garfield School Area	--	--	2-3.5	1
LYNN				
Lynn Harbor & Lynnway Com. Area	6-8	6-7	4-5	1.5-3
General Electric	4-6	4-5	2.5-4	1.5-3
Saugus River, Upstream	4-6	4-5	3-4	2-3
SAUGUS				
Ballard Street, Saugus River	5-7	5-6	4-5	2
Ballard to Bristow Sts.	5-9	7-8	5-6	3-3.5
Bristow to Marsh	5-7	5-6	3-4	1.5-3

For a recurring 1978 flood of record (100 year tidal storm) depths of flooding would be reduced between 5 to 7 feet preventing over $100 million in damages. Over the full range of events the plan would eliminate almost $7 million in average annual damage from inundation of buildings and roads at the lowest estimated level of flood reduction when coastal storms are accompanied by significant interior runoff. (Table 10).

TABLE 10

SELECTED PLAN
REDUCTION IN FLOOD INUNDATION DAMAGES
(1988 Price Level in $1,000)

Average Annual Flood Damages

	Flood Damages without Project from Coastal & Interior Runoff Flooding	Coastal Damages Prevented by Selected Plan	Percent Reduction in Total Damages
Revere	$3,967	$3,212	81%
Lynn	2,970	2,835	95%
Saugus	1,083	1,017	94%
Total	**$8,020**	**$7,064**	**88%**

This represents almost 90 percent of the total damage. In areas with inadequate drainage systems, the remaining damages are primarily due to flooding from interior runoff which may accompany coastal storms. Economic Benefits have been taken in the tidal floodplains of Revere, Lynn and Saugus.

In Revere, SPN protection is provided to 1,300 buildings in the following areas:

- Ocean Avenue and Wonderland Park areas,
- Revere High School and Towle Areas,
- Kelley's Meadow and Diamond Creek areas,
- Riverside, the Pines River, Northgate, and Brown Circle areas;

In Saugus SPN protection is provided to over 600 buildings including all of the East Saugus area along the Saugus River to the Saugus Iron Works, and bordering the Saugus Marsh.

In Lynn SPN protection is provided to 1,240 buildings including the entire tidal floodplain along Lynn Harbor, the Lynnway, General Electric and the Saugus River.

Protection is provided to the 1978 (100 year level), and some flood reduction for higher levels for the 500 buildings located at Point of Pines and the Garfield School Areas in Revere. For the 30 homes directly behind the north end of Revere Beach partial flood reduction is provided up to the SPN level.

Benefits have not been taken in many areas for reduction in damages offered by the project to improved drainage when ocean levels rise above 8 ft. NGVD. Areas in which eco-

nomic benefits have not been taken include 1,300 buildings in Town Line and Linden Brook in Revere and Malden, the Upper Saugus River and Shute Brook floodplains in Saugus, also other areas above the tidal floodplains in Lynn, Revere and Saugus.

Substantial reduction in damages is also offered against sea level rise with an estimated 79 percent of these additional damages prevented for a one foot gradual rise over the next 100 years. (Table 11). If an accelerated rate of sea level rise occurs additional damages would be prevented.

TABLE 11

AVERAGE ANNUAL DAMAGES SEA LEVEL RISE
(1988 Price Level, In $1,000)

	Increased Coastal Flood Damages w/o Project	Reduced Flood Damages with Selected Plan	Percent Reduction in Sea Level Rise Damages
Revere	$ 694	$ 629	91%
Lynn	490	328	67%
Saugus	241	175	73%
Total	**$1,425**	**$1,132**	**79%**

The Regional Plan offers almost $1.7 million reduction in the replacement and repair costs to the existing 30 miles of shoreline structures and piers (Table 12). These structures would no longer take the brunt of coastal storms and the resulting damage from overtopping, undermining and deterioration.

TABLE 12

DAMAGES TO EXISTING SHOREFRONT STRUCTURES
REDUCTION IN AVERAGE ANNUAL REPLACEMENT & REPAIR COSTS
(1988 Price Level, In $1,000)

Revere	$ 330
Lynn	390
Saugus	245
Piers	695
Total	$1,660

The Regional Plan would benefit many aspects of the regional economy. Benefits result to the 300,000 residents and employees, in the four communities of Lynn, Malden, Revere and Saugus, including the commuters who pass through their floodplains. Flood protection is provided to North Shore Road (Route 1A), Salem Turnpike (Route 107), the MBTA Blue Line, and the B&M Commuter Rail which serve North Shore communities to Boston. Many North Shore communities benefit from the protection of the Lynn Regional Waste Water Treatment Plant, Boston Gas Reserve Supply, and Mass. Electric switching station. Flood protection to other major industries and services include the General Electric River Works Company, Phillips Lighting and Norelco, West Lynn Creamery,

RESCO, Wonderland Park, Towle Industry Building, the General Edwards Bridge, North Shore Community College and hundreds of other companies and public buildings. The cost of the MDC's Town Line and Linden Brook Flood Control Project, scheduled for construction in the near future, would be reduced by nearly $1 million by eliminating the need for an extensive dike and wall along the shorefront. The average annual cost of this savings ($78,000) is a benefit from the Regional Plan.

The communities, state and Federal governments expend resources just about every year for emergency flood services. The Regional Plan is expected to result in an average annual savings of $163,000 in emergency costs.

Development is continuing throughout the study area floodplain. Benefits for future development includes those buildings currently under or nearing construction. Future developments include the high rise condominiums under construction along Revere Beach and the Lynn Harborside Landing. Benefits to these buildings are only taken above the 100 year event since their first floors must be above the Flood Insurance Base Flood Level.

Affluence benefits are the increase in value of residential contents. As content values grow the potential dollar amount of damages grow.

A national cost for the flood insurance program is its administrative expense. The cost of servicing flood insurance policies is determined based upon the average cost per policy, including agent's commission, and the cost of administering and adjusting claims. This benefit or reduction in cost is considered for all structures eligible for flood insurance.

The land behind Revere Beach is currently sloped toward the traffic and noise on Ocean Avenue, and offers little recreational opportunity. Development of the Park Dike behind Revere Beach results in 3,400 linear feet of parkland sloped toward a more pleasant easterly exposure to Revere Beach and buffered from the noise and activity along Ocean Avenue. The recreation opportunity of this currently under-utilized land is realized to the project by its projected increased use. The parkland will provide passive recreation for thousands of visitors throughout the year. It will also help to reduce the congestion that now results from people sitting on sidewalks and seawalls along Revere Beach.

