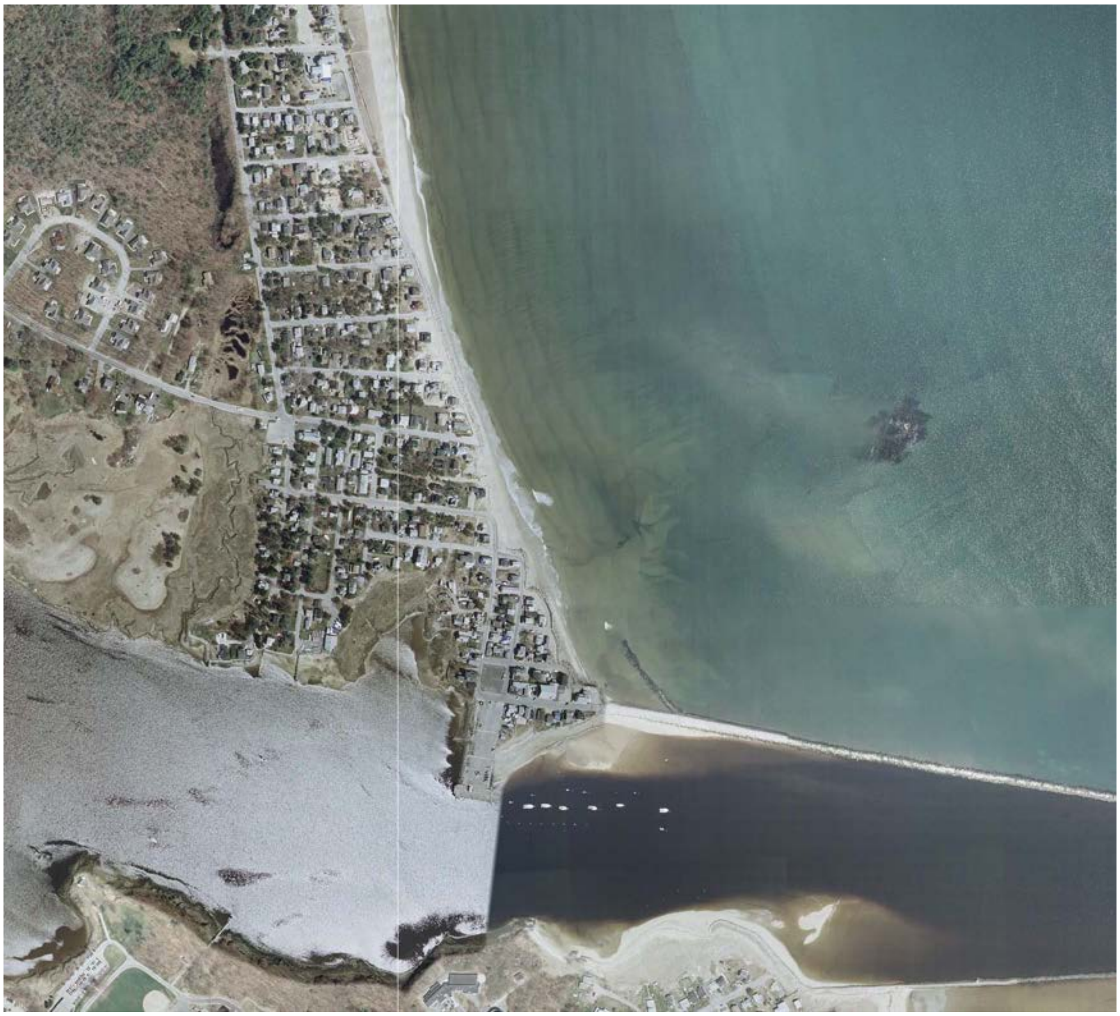
Section 111 Shore Damage Mitigation Project
Draft Decision Document and Environmental Assessment
Including Finding of No Significant Impact
and Section 404(b)(1) Evaluation

Saco River and Camp Ellis Beach
Saco, Maine



April 2013

US Army Corps
of Engineers®
New England District

Executive Summary

This Decision Document for shore damage mitigation at Camp Ellis Beach in Saco, Maine was prepared under the continuing authority of Section 111 of the 1968 River and Harbors Act, as amended. The report consists of a main report summarizing the existing conditions of the project area, problem identification, plan formulation and evaluation, and a recommendation. An Environmental Assessment of the proposed action is included with the report. Appended supporting documentation includes Pertinent Correspondence, Coastal Engineering Study Reports, Geotechnical Design, Engineering Design and Cost Estimates, Economics, Real Estate and Archaeological Survey. The study accomplished the following:

- Examined existing conditions and assessed the extent of problems associated with shoreline erosion caused by the existing Saco River Navigation project.
- Developed and evaluated alternative solutions to shoreline erosion at Camp Ellis Beach.
- Assessed the environmental and other impacts of alternative solutions and the recommended plan.
- Determined the extent of Federal interest in participating in mitigating for shoreline erosion.
- Developed the most cost effective plan to mitigate for shoreline erosion caused by the Federal navigation project.
- Identified the capability and willingness of the non-Federal sponsor, the city of Saco, Maine, to participate in recommended improvements.