The collective benefits from the Regional Plan are shown in Table 13. The 1988 price level was increased 4 percent to reflect inflation for the 1989 price level.

TABLE 13

SELECTED PLAN
ESTIMATED ANNUAL BENEFITS
NED REGIONAL SAUGUS RIVER FLOODGATE PLAN

Project Benefits	Average Annual Benefits 1988 Price Level ($1,000)
Flood Damage Reduction:	
Inundation Reduction	$ 7,064
Sea Level Rise	1,132
Storm Damage Reduction to Shorefront Structures:	1,660
Reduction in Future Costs to MDC's Town Line Brook Project	78
Other Cost Savings:	
Emergency Costs	163
Future Development	141
Affluence	244
Flood Insurance Overhead	59
Recreation Benefits	415
TOTAL 1988 Price Level	$10,956
TOTAL 1989 Price Level	**$11,390**

OTHER OPPORTUNITIES AND BENEFITS ASSOCIATED WITH THE PROJECT

The Saugus Marshes, one of thirteen areas in Massachusetts designated as an Area of Critical Environmental Concern, is under considerable development pressure. The value of land along the shorefront is escalating near Boston, and in the study area has reached as high as $1 million an acre. The pressure to expand properties and fill in the estuary is evident by the seven "cease and desist orders" issued by the Corps from July 1988 to January 1989. Development pressures are expected to increase with increasing real estate values. The project requires protection of the natural flood storage the estuary provides. The Regional Plan's features to acquire and protect estuary storage should considerably reduce and deter the loss of this valuable ecological resource. A safer port of refuge for the 400 vessels in the estuary and transient vessels would also be provided by the plan by preventing tidal surges from lifting vessels off their moorings. Economic benefits for this protection are not included in the analysis. Protection of resources in the marsh necessary for a thriving commercial fishery are not included in project economics, but would benefit the region.

Table 14 compares the impacts on the people, economy and natural and cultural resources of the study area of implementation of the selected plan versus what could be expected to occur if no action is taken to reduce vulnerability to coastal flooding. As the information in the table indicates, the selected plan provides opportunities to achieve significant environmental, economic and public safety objectives.

TABLE 14

COMPARATIVE IMPACTS (LONG-TERM)
NED REGIONAL FLOODGATE PLAN

RESOURCE EVALUATED	SELECTED PLAN	NO ACTION
Flood Protection	Protect 20,000 residents, as many employees, 5,000 buildings, 4 major transportation arteries and other North Shore utilities and resources.	Flood damages continue to increase with growth, affluence and sea level rise.
Hydrology	Eliminate flood tides above 8 ft NGVD (one year event). About 0.1% reduction in estuary flushing. Velocities at gate increased somewhat but assured safe for navigation.	Flood tides potential above EL. 12. Flushing increases with sea level rise and velocities increase.
Water Quality	Temporary (1-2) hour concentrated pollutants near source behind closed gates initially 2-3 times/year.	Improved quality with elimination of combined sewer overflow and increased flushing.
Wetlands	No impact, and wetlands protected with estuary storage protection.	Continued loss of wetlands of about 0.5 acres/year.
Benthic Habitats	2 acre intertidal and 1 acre subtidal loss mitigated by 2 acre new clam flat and 1 acre subtidal habitat. Also benefit from protection of estuary.	Some habitat loss from illegal fills.
Fish, Lobsters	Minor impact from mitigated benthic habitat loss. Minor impact from gates (reduced by size of flushing gates, rounded edges on gates and mitigated by protection of estuary and by construction of wetland fringe at mitigation site).	Impact from loss of benthic habitat and wetlands.

RESOURCE EVALUATED	SELECTED PLAN	NO ACTION
Wildlife	Minor impact with mitigated benthic habitat loss. Loss reduced by protection of estuary.	Impact from wetland and benthic habitat loss.
Rare, Threatened and Endangered Species	No impact.	No change from the present.
Sandy Beaches, Artificial Shorelines	At Point of Pines: 0.1 acres of beach lost; 6 acres of new beach created. Also, 1,600 feet of dunes would be removed, then replaced and replanted, atop the new revetment.	Revere Beach nourished by Corps project. Need for replacement of non-Federal structures along the Lynn and Revere shorefronts and along the estuarine shorefront would continue.
Historic and Archaeological Resources	No impact.	Possible impact associated with wetland loss.
Economics	Average annual flood damages or losses reduced by nearly $11 million. National economic development benefits: net increases of about $2 million per year.	Average annual damages and losses exceed $12 million.
Navigation	Safer port of refuge for existing 400 vessel fleet in the Saugus and Pines Rivers.	Continued vessel safety problems and damages along the rivers due to tidal flooding and surges.
Recreation	Protect existing recreation resources; develop new public parkland behind Revere Beach.	Improved recreational facilities in the communities. Revere Beach facilities upgraded and beach nourished by Corps project.
Visual Resources	Views blocked for 15-20 residences. Also, aesthetic impacts of structures.	No significant change.

SUMMARY OF PLAN ACCOMPLISHMENTS

The project would prevent the loss of life, injury, hardships, suffering and psychological affects of coastal disasters. It would also help protect the open space, aesthetics and resources of the estuary. Benefits include significant improvements to the future well-being of the region.

PROJECT JUSTIFICATION

The Benefit-to-Cost Ratio (BCR) indicates whether or not a project is economically justified. This comparison is done on an annual basis. The total estimated annual benefits and annual costs are shown below in Table 15. The BCR and net benefits for the NED plan show the project is economically justified. That is, the benefits outweigh the costs of implementation.

TABLE 15

Economic Analysis Summary (1989 Price Level)

Average Annual Cost	$ 8,990,000
Average Annual Benefits	$11,390,000
Benefit-to-Cost-Ratio (BCR)	1.3 to 1.0
Average Annual Net Benefits	$ 2,400,000

PLAN IMPLEMENTATION

This section describes the institutional requirements to implement the plan, including cost sharing and Federal and non-Federal responsibilities. The views of sponsors, Federal and State agencies, and other non-Federal interests are also summarized.

INSTITUTIONAL REQUIREMENTS

COST ALLOCATION

All measures of the selected plan are required for flood control; and their costs are allocated to hurricane and storm damage reduction. Although the park dike provides for joint flood control and recreation use, there are no separate or additional features or costs for recreation.

COST APPORTIONMENT

All of the requirements in the Water Resources Development Act of 1986, including those regarding cost-sharing have been reflected in this report.

For cost-sharing on structural hurricane and storm damage protection the Federal share is limited to a maximum of 65 percent for costs allocated to flood control. Costs allocated to recreation including the additional cost of the park dike embankment required for recreation are cost shared 50/50. Acquisition of necessary lands, easements, rights-of-way and all necessary relocations are all credited toward the minimum 35 percent non-Federal share for flood control. The entire non-Federal share must be paid during the construction period. Operation, maintenance and major replacements of the project facilities are also non-Federal responsibilities.

The costs as presented will be refined as project design is finalized during Preconstruction Engineering and Design (PED). Interest During Construction (IDC) is included on investment costs for the 1 to 4 year construction periods. Tables 16, 17 and 18 present a summary of project investment (reflecting consideration of the current Federal interest rate of 8 7/8 percent and IDC), Estimated Annual Costs and Cost Apportionment.

TABLE 16

ESTIMATED TOTAL INVESTMENT
REGIONAL FLOODGATE PLAN

	1989 Price Level
Total Project First Cost	$ 88,500,000
Interest During Construction	10,200,000
TOTAL INVESTMENT	**$ 98,700,000**

TABLE 17

ESTIMATED ANNUAL COSTS
REGIONAL FLOODGATE PLAN

	1989 Price Level
Interest and Amortization on Investment (8 7/8%, 100 years)	$ 8,760,000
Operation, Maintenance and Replacement	230,000
TOTAL ANNUAL COST	**$ 8,990,000**

TABLE 18

COST APPORTIONMENT
1989 Price Level

Cost Allocation:

Flood Control	$87,300,000
Recreation (Park Dike)	1,200,000
TOTAL FIRST COST	$88,500,000

Cost Apportionment:	**Federal Cost**	**Non-Federal Cost**
Contributions: Flood Control	$56,700,000 (65.0%)	$30,600,000 (35.0%)
Recreation	600,000 (50.0%)	600,000 (50.0%)
TOTAL	$57,300,000 (64.7%)	$31,200,000 (35.3%)
Lands, Easements, Rights of Way and Relocations (LERR)	——	$9,200,000
Remaining Cash	——	22,000,000*
	$57,300,000	$31,200,000
TOTAL PROJECT FIRST COST	**$88,500,000**	
Annual Operation, Maintenance and Replacement	——	$230,000

* Note: The cash contribution includes $21,400,000 for flood control and $600,000 for recreation.

IMPLEMENTATION RESPONSIBILITIES

The Local Cooperation Agreement (LCA) is a legal binding agreement of responsibilities between the Government and non-Federal sponsors needed in order to implement the project. The LCA includes: Obligations of Parties and Operation, Maintenance and Rehabilitation among other items.

OBLIGATIONS OF PARTIES

a. The Government, subject to and using funds provided by the local sponsor and appropriated by the Congress, shall expeditiously construct the project (including alterations or relocations of railroad bridges and approaches thereto), applying those procedures usually followed or applied in Federal projects, pursuant to Federal laws, regulations, and policies. The local sponsor shall be afforded the opportunity to review and comment on all contracts, including relevant plans and specifications, prior to the issuance of invitations for bids. The local sponsor also shall be afforded the opportunity to review and comment on all modifications and change orders prior to the issuance to the contractor of a Notice to Proceed. The Government will consider the views of the local sponsor, but award of the contracts and performance of the work thereunder shall be exclusively within the control of the Government.

b. When the Government determines that the project, or functional element thereof, is complete, the Government shall turn the completed element or project over to the local sponsor, which shall accept the project or element and be solely responsible for operating, maintaining, replacing, and rehabilitating the project or element in accordance with The Operation, Maintenance and Rehabilitation article.

c. As further specified in the Lands, Facilities and Relocation Assistance article, the local sponsor shall provide all lands, easements, rights-of- way, and perform all relocations and alterations of buildings, utilities, highways, bridges (other than railroad bridges and approaches thereto), sewers, and related and special facilities determined by the Government to be necessary for construction of the project (currently estimated at $9,200,000).

d. If the value of the contributions provided under paragraph c. of this Article represents less than 35 percent of the project cost associated with flood control, the local sponsor shall provide during the period of construction an additional cash contribution in the amount necessary to make its total contribution for flood control equal to 35 percent of the total project costs for that purpose (currently estimated at $21,400,000).

e. As further specified in Method of Payment, the local sponsor shall provide during the period of construction a cash contribution of 50 percent of total project costs allocated to separable recreation features (currently estimated at $600,000).

f. With respect to areas protected from floods by the project, the Local Sponsor shall through agreements with the communities, participate in and comply with the applicable Federal flood plain management and flood insurance programs.

g. No less than once each year the local sponsor shall, through agreements with the communities, inform affected interests of the limitations of the protection afforded by the Project.

h. The local sponsor shall publicize flood plain information in the area concerned and shall through agreements with the communities, provide this information to zoning and other regulatory agencies for their guidance and leadership in preventing unwise future development in the flood plain and in adopting such regulations as may be necessary to prevent unwise future development and to ensure compatibility with protection levels provided by the project.

i. The local sponsor shall, to the extent of its powers through agreements with the communities, prescribe and enforce regulations to prevent obstruction of or encroachment on the project, including the estuary area that would reduce the level of protection it affords or that would hinder operation and maintenance. To effectively operate the project and protect the required storage area, the selected plan calls for acquisition of the estuary storage area in fee or easement up to elevation 7 feet NGVD.

j. The local sponsor will ensure, through cooperative agreements with the communities, maintenance of existing project dependent, non-Federally constructed seawalls and associated protective works along the shorefront in Revere and Lynn.

k. The local sponsor through cooperative agreements with the communities, will maintain in good working order all existing tide-gate structures to the estuary area including for example, the Towle areas, Diamond Creek, Ballard Street and Town Line Brook tidegates. Any proposed future development in this area should be reviewed by the local sponsor to assess its impact on existing drainage problems.