Camp Ellis Beach is located in Saco, Maine, about 16 miles south of Portland, Maine. The beach is situated on the southern portion of the Saco Bay shoreline near the mouth of the Saco River (See Figure 1). At the entrance to the river, the Saco River Federal Navigation Project consists of an 8-foot deep channel, 200 feet wide, that is protected by a 6,600-foot long jetty to the north and by a 4,800-foot long jetty to the south. The navigation project currently supports a wide variety of commercial and recreational activities. A commercial fishing fleet of nearly 40 vessels anchors and unloads at the fishing pier at Camp Ellis. The pier is also used by several charter and sport fishing boats. A commercial boat yard, situated further upstream on the Biddeford side, manufactures and services commercial and pleasure craft. Approximately 120 tons of paper products are also exported from this boat yard yearly. The project supports the State's largest recreational boating and fishing population. There are three marinas that provide berths or moorings for about 290 recreational boats, and three public boat ramps provide additional access to the river. The State ramp at Meeting House Eddy is the most heavily used ramp in the State with over 300 launches per day. Other related activities, such as marine programs at the University of New England and kayak rentals, are supported by the project.

As shown on Figure 2, Camp Ellis Beach lies adjacent to the north jetty and extends about 2,500 feet north to Ferry Beach. The north jetty separates the river from Camp Ellis Beach to the north. The Federal navigation project was authorized and constructed in several increments between 1828 and 1968. Initial construction included stone and timber crib jetties in the river and two jetties at the river mouth with stone beacons. Persistent inlet instability and shoaling resulted in the reconstruction and extension of the north jetty between 1867 and 1873. Shoaling continued as sediment continued to collect in the navigation channel and areas along the Biddeford coastline south of the inlet. This prompted construction of a south jetty that was initiated in 1891. This jetty has contained the sand that is present in areas to the south, and wave forces in this area have formed a typical crescent shaped beach south of the jetty and accretion on the south side of the jetty. Channel instability continued and the south jetty was extended to 4,800 feet in 1911. Severe erosion on the north side of the north jetty prompted construction of a 400 foot spur jetty in 1912 to prevent flanking of the jetty. Continued erosion in this area has overwhelmed this jetty which can now be seen as a dispersed ribbon of rocks about 300 feet from shore. Inlet instability continued and sections of the north jetty were raised and tightened, and sections were added in 1930 and 1938 to achieve the current length of 6,600 feet. The navigation project provides for navigation safety at the mouth of the river and a reduction in the frequency of maintenance of the lower river channel and anchorage areas. During the last modification in 1968, the shoreward end of the north jetty was raised and tightened to reduce the maintenance dredging frequency in the river channel. The area of Camp Ellis beach within about 2,500 feet of the jetty has experienced severe erosion over the past several decades, with losses of over 30 homes and property, roadways, and public and private infrastructure. These continuing losses prompted the city of Saco to request Federal assistance from the Corps of Engineers to reduce or eliminate further shoreline impacts. Historic shoreline positions and shoreline areas lost to erosion are shown on an aerial photo included as Figure 3.