OPERATION, MAINTENANCE AND REHABILITATION

a. After it is turned over by the Government, The local sponsor shall operate, maintain, replace, and rehabilitate the project or functional element thereof in accordance with regulations or directions prescribed by the Government.

b. The local sponsor hereby gives the Government a right to enter, at reasonable times and in a reasonable manner, upon land which it owns or controls for the project for the purpose of inspection, and, if necessary, for the purpose of completing, operating, repairing, maintaining, replacing, or rehabilitating the project. If an inspection shows that the local sponsor for any reason is failing to fulfill its obligations under this Agreement without receiving prior written approval from the Government, the Government will send a written notice to the local sponsor. If the local sponsor persists in such failure for 30 calendar days after receipt of the notice, then the Government shall have a right to enter, at reasonable times and in a reasonable manner, upon lands the local sponsor owns or controls for the project for the purpose of completing, operating, repairing, maintaining, replacing, or rehabilitating the project. No completion, operation, repair, maintenance, replacement, or rehabilitation by the Government shall operate to relieve the local sponsor of responsibility to meet its obligations as set forth in this Agreement, or to preclude the Government from pursuing any other remedy at law or equity to assure faithful performance pursuant to this Agreement.

OPERATION AND MAINTENANCE (O&M) OF FLOODGATE AND ESTUARY STORAGE

The operation and maintenance of the floodgates requires careful attention to many hydrologic variables to assure proper operation for flood control without adversely affecting the delicate estuary ecosystem and navigation interests. The project should be operated only for coastal storms and high tides which may cause damages which start at about EL. 8 ft. NGVD. Closure should occur about 2 to 3 times per year for only a few hours each time. With rising sea level, the number of operations is expected to gradually increase over the next century to about 40 times a year. Closure except in rare cases would generally occur at EL. 7; the gates would reopen when the ocean tide level recedes to the

estuary level. This elevation allows normal submersion patterns of estuary wetlands to remain largely unchanged. Frequent floodgate closures at one foot lower would significantly reduce the salt water from reaching wetlands. This should not be allowed to occur. To accurately predict closure in sufficient time to alert navigation interests, and yet not close the gates too soon, requires careful monitoring, knowledge of tidal parameters, and experience in interpreting developing storm conditions along the coast. Navigation interests must be alerted well enough in advance to assure sufficient time to allow vessels to enter the estuary for protection. Careful attention to tide levels, wind, temperature and interior runoff and required storage is important to assure that flood damages are prevented without causing damage to the ecosystem.

The Corps would prepare and provide an Operations & Maintenance manual in enough detail that any agency can conduct Operations & Maintenance given sufficient funds and manpower.

VIEWS OF NON-FEDERAL PARTIES — PRIOR TO FEASIBILITY REPORT REVIEW

An extensive public involvement process has been carried out throughout the study through the four Citizens Steering Committees, the Technical Group and coordination with other local, State and Federal interests. Workshop meetings with the Point of Pines residents and social surveys have also provided additional input into the evaluation of alternative plans. Contacts have been carried out during the study, through correspondence, informal and formal discussions, meetings and a field trip. Involvement of non-Corps interests has had a profound impact on the directions taken by the study as it progressed toward the development of a technically feasible, economically justified, socially and environmentally acceptable, implementable plan.

Congressman Edward J. Markey (7th Congressional District) expressed strong support for the project and development of a comprehensive plan to prevent extensive property damage, given the history of severe flooding (Letter dated 8 April 86). Congressman Nicholas Mavroules (6th Congressional District) reiterated support for the Regional Plan which offers maximum protection to the study area (Letter dated 13 April 87).

Letters supporting the Regional Plan have been received from the Metropolitan District Commission (State sponsor), the cities of Lynn and Revere, and the town of Saugus. State Representative Saggese (Revere) by letter offered his legislative support for funding. State Representative Angelo (Lynn and Saugus) in a meeting with Saugus and the Corps offered his assistance to establish funding for the Regional Plan. At the 23 June 1988 Public Hearing concerning the proposed Broad Sound Area of Critical Environmental Concern, (ACEC), state legislators Senator Doris (Revere and Saugus) and Representatives Reinstein (Revere and Malden), Angelo and Saggese spoke in support of the Regional Plan. At that same hearing, other area legislators, public officials and residents spoke or provided letters strongly supporting both the ACEC nomination **and** this Regional Flood Reduction Project, as well as other Corps projects. The Regional Project and other Corps projects were ultimately exempted from ACEC requirements.

Federal, State and local agencies have expressed strong appreciation for their involvement in the planning process, thus far. State Agency comments that have been made prior to review of this report include:

- The Metropolitan District Commission (MDC), in a letter dated 9 October 1987, stated their vital interest in the project and recommended the MDC be named as the proponent state agency, a recommendation which was accepted by the Secretary of the Executive Office of Environmental Affairs. In a letter dated 27 March 1989, the MDC requested assistance from the Corps to operate and maintain the floodgate structure with funds anticipated from the MDC (requiring legislative approval), and noted that the exception of the Flood Reduction Project from ACEC requirements had been mandated by strong community and statewide support for the project.

- MA Coastal Zone Management Office is interested in a detailed investigation of potential impacts in the estuary.

- MA Division of Fisheries and Wildlife is concerned about impacts on Black Duck feeding habitat.

- MA Division of Environmental Quality Engineering is concerned about any alteration of coastal resource areas.

Views of Federal Agencies have included:

- U.S. Environmental Protection Agency believes, from a Section 404 and overall environmental perspective, the Regional Plan is the most promising action. EPA's main concern with the Regional Plan is the protection of the estuary. EPA is also concerned about the loss of intertidal habitat along Lynn Harbor, and indicated the desirability of realigning the dikes to reduce this impact.

- The U.S. Fish & Wildlife Service favors the use of non-structural alternatives, such as flood insurance, viewing these approaches as least damaging to the wetland and aquatic resources of the study area. The F&WS is particularly concerned that project impacts be avoided on fish passage, that actions to reduce coastal flood vulnerability not induce development and increase loss of wetlands, that losses of intertidal habitat be avoided at Lynn Harbor and that the dynamics of the estuary not be affected, with or without sea level rise.

- Federal Emergency Management Agency has stated that the Regional Plan represents the most beneficial solution for tidal flood protection.

- National Marine Fisheries Service states that a flood damage reduction structure must (1) provide for the maintenance of the estuary's aquatic resources, (2) maintain tidal flushing and circulation and (3) minimize the disturbance of fish and shellfish populations.

VIEWS OF NON-FEDERAL PARTIES — FOLLOWING THE DRAFT FEASIBILITY REPORT REVIEW

A summary of public comments and Corps responses to letters received during the agency and public review process follows. Appendix J includes full copies of all comments and Corps responses.