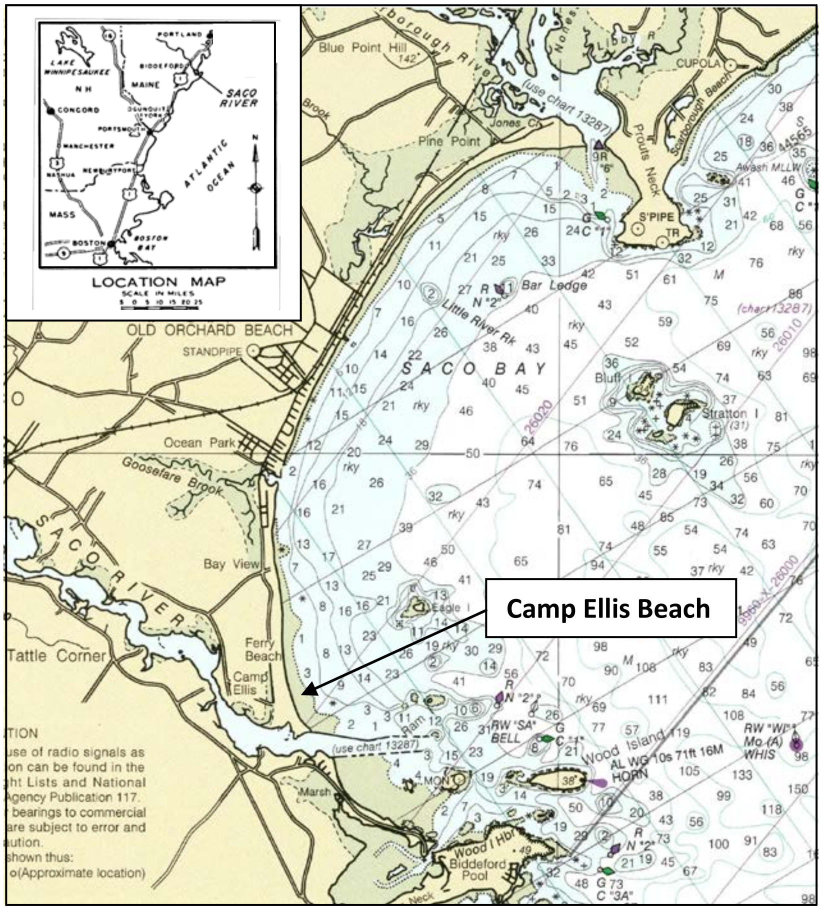


Figure 1 – Saco Bay

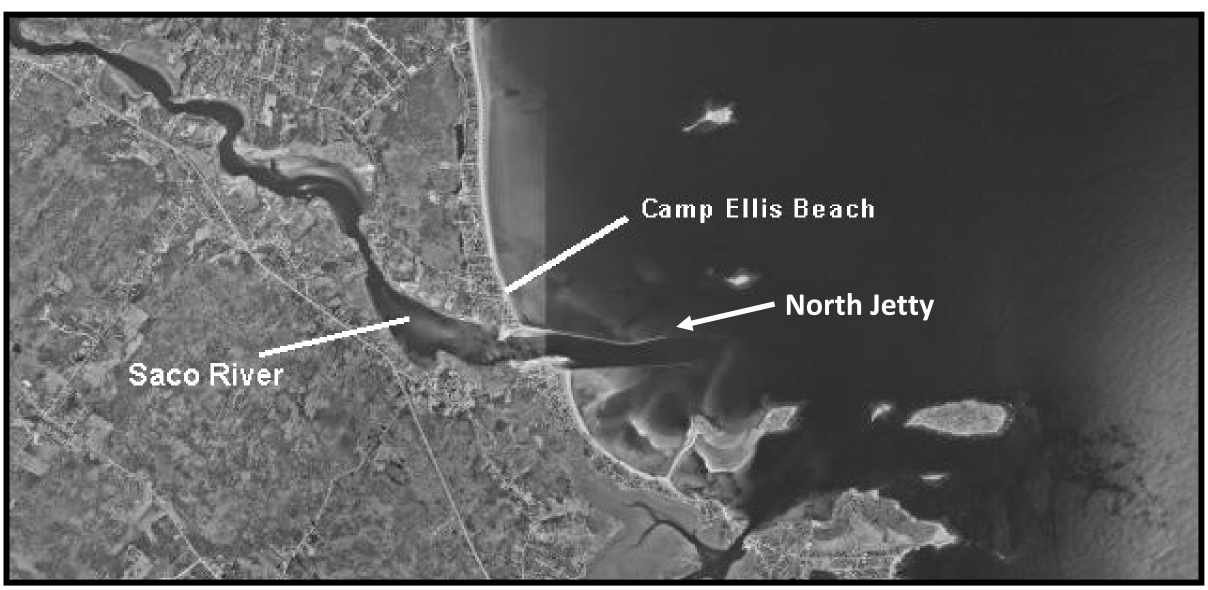
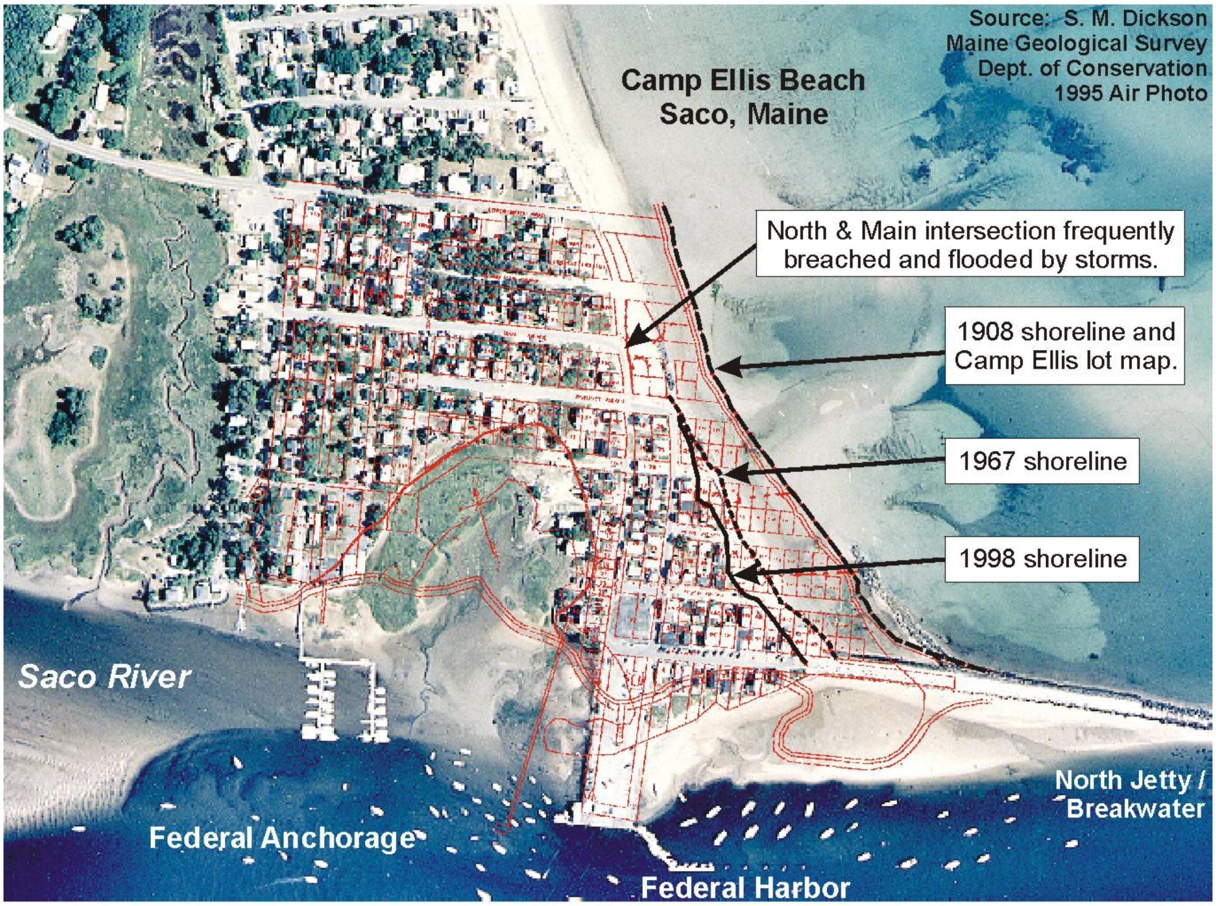


Figure 2 – Study Area

Past Shoreline Positions



Over 30 properties have been lost in less than 100 years. Historical lot map modified from Appendix E of the Saco Bay Regional Beach Management Plan, 2000. Shorelines mapped in 1998 by the Saco Bay Beach Erosion Committee.

Figure 3 – Historic Shoreline Positions

Section 111 provides authorization for the Corps of Engineers to study, plan and implement structural or nonstructural measures to prevent or mitigate damage to shorelines to the extent that such damages can be directly attributable to Federal navigation projects. The Federal share of costs for any one project is normally $5 million. However, as costs of plans to mitigate further shoreline erosion were expected to exceed this limit, action by the Maine Congressional delegation resulted in the inclusion of Section 3085 in the Water Resources Development Act of 2007 that raised the limit at Camp Ellis to $26.9 million.

Shoreline change at Camp Ellis has been the subject of numerous studies over the years. These studies, conducted by the Corps and others, indicate that the Saco River has been the primary sediment source for the Saco Bay beaches, and that the primary direction of sediment movement along the shoreline is south to north. However, with construction of the north jetty, sands from the Saco River were retained in the channel or transported offshore into deeper waters, and were not available as beach nourishment at Camp Ellis Beach. The other major impact to the area is significant wave reflection off of the northern jetty. Upon impacting the structure, waves are reflected back towards Camp Ellis Beach and a portion of shoreline directly adjacent to the breakwater is impacted not only by incident wave energy, but also by reflected wave energy. In summary, the destabilization of Camp Ellis Beach and the resultant high erosion rate can be attributed to several factors directly related to construction of the north jetty. These include interruption of natural riverine sediment supply to the downdrift beach, diversion of riverine sediment farther offshore, and wave focusing along the beach due to reflection of waves by the breakwater.

Mitigating for shoreline loss along Camp Ellis involved the development and evaluation of a wide range of alternatives that included both structural and non-structural measures. Structural measures included jetty removal or modification, and construction of spur jetties, breakwaters and T-groins along the beach. Beach nourishment, as a stand-alone alternative, or in conjunction with other measures was also considered. The primary non-structural alternative was the purchase and demolition of structures within the potential area of erosion. The effects of structural alternatives were evaluated using the results of extensive modeling studies that were conducted as part of the study. These modeling studies included extensive data collection and numerical modeling to simulate existing conditions in the vicinity of Camp Ellis. The numerical modeling portion of the study was used to evaluate the performance of each considered alternative. Final screening of alternatives was conducted based on performance, cost effectiveness, completeness, effectiveness and acceptability. This screening resulted in the selection of Alternative 6 (750-foot long spur jetty and beach nourishment) as the recommended plan. This alternative is the least costly, technically feasible, and environmentally acceptable shore damage mitigation plan.

The recommended plan (see Figure 4) consists of a 750-foot long spur jetty and beach fill along Camp Ellis Beach to prevent further shoreline losses north of the existing northern jetty. The spur jetty would be attached to the existing north jetty at a point about 1,475 feet from the shoreline. The top of the structure would be about 15 feet wide and at an elevation of 14.5 feet MLLW. Seaward and landward side slopes of the jetty would be 1 vertical on 2 horizontal. Due to increased turbulence at the spur and jetty junction, about 400 feet of the existing jetty seaward on the spur jetty would require reinforcement. Modifications to the first 200 feet of the north jetty include raising the top elevation to reduce overtopping, flattening the slope to 1 vertical on 2 horizontal, adding armor stone, and reinforcing the toe to prevent scour. An additional 200 feet of the north jetty would receive toe reinforcement only. Beach fill along Camp Ellis Beach would begin at the north jetty and extend about 3250 feet to the north. The proposed beach berm elevation is 17.4 feet MLLW, which is roughly equivalent to the natural beach berm elevation in areas north of the study area and the top elevation of the north jetty. The seaward slope of the beach fill would be 1 vertical on 10 horizontal. The estimated volume for sand required for beach construction is about 365,000 cubic yards, and beach renourishment would be required every 11.6 years to maintain an effective beach width. Sand volumes for each renourishment would vary depending on actual changes in future sea levels. Estimated volumes for the three potential sea level change scenarios are: 116,000 cubic yards for the historic rate; 192,000 cubic yards for the intermediate rate; and 236,000 cubic yards for the high rate. The major impact of the proposed project is the loss of subtidal habitat due to the placement of sand on the beach and construction of the spur jetty. This impact, however, is offset by the creation of reef along the spur that will provide habitat for numerous species, the availability of upland sandy beach areas suitable for Piping Plover nesting, and increased stability of the shoreline. Actions related to the project as proposed will provide little measurable cumulative impact.

The total estimated cost of implementing the recommended plan is $19,471,000, not including initial planning and design, and future renourishment costs. Section 111 requires that non-Federal sponsors share in the initial costs of mitigation measures in the same proportion that they shared in the costs of the navigation project causing the damage. Since construction of the Saco River navigation project was 100 percent federally funded, the city of Saco will not have to share in initial construction costs up the new cost limit of $26,900,000. However, as specified in Section 215 of Public Law 106-53, non-Federal interests will be responsible for 50 percent of the costs for periodic beach renourishment. The city of Saco is aware of these requirements and supports implementation of the recommended plan.