Congressman Edward J. Markey (7th Congressional District) supported (Letter dated 25 August 89) the flood damage reduction study to solve the coastal flooding problems and after reviewing comments of the residents and city officials, concluded the Regional Floodgate Plan offers the highest level of protection with the least amount of environmental impacts for the residents of Revere, Malden, Saugus and Lynn. The Plan is reasonable and vital to the safety of the residents of these communities and to our environment.

Congressman Nicholas Mavroules (6th Congressional District) commented (Letter dated 10 July 89) that the Regional Plan would provide the highest level of coastal flood protection for the areas of Saugus, Lynn, Malden and Revere and projects a sound plan with high economic benefits and preservation of valuable environmental resources.

State Representative William G. Reinstein strongly supported the project and urged support of recommendations of those who are deeply concerned with both flood protection and what effect the floodgate construction could have on the estuary*.

VIEWS OF PROJECT SPONSORS:

Commissioner M. Ilyas Bhatti of the Metropolitan District Commission (Letter dated 5 Sep 89) expressed support as the Commonwealth's designated local sponsor. This project would provide a high level of coastal flood protection to the 5,000 buildings and the 400,000 residents, employees and commuters in this region which is frequently threatened and flooded from tidal storms. The project would also protect major industries, utilities, transportation arteries, recreational facilities, a valuable salt water estuary, navigation fleet and other resources important to Boston and the north shore. The MDC intends to sign the Local Cooperation Agreement (jointly with the communities for those items not solely within MDC's authority including protection of the estuary*, enforcement of flood plain management and maintenance of existing features) and will request funds from the Legislature to meet the State's cost share.

In a subsequent letter dated 5 August 1989 the MDC expressed concerns for the protection and size of the mitigated clam flats*, coordination with Point of Pines residents, the possibility to use the floodgates as a fishing site, the possibility to reuse the dredged sand at the floodgates, the need to use natural material on the floodgates for aesthetics, the need of coordination of all parties to ensure funds are legislatively mandated and the need to insure protection of the estuary*.

*See "Project Revisions Following Draft Report Review", which follows this section.

Mayor Albert V. DiVirgilio, City of Lynn, (Letter dated 23 Oct 89) stated that the city remains in favor of the Regional Plan as the preferred alternative and intends to support the MDC in petitioning the State Legislature for project funding. The city would adhere to obligations essential to the plan and cited those local assurance items not within the direct control of the MDC. Direct coordination with the Corps was requested throughout the design phase.

Mayor James S. Conway, City of Malden (Letter dated 24 Oct 89) expressed support for the Regional Plan to protect the four communities, eliminate the threat of tidal surges and improve the flood storage capacity of the marshes*. He intends to request the State legislature to fund the project at the appropriate time currently scheduled for 1994.

Mayor George V. Colella, City of Revere (letter dated 25 July 89) stated the city strongly supports the general principle and concept of the Regional Plan because of the very high level of coastal flood protection it provides. The location of the floodgate structure must insure minimal disruption of the beach and tidal area at the mouth of the estuary*. Also the city supports dune restoration and sand replenishment in lieu of a stone revetment along the ocean front of Point of Pines. He intends to request the state legislature fund the project at the appropriate time, and agrees to those items of local cooperation not within the direct control of the MDC.

Revere City Councilor John R. Arrigo is very supportive of the overall plan to prevent devastation when coastal storms ravaged the low-lying areas of the four communities. His main concerns were that: the Point of Pines beach remain in the control of the association; the Floodgate dike be replaced by a wall tieing in near the pump station*; the revetments be replaced by sand dunes; the area be landscaped and dune grass be replenished; a strict maintenance and operation plan be established with an escrow account to cover all maintenance costs; and other concerns regarding coordination with Point of Pines residents and protection of the estuary*.

Revere City Councillor Linda (Santos) Rosa appreciated the efforts in bringing a plan of this nature to Revere and looks forward to working to improve the plan. Major concerns are reduction in construction* and aesthetic impacts and assure a high degree of flood protection at Point of Pines, as well as effective operation of the gates.

The Revere Planning and Community Development Office stated that the Regional Plan provides the highest level of flood protection to the Point of Pines and backshore areas of Revere, Malden, Saugus and Lynn. Also, the Point of Pines should retain control of their beach to preserve an environmentally sensitive coastal resource. Landscaping and access to the shorefront should be provided, sand dunes in lieu of revetments should be explored, the floodgate dike minimized to reduce beach impacts*, and a strict operation and maintenance plan be established.

The Revere Beach Citizens Advisory Committee supports the Regional Plan and agrees the plan provides a high level of flood protection. All efforts must be made to minimize disruption at the beach and tidal area at the mouth of the estuary*, and supports the use of dunes in lieu of revetments at Point of Pines.

*See "Project Revisions Following Draft Report Review", which follows this section.

The Oak Island Residents Association supports the Regional Plan both from a flood protection and environmental standpoint. The dynamics and ecological balance of the estuary must be maintained, and protecting the estuary and storage area from development*.

The Pines Riverside Association feels the Regional Plan provides the highest level of flood protection with the least amount of environmental impact and is necessary due to rising sea level. Concerns relate to protection of the critical estuary from development*, Point of Pines maintaining control of their beach and dunes, and a wall be used in lieu of a dike at the floodgates to tie in near the pump station*.

Mr. Norman B. Hansen, Town Manager of Saugus (Letter dated 25 July 89) reaffirmed the town's interest in controlling flood damage in the Saugus River. The Town plans to continue its flood insurance program and is pledged to enforcing all wetland laws, and recognized there is limited or no funds available within the Saugus budget at this time to maintain or operate the flood control gates. In a subsequent letter dated 22 March 1988, the Saugus Board of Selectmen voted to go on record in favor of the Saugus River Floodgate Plan.

The Saugus Conservation Commission commented the project has great merit in the amount of protection afforded to the greatest number of homes and businesses in the study area. Major concerns were expressed for the ecosystems of the salt marsh in the rare event the gates close longer than anticipated coincidental with heavy fresh water runoff, the need to zealously guard the existing estuary/flood storage area*, and urges the state to fund the non-Federal portion of the project cost.

VIEWS OF STATE AGENCIES:

John DeVillars, Secretary, Executive Office of Environmental Affairs, issued the Certificate stating that the draft EIR properly complies with MEPA and its implementing regulations and was pleased that the joint EIS/EIR process has moved towards an informed decision on both the Federal and State level. The final EIR must follow up the issues and identify the need for future compensatory storage behind the structures. The tidal flood zone data should be reviewed by the appropriate FEMA staff so the predicted flood elevations can be adopted by the affected communities upon implementation of the project.

The Massachusetts Coastal Zone Management Office stated their satisfaction with the coordination efforts that accompanied the generation of the Draft Report. Their major comments addressed the following concerns: the nonstructural methods are preferred over more costly structural ones, and would like more detail*. Their office does not favor the structural approach; the affect of tidal flushing*, runoff and gate closure on water quality*; the mitigation should be at a 2 for 1 replication; and the mitigation site adjacent to the highway is not desirable*; illegal filling continues in the estuary and pressures on the estuary will increase with the project*; ownership of the salt marsh must be an integral component of the Plan*; once the present sea-level condition is exceeded, the number of annual gate closures and duration will begin to be more significant to potential estuary impacts*, and the projected rates of sea level rise should be anticipated and planned for before approval of a project of this magnitude*.

*See "Project Revisions Following Draft Report Review", which follows this section.

The MA Department of Environmental Management believes a nonstructural approach is preferable and structural solutions should be implemented only if nonstructural techniques and fail to meet the desired goals*. In an effort to assess the level of protection provided for the dollars spent on this project, an itemized cost report is needed which would provide projected costs necessary to achieve 100% protection through nonstructural measures of the four major vulnerability categories—transportation, employment, property damage, and personal safety, for the 100 year flood with a foot of sea level rise and the SPN level*. Other measures of concern are a Community Floodplain Management Plan, an inter-community Commission to monitor and oversee land use after construction of the floodgates, a Comprehensive Emergency Management Plan, and induced development in the floodplain*.

The Department of Environmental Protection supports nonstructural means to provide flood protection and the measures should be addressed in more detail*. The impacts of developing the mitigation site surrounded by salt marsh and other resources should be investigated*. More detail is needed on the immediate and long term project impacts*, and on the long term State/local financial commitment. Failure of the structure could have severe environmental consequences. Variance issues need to be more fully discussed in relation to the criteria, including the nonstructural option for the wetland regulations*, and criteria affecting the Waterways Licenses.

Massachusetts Executive Office of Transportation and Construction requested the proponents work closely with the MA. DPW in developing plans for mitigation and other improvements which may affect state highways.

Metropolitan Area Planning Council believes the DEIR adequately describes environmental impacts associated with recommended mitigation of the flooding.

MA Division of Fisheries and Wildlife stated the proposed project will increase the value of protected areas, encouraging further development* and provide windfall profits to existing landowners. They believe protective retaining walls should be built on upland sites instead of tidal and subtidal areas*, and wintering black ducks in Lynn Harbor* are not likely to use riprapping for food supplies. Success or failure of mitigative measures should be determined prior to destruction of habitat, and the project will increase pressure to dredge and provide moorings resulting in wetland losses*.

MA Division of Marine Fisheries believes that the Regional Plan which reduces flushing less than 0.1 percent, eliminates tides above the maximum astronomic high water, produces gate velocities slightly higher than found presently, and does not promote larval fish impingement, would result in minimum adverse impacts to resident and migratory fish. However, with sea level rise increased gate closures may lead to temporary reduction in water quality behind the gates and to the potential for long-term ecological impacts*. The destruction of 9.4 acres of shellfish habitat* would be an unnecessary and avoidable impact, while nonstructural measures are supported.

*See "Project Revisions Following Draft Report Review", which follows this section.

VIEWS OF FEDERAL AGENCIES:

Federal Highway Administration, Region One commented that the mitigation site might impact Massachusetts DPW plans to construct a "Revere Beach Connector" and MDPW should be contacted.*

USDA Soil Conservation Service stated the proposal is a significant flood protection program for this vulnerable coastal urban area.

U.S. Fish and Wildlife Service supports non-structural solutions and was unable to support the floodgate alternative because the project would: induce development in the estuary causing wetland losses*; cause the loss of aquatic habitat, and impact on black ducks, other waterfowl, shellfish and water quality from construction of the Lynn Harbor dikes on the tide flats*; and adversely affect the ecology of the estuary by future project operations in conjunction with rising sea level*.

Department of Health and Human Services, U.S. Public Health Service concur that the proposed flood protection will greatly reduce the risks to life, health and safety faced by residents and businesses in the project area, and the Regional Floodgate Plan is the most feasible alternative.

USDI, Office of Environmental Review supports nonstructural measures and commented that the Regional project should avoid impacts to productive habitat in Lynn Harbor*; avoid adverse affects on fish passage*; acquire the wetlands in fee or easement to avoid induced development*; and mitigate the potential affects of increased project operations and impacts associated with future rates of sea level rise.*

U.S. Environmental Protection Agency commented: that the Regional Plan does not comply with EPA Section 404 Guidelines because the placement of fill on intertidal and subtidal habitat in Lynn Harbor can be avoided*; that strategies to preserve the wetland and floodplain land be developed as part of the mitigation plan*; and, that the areas behind existing tide gates be restored to productive salt marsh by removing existing tide gates or replacing them with self-regulating tide gates. Design or operation of the floodgates over the life span of the project, such to, impede or block existing fish migration or to reduce inundation of wetlands may affect Massachusetts water quality certification*. Minimal dredging is desirable and should be strived for, and removal of the I-95 fill for restoring the wetlands is supported.

National Oceanic and Atmospheric Administration, National Ocean Service, Office of Charting and Geodetic Services commented that because the overall plan is expected to provide protection from flood damage, C&GS agrees that the recommended plan provides the optimum solution for all concerned. Since the floodgates would adversely affect navigation during construction, mariners and C&GS should be kept informed of the hazards created and plans during this period, and for later depicting on nautical charts.

*See "Project Revisions Following Draft Report Review", which follows this section.

National Marine Fisheries Service requested the project avoid filling in intertidal areas*; mitigate at a 2 to 1 ratio; seek alternatives to reduce restricted flows*; address concerns for forecasted conditions of sea level rise*; reduce the 13.2 acres of aquatic habitat loss*; and consider a combination of non-structural alternative (flood warnings, land acquisition*, removal of the I-95 fill; levees, landward structures*, etc.) to minimize adverse impacts.

VIEWS OF INTEREST GROUPS:

Point of Pines Yacht Club strongly supports the Regional Plan and floodgate location, which protects their property.