Figure 4 – Recommended Plan

SACO RIVER AND CAMP ELLIS BEACH
SECTION 111 SHORE DAMAGE MITIGATION PROJECT
SACO, MAINE

DECISION DOCUMENT

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APPENDICES

Acronyms Used in this Document

Acronym	Meaning
CY	Cubic Yards
FEMA	Federal Emergency Management Agency
ME DEP	Maine Department of Environmental Protection
MGS	Maine Geological Survey
MHW	Mean High Water
MLLW	Mean Lower Low Water
MLW	Mean Low Water
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
OMRR&R	Operation, Maintenance, Repair, Replacement and Rehabilitation
SBIT	Saco Bay Implementation Team
USACE	U. S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Service
WHG	Woods Hole Group
WRDA	Water Resources Development Act

1.0 INTRODUCTION

Camp Ellis Beach is located in Saco, Maine, about 16 miles south of Portland, Maine. The beach is situated on the southern portion of the Saco Bay shoreline near the mouth of the Saco River. The river is the boundary between the cities of Saco and Biddeford. The Saco River Federal Navigation Project includes an entrance channel that is 200 feet wide, and a depth of 8 feet at mean lower low water. The channel is protected to the north by a 6,600-foot long jetty and to the south by a 4,800-foot long jetty. Camp Ellis Harbor upstream of the jetties includes three public anchorage areas that are part of the Saco River project and a large public fish pier. The channel continues upriver several miles to downtown Saco and Biddeford. Camp Ellis Beach lies adjacent to the north breakwater and extends 2,500 feet north to Ferry Beach. The north jetty at the mouth of the Saco River separates the river from Camp Ellis Beach to the north (see Figures 1 and 2). The Federal navigation project was authorized, constructed and modified in several increments between 1828 and 1968. The navigation project provides for navigation safety by reducing wave energy and heights at the mouth of the river, and a reduction in the frequency of maintenance of the lower river channel and anchorage areas. During the last modification in 1968, the shoreward end of the north jetty was raised and tightened to reduce the maintenance dredging frequency in the river channel. The area of Camp Ellis beach within about 2,500 feet of the jetty has experienced severe erosion over the past several decades, with losses of over 30 homes and property, roadways, and public and private infrastructure. These continuing losses prompted the city of Saco to request Federal assistance from the Corps of Engineers to reduce or eliminate further shoreline impacts.

1.1 Study Authority

This report was prepared under authority contained in Section 111 of the River and Harbor Act of 1968 (Public Law 90-483), as amended. Section 111 provides authorization for the Corps of Engineers to study, plan and implement structural or nonstructural measures to prevent or mitigate damage to shorelines to the extent that such damages can be directly attributable to Federal navigation projects (this authority is cited below).

> “(a) IN GENERAL.-The Secretary of the Army, acting through the Chief of Engineers, is authorized to investigate, study, and implement structural and nonstructural measures for the prevention or mitigation of shore damages attributable to Federal navigation works and shore damage attributable to the Atlantic Intracoastal Waterway and the Gulf Intracoastal Waterway, if a non-Federal public body agrees to operate and maintain such measures, and, in the case of interests in real property acquired in conjunction with nonstructural measures, to operate and maintain the property for public purposes in accordance with regulations prescribed by the Secretary. (b) COST SHARING.-The costs of implementing measures under this section shall be cost-shared in the same proportion as the cost-sharing

> provisions applicable to the project causing the shore damage. (c) REQUIREMENT FOR SPECIFIC AUTHORIZATION.-No such project shall be initiated without specific authorization by Congress if the Federal first cost exceeds $5,000,000. (d) COORDINATION.-The Secretary shall-(1) coordinate the implementation of the measures under this section with other Federal and non-Federal shore protection projects in the same geographical area; and (2) to the extent practicable, combine mitigation projects with other shore protection projects in the same area into a comprehensive regional project."

As cited above, the Federal share of costs for any one project is normally $5 million. However, Section 3085 of the Water Resources Development Act of 2007 raised the limit at Camp Ellis, Saco, Maine to $26.9 million based on initial estimates of plans to mitigate shoreline erosion. Section 3085 states the following:

> "The maximum amount of Federal funds that may be expended for the project being carried out under section 111 of the River and Harbor Act of 1968 (33 U.S.C. 426i) for the mitigation of shore damages attributable to the project for navigation, Camp Ellis, Saco, Maine, shall be $26,900,000."

1.2 Purpose and Scope

The study purpose is to prevent or mitigate for shoreline erosion losses and damage directly attributed to the existing Federal navigation project. This decision document evaluates alternatives, and identifies the least costly, technically feasible, and environmentally acceptable alternative. An additional purpose was to establish the level of support and willingness of the non-Federal sponsors to participate in recommended improvements.