Saugus Action Volunteers for the Environment (SAVE) endorses the floodgate plan which should protect the estuary and the properties of many Saugus residents. SAVE also commented that the ocean would no longer be allowed as the compensatory storage area for any wetland filling. The state should consider this project as an economic gain because the cost in disaster relief, damage to roads and loss of taxable business income in the event of major storms would exceed the State cost of this project over its life expectancy.

Bay Marine, Inc., a waterfront marine business in Lynn Harbor endorses the plan to construct coastal flood protection in the communities and request it be expedited. The difficulties faced by shoreline owners and users are of minor consequence when compared to the massive social disruption and property damage caused by coastal flooding.

Concerned Coastal Sportsmen Association, Inc. agree that the Regional Plan is most effective. Major concerns are to ensure the traditional activities of the area are not impinged by any construction impacts, i.e., pollution, extreme sedimentation, insufficient tidal flow, disturbance of wildlife habitat.

Nahant Safer Waters in Massachusetts stated the project should not be built as it would set a dangerous precedent for damming up salt marshes coast to coast, and the natural processes will be destroyed, and the slow shoreward march of Revere Barrier Beach cannot be stopped.

Massachusetts Association of Conservation Commissions, Inc., is not in favor of the floodgate project but supports the nonstructural option as it eliminates the environmental impacts. They fear the project would promote development and filling in the marsh*, and questions the threat of coastal flooding. They are opposed to the loss of Black Duck habitat in Lynn Harbor*. Protection to the SPN level is rare and unusual, ruling it out by Corps guidelines. Although the floodgates have been designed to accommodate most of the concerns of fisheries experts, they believe future stages to reduce costs will lead to reduced gates without concern for the environment*. They are alarmed at the proposal to turn over the operation of the floodgates - hopefully never to be built - to other than Corps personnel.

*See "Project Revisions Following Draft Report Review", which follows this section.

Massachusetts Audubon: North Shore is strongly opposed to the Regional Plan since it would destroy valuable intertidal* and subtidal habitat*, foster development in the floodplain*, encourage the development of the salt marsh*, and counter well-established environmental policies. They recommend developing a nonstructural plan*, acquiring the wetlands*, and providing greater than 1:1 mitigation. Concern was expressed for impacts related to increased closures with sea level rise*, loss of black duck habitat in Lynn Harbor*, restricting flows, altering contaminated sediments, use of government funds to encourage growth and development*, the disruption of natural sand movement and monitoring mitigation.

Conservation Law Foundation of New England, Inc., found that the draft EIS/EIR was seriously flawed and inadequate in presenting nonstructural alternatives*, protecting the wetlands*, flood development*, intertidal habitat losses in Lynn Harbor*, fish passage impacts* and the potential for wide-scale ecological impacts within the estuary from increased floodgate operation in the future*, mitigation proposals and the cost/benefit analysis.

Sierra Club, New England Chapter cannot support the Regional Plan due to the substantial impact it has on the surrounding tidal and wetland areas*, although recognizes the need to prevent future flooding and damage to the communities by implementing a plan that is the most successful for that area. Concerns included* that the plan adopted should have as little impact upon this ACEC area as possible, sea level rise and gate closures*, future development in the floodplain*, loss of intertidal habitat*, and implementing a nonstructural plan*.

New England Fishery Management Council is concerned about the potential impact of the project on marine fish resources within the estuary and Lynn Harbor*. A series of questions were provided with responses in Appendix J.

VIEWS OF INDIVIDUALS:

Michael F. Furlong, Revere, recommended placing the project to prevent flooding from entering near the Point of Pines Yacht Club* and extend the Pines pumping station outlet.

Joseph Felzoni, Revere, is in favor of the flood project, eliminating NFIP premiums, consideration given to Point of Pines tax payers whose area is being used, concern for their private beach and dunes, easy access to the waterfront, and maintenance of the facility.

Stephen A. Swidler, Philips Lighting, Lynn, is concerned about the blockage of his access road during construction.

William F. M. Hicks, Cuddy, Lynch, Manzi & Bixby Attorneys at Law, is concerned about potential impacts to future developments at the Lynn South Harbor property*.

Alexandra D. Dawson, Hadley, MA. writing on behalf of MACC and Sierra Club stated that the floodgate plan is a bad option environmentally since it encourages development of the floodplain and wetlands*. The nonstructural plan*, estuary acquisition*, reduction of black duck impacts in Lynn Harbor*, project operations, and SPN protection were major concerns.

*See "Project Revisions Following Draft Report Review", which follows this section.

PROJECT REVISIONS FOLLOWING DRAFT REPORT REVIEW

Major revisions to the report as a result of the review process include:

- an evaluation of a total nonstructural plan to compare its cost and effectiveness to the other options;
- additional evaluation of the sensitivity and modifications of the Regional Plan due to accelerated sea level rise to avoid frequent closures and associated estuary water quality and wetland impacts and restore the level of protection lowered by sea level rise;
- eliminating the intertidal impact and impact on Black Ducks from the Lynn Harbor dikes by moving structures inland;
- eliminating over an acre of lost beach and intertidal impact at Point of Pines by replacing the Floodgate dike with a gravity wall tieing in near the pump station which also reduced the construction time 4.5 months and the interest during construction;
- reducing the total intertidal impact on clam flats from 9.4 acres to 2.0 acres and thus reducing the size of the mitigation site;
- relocating the mitigation site away from the proposed location of the Revere Connector highway;
- eliminating the concern that the project would induce secondary development and wetland filling thus, promoting long term impacts in the estuary and significantly improving the capability of the sponsor to protect the estuary storage area through acquisition of the estuary storage area;
- reducing the concern for impingement of plankton and juvenile fish on the floodgate since all gate edges would be rounded;
- summary of Public Views following Draft Report review;
- the extra embankment at the park dike is cost shared 50-50 for recreation;
- evaluated the sensitivity of the Revere Beach Erosion Control Project to reducing overtopping and damages;
- determined that protection afforded by the Park Dike, as well as Point of Pines, can be separately optimized and flood damage benefits result upon their completion, reducing the interest during construction;
- revised the project costs and economic analysis of the plans to reflect project changes; and,
- Obligations of Parties and O&M requirements appear verbatim from the draft Local Cooperation Agreement.

See separate list of revisions to EIS/EIR following page EIS - 2.

PROCEDURE

This report was submitted to the Board of Engineers for Rivers and Harbors (CEBRH), and the Office of the Assistant Secretary of the Army (OASA) for review and approval. The Board will review the report and comments received in response to the Division Engineer's Public Notice, and send its recommendations to the Chief of Engineers who will solicit formal review and comment from the Governor and interested Federal and state agencies.