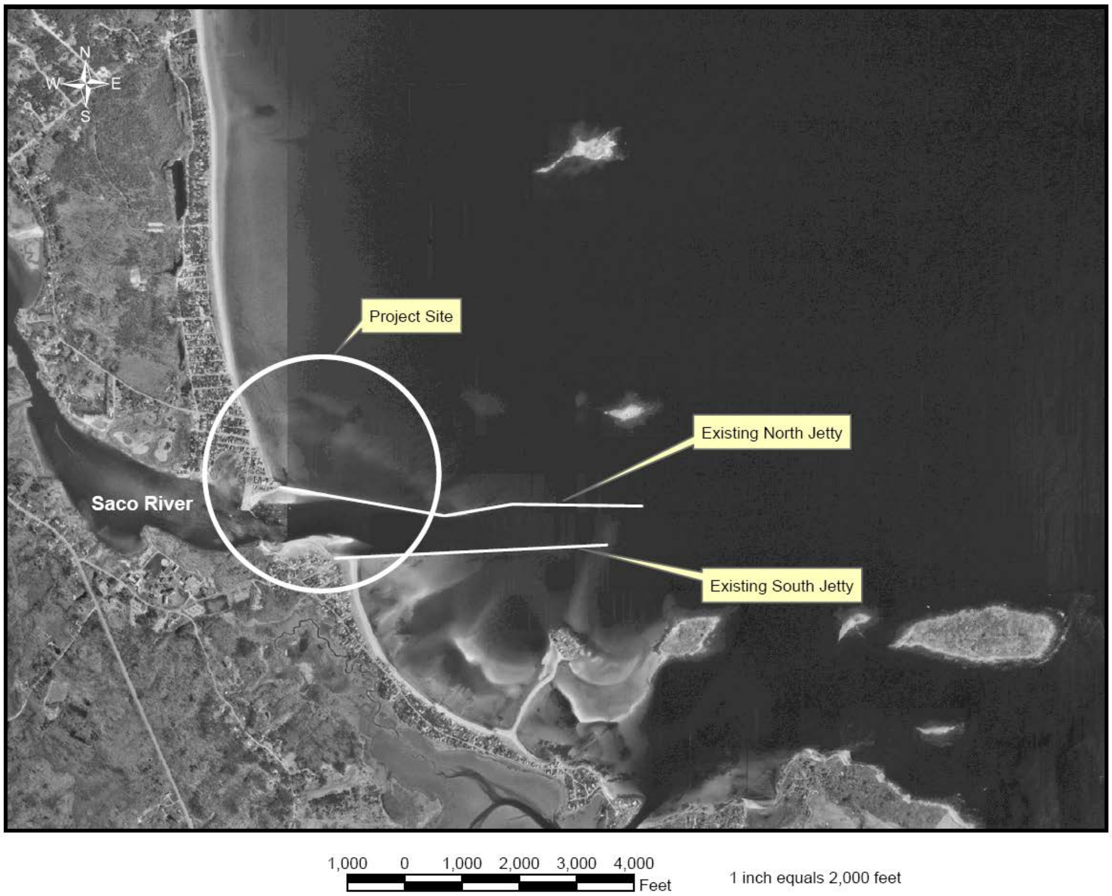
Figure 1 – Vicinity Map

1.3 Study Area

The primary study area is the Camp Ellis shoreline that continues to be threatened by erosion caused by the Saco River Federal Navigation Project, and more specifically, the north jetty. This area is shown as the project site on Figure 2. Studies of Saco Bay and its shoreline, and the Saco River were conducted to identify conditions that ultimately effect and impact the Camp Ellis shoreline.

Camp Ellis Beach is approximately 2,500 feet long and extends northerly from the north jetty at the mouth of the Saco River to Ferry Beach. Camp Ellis Beach is at the southern end of the largest beach and salt marsh system in the State of Maine. Camp Ellis is a relatively small, primarily recreational and fishing village of the city of Saco situated at the mouth of the Saco River.

Figure 2 - Camp Ellis, Saco, Maine - Location Map



1.4 Existing Federal Navigation Project

The Saco River navigation project (see Figure 3) provides for a channel 8 feet deep (9 feet in ledge) that extends from the sea to the head of navigation below the Dam at Saco and Biddeford, a distance of about 6 miles. The channel width varies from 140 feet at the bar, 200 feet in the lower section between the jetties, 140 feet in the middle section, to 100 feet in the upper section. A stone jetty about 6,600 feet long extends from the north side of the river mouth and stone jetty about 4,800 feet long extends from the south side of the river mouth. In the lower river just inside the mouth there are three anchorages that provide about 13.5 acres of mooring space. The 3 acre anchorage area situated east of the City pier is protected by 11 icebreaker structures. A 10 acre maneuvering basin is also situated at the head of navigation. The anchorages and maneuvering basin are maintained to a depth of 6 feet. There are also a number of small stone training walls along the river that were constructed in the early 1800s to constrict the channel flow and reduce shoaling.

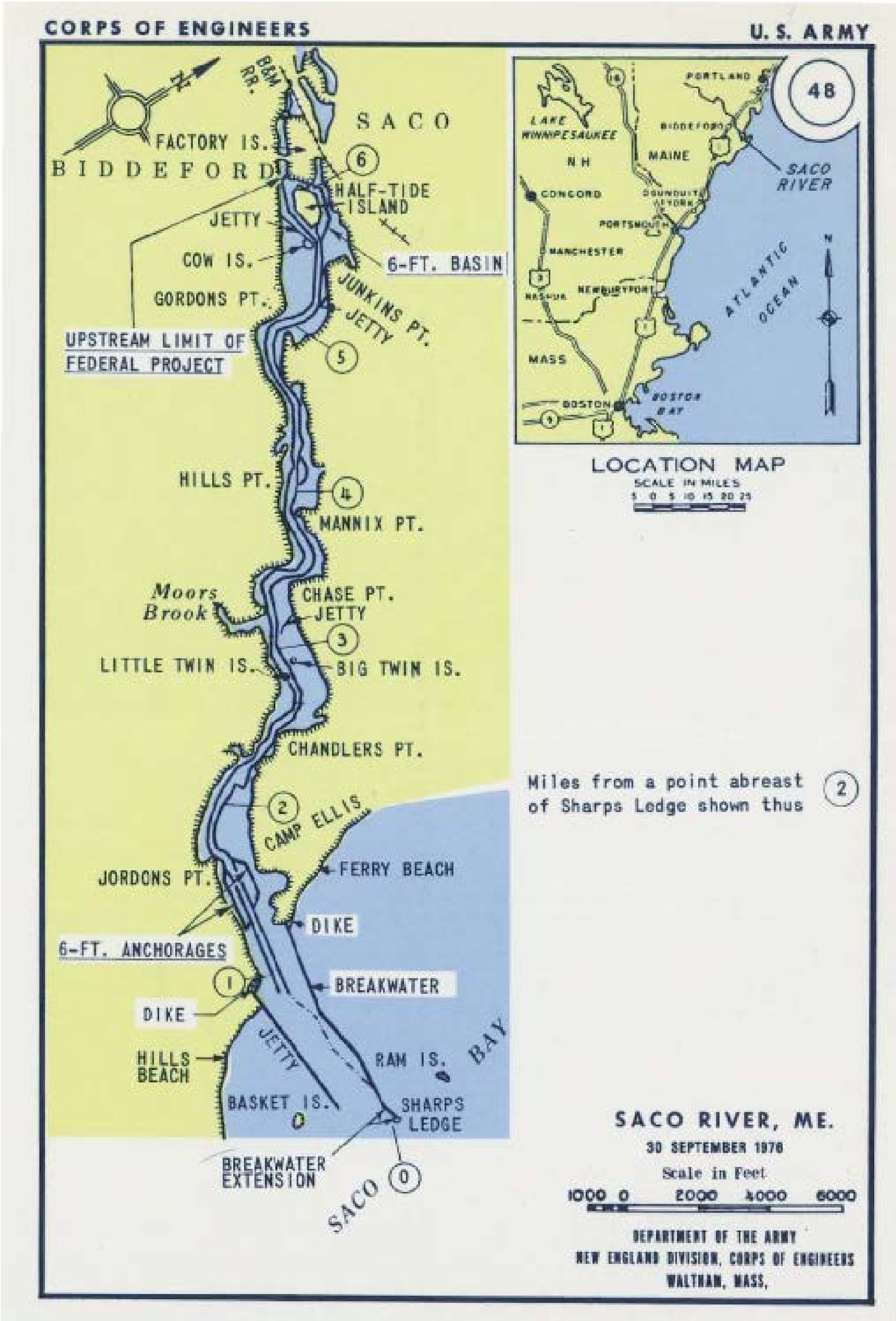


Figure 3 – Saco River, Maine Federal Navigation Project

1.4.1 Construction History of the Navigation Project

Historically, navigating the mouth of the Saco River was difficult due to sandbars at the tidal delta at the mouth of the Saco River. To support commercial activities in Saco and Biddeford, Congress authorized construction of 14 piers, the placement of beacons and buoys, and removal of several obstructions from the river in 1827. Several of the river piers were removed and others reconstructed entirely of stone in later modifications. In response to additional commercial needs and continued shoaling at the mouth of the river, a 4,200 foot long jetty north of the river mouth was authorized by Congress in 1867. Prior to construction of the jetty, a fairly deep single entrance channel forked into two shallow channels just east of the inlet. One channel was 4-6 feet deep and oriented to the east-northeast, and the other was 4-5 feet deep and oriented to the east. Construction of the jetty closed the east-northeast channel, and paralleled the northern edge of the easterly channel. Between 1885 and 1897, the jetty was raised to reduce channel shoaling.

During the period from 1891-1894, a 4,500 foot long south jetty was constructed to stabilize the entrance channel. Construction of a 300 foot seaward extension of this jetty was completed in 1912. A 400 foot long spur jetty was also constructed off the north jetty after a number of destructive northeast storms threatened to flank the jetty. In the 1930's the northern jetty was extended to its current length of about 6,600 feet. The total length of the south jetty is 4,800 feet.

The most recent modification to the north jetty occurred in 1968 when the inshore 850 feet of the structure was raised, resurfaced and tightened. The most recent work on the south jetty occurred in 1969 when 850 feet of the jetty was raised to 17.3 feet MLLW. Stone revetment was placed along the shores on both sides of the river to prevent flanking of the structures. Stone revetment north of the north jetty was completed in 1970, and revetment was placed south of the south jetty in 1971.

The Saco River Channel has been gradually deepened since authorization of the navigation project. The channel was deepened to 5 feet in 1871, to 6 feet in the upper reaches between 1887 and 1894, to 7 feet in 1912, and to 8 feet in 1928. The majority of material dredged from the river was disposed of off shore until 1969 when the Corps began placing it on nearby beaches that were experiencing erosion problems. In 1969, dredged material was placed on both Camp Ellis Beach and Hills Beach in Biddeford. Material from maintenance dredging in 1978 was also placed on these two beaches. Improvement dredging of the 6 foot outer anchorage was placed on Camp Ellis Beach in 1983. During the most recent maintenance dredging operation in 1992 and 1993, dredged material was placed on Camp Ellis Beach. Additional details concerning the project history are provided in Appendix I.

1.4.2 Navigation Uses of the Federal Navigation Project

The navigation project supports a wide variety of commercial and recreational activities along the Saco River. A commercial lobster and fishing fleet of nearly 40 vessels anchors in the lower river and unloads at the fish pier at Camp Ellis. The pier is also used by several charter and sport fishing boats. A commercial boat yard, situated further upstream on the Biddeford side of the river, manufacture and services commercial and pleasure craft. Approximately 120 tons of paper products are also exported from this boat yard yearly. The project supports one of the State's largest recreational boating and sport fishing populations. Three marinas provide berths or moorings for about 290 recreational boats, and three public boat ramps provide additional access to the river. The State boat ramp at Meeting House Eddy near State Route 9, is the most heavily used ramp in the State with over 300 launches per day during the peak boating season. Other related activities, such as marine programs at the University of New England in Biddeford, and kayak rentals, are supported by the project.

2.0 PLANNING SETTING AND PROBLEM IDENTIFICATION

2.1 General Setting

Camp Ellis Beach is situated at the southern end of Saco Bay, an eight mile long crescent shaped shoreline that is bounded by the Prouts Neck headland in Scarborough to the north and Fletchers Neck headland in Biddeford to the southeast. The Saco River discharges into Saco Bay between Camp Ellis Beach to the north in Saco and Hills Beach to the southeast in Biddeford. Camp Ellis Beach originates at the Saco River Federal navigation project's north jetty and extends about 2,500 north where it meets Ferry Beach. Figure 4 shows the major features of Saco Bay.

Camp Ellis is a seaside community located on Saco Bay just north of the Saco River. It is a predominately residential and largely seasonal community that is oriented to the beach on its eastern border. In addition to the large number of homes, the area contains several restaurants, commercial and recreational boating facilities including the State/City fish pier, churches, a fire station, and several small commercial businesses.

2.2 Topography and Geology

2.2.1 Physiography

The project area is in the New England physiographic province of southeastern Maine. The Camp Ellis area is located in the Seaboard Lowland section. The Seaboard Lowland section rises uniformly from sea level to an elevation of about 300 to 400 feet with occasional hills rising above this elevation. Relief is generally low with rivers flowing southeasterly to the Atlantic Ocean.

2.2.2 Marine Geology and Geophysics

Bedrock geology defines the overall shape of the Maine coastline by controlling the location and orientation of islands, bays, and peninsulas. The surficial materials of Maine's inner continental shelf of the northwestern Gulf of Maine are the most complex of any place along the Atlantic continental margin of the United States. The study area has a generally sandy bottom with mixtures of mud, gravelly-sand, and gravel.

Saco Bay is an eight mile long curved stretch of shoreline bound to the south by Fletcher's Neck and the Saco River and to the north by the Scarborough River and Prouts Neck. The majority of Saco Bay's coastline is densely developed consisting of small beachfront communities. The Bay represents the largest sand beach and salt marsh system in Maine.

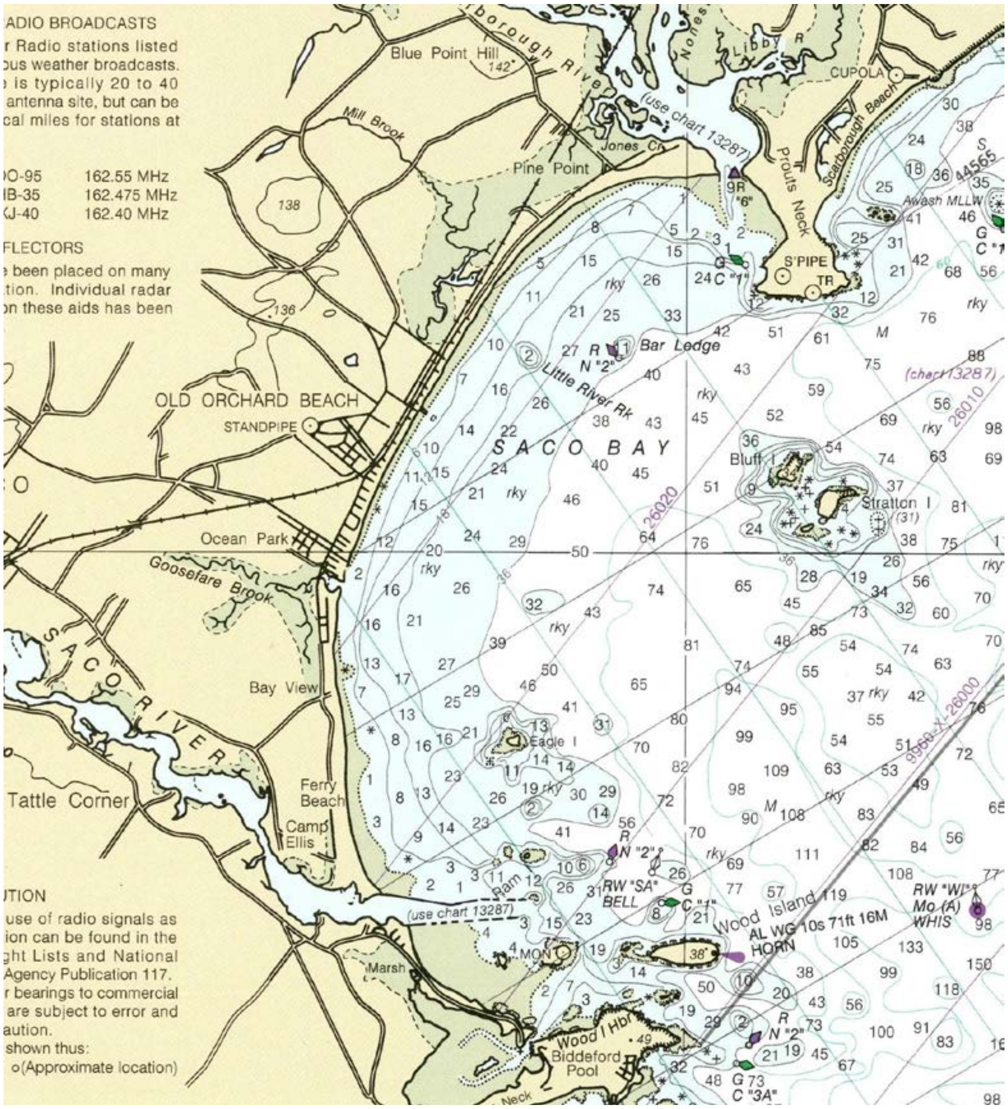


Figure 4 – Saco Bay

2.3 Soils and Sediments

2.3.1 Onshore (Upland) Soils

Beaches consist primarily of sandy coastal areas that are partially or entirely covered by water during high tides or stormy periods. The natural slope of beaches in the study area is approximately I vertical on 8 horizontal, or about 12 percent. Beaches are narrow in the study area and widen as one travels north. The beach is used for recreation such as surf fishing, sunbathing, swimming, walking, and wildlife habitat. Backshore upland soils are well drained and dominated with fine sands. Dunes range from stable vegetated area to unstable sand mounds and troughs with no plant cover.

2.3.2 Marine Sediments

The primary source of sediments to the Saco Bay/Camp Ellis area is from sediment transport in the Saco River. Fitzgerald et al. (2002) concluded that the Saco River contributed sand to the nearshore zone in Saco Bay during periods of high riverine discharge. Detailed studies of the sediments in the outer Saco Bay, the Saco River estuary, and the beach systems of the bay provide