Following the state and interagency review and after receipt of comments from the Office of Management and Budget regarding the relationship of the project to the program of the President, the final report of the Chief of Engineers will be forwarded by the Secretary of the Army to Congress. Congressional authorization of the proposed project will be required and the report will be submitted to the appropriate Congressional committee for consideration. Congressional procedure normally includes review and hearing by the Public Works Committees and authorization by inclusion in legislation.

Upon completion of the study and submission of the final report to the CEBRH, Preconstruction Engineering and Design (PED) will begin if there are no significant unresolved issues with the report recommendations and require about four years to complete. Plans, specifications, and detailed estimates will be completed prior to advertising for bids and awarding of construction contracts.

Once the construction funds are appropriated, the sponsor must satisfy the requirements of local cooperation, including signing the Local Cooperation Agreement (LCA) and providing for the non-Federal share of the project cost. Construction of the project would be accomplished in about four years.

CONCLUSIONS

Analysis of alternative flood damage reduction measures indicate that protection is both technically and economically feasible, and socially and environmentally acceptable. Below are concise statements relating to some of the conclusions developed during the study:

EXISTING AND HISTORICAL CONDITIONS

- Serious threat of flooding exists with potential damage in the millions of dollars. Area residents suffered through the Blizzard of '78 with 3,100 buildings flooded and over 4,000 evacuated in freezing weather. Many have experienced four major floods in the last 17 years. A recurrence of the "Great Blizzard of 1978" (a 100-year event) would result in losses exceeding $100 million to area residents and businesses.

- Tens of thousands of commuters are cut of from direct access to and from Boston by the flooding of four major north shore transportation arteries.

- The public desires improvements offering a high degree of protection.

- Effective advanced flood warning and evacuation for the communities is not possible due to the large areas involved and complexity and uncertainty of forecasting.

- Sea level has been rising relative to the land along the northeast coast at a relatively slow rate of almost one foot per century, causing gradual retreat of beaches and marshes, with increased water depths, wave action and flooding. We are now faced with the possibility of accelerated sea level rise.

- Illegal filling in wetlands continues, despite strong regulatory constraints. The salt-water estuary has lost wetlands at a rate of about 0.5 acres per year since 1978.

FUTURE WITHOUT CONDITION

- The study area will continue to grow in population, number of household units, businesses and industries largely at the expense of existing developed areas. Future average annual damages and losses would exceed $12 million to 5,000 residential, commercial, industrial and public buildings and major transportation arteries. A recurring coastal storm similar to the Blizzard of '78 would cause damages estimated to exceed $100 million. A Standard Project Northeaster would approach $500 million.

- Loss of wetlands due to illegal filling is expected to continue at a rate of about 0.5 acres per year without the Regional Project.

- The threat of flooding and its associated damages will continue to grow due to growth in the number of households and businesses, more intensive development of the floodplain, greater affluence and rise of sea level.

- Any reduction in potential flood losses resulting from nonstructural measures taken by individual property owners is not anticipated to be significant. Coastal flood forecasting and warning for effective evacuation is not expected to improve.

ALTERNATIVES

Three principal options were investigated during this study. The Selected Plan (Regional Saugus River Floodgate Plan) offers a very high degree of protection, reduces severe flooding and demonstrates the highest net benefits of any plan. There are no significant adverse environmental or social impacts. (See Table 18.) This selection has been supported by the cities of Lynn, Malden and Revere and the town of Saugus. The Metropolitan District Commission has expressed a vital interest in the project and, at its request, was approved as the proponent state agency.

RECOMMENDATIONS

I recommend that the Regional Saugus River Floodgate Plan, selected herein to reduce coastal flood damages in Lynn, Malden, Revere and Saugus, Massachusetts, be authorized for implementation as a Federal project, with such modifications as in the discretion of the Chief of Engineers may be advisable; at a first cost presently estimated at $88,500,000.

This plan incorporates existing seawalls, beaches and tide gates with proposed walls, dikes, revetments, and dune and beach restoration along the Revere and Lynn shorefronts, includes construction of a floodgate structure across the mouth of the Saugus River and acquisition of about 1660 acres of estuary storage area including a ponding area near the north end of Revere Beach. The plan would result in some loss of intertidal and subtidal habitat, for which mitigation is planned through the creation of clam flats and subtidal habitat. A flood forecast, warning and evacuation plan would be developed for the communities. The combined elements of the plan provide protection to over 5,000 structures in the floodplain and prevent nearly all the damages from coastal flooding in the study area.

This recommendation is subject to the provision that a non-Federal, public sponsor agree to all items and provisions required in accordance with the Water Resources Development Act of 1986. These include, but are not limited to:

1) a total contribution equal to 35.3 percent of the project first cost. The non-Federal share (currently estimated at $31,200,000) includes the value of lands, easements, rights-of-way and relocations, and a required cash contribution.

2) provision without cost to the United States of all lands, easements, and rights-of-way necessary for construction of the structural elements of the project; and of all alterations and relocations made necessary by construction of the project;

3) protection of the natural storage capacity of the estuary through acquisition and protection of the estuary storage area, sound floodplain management, and public education;

4) operation and maintenance of the project in accordance with regulations prescribed by the Secretary of the Army;

5) ensured maintenance in good working order of all project-dependent, non-Federally constructed protective works along the shorefront and estuary; and

6) hold and save the United States free from damages due to construction, operation and maintenance of the project, not including damages due to the fault or negligence of the United States or its contractors.

I have considered all significant aspects in the overall public interest including environmental, social, and economic effects, and engineering and financial feasibility in concluding that the NED plan of protection described herein is the best implementable alternative meeting the objectives of this investigation subject to final comments and financial commitment.

DATE 14 Dec 87

Daniel M. Wilson LTC, CE
Colonel, Corps of Engineers
Division Engineer

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 transmitted to the Congress as proposals for authorization and implementation funding.

ACKNOWLEDGEMENTS

ACKNOWLEDGEMENTS

SAUGUS RIVER AND TRIBUTARIES FLOOD DAMAGE REDUCTION STUDY CITIZEN STEERING COMMITTEES

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Rep. William Reinstein (Revere and Malden) and James Powers, Aide
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SAUGUS RIVER AND TRIBUTARIES FLOOD DAMAGE REDUCTION STUDY

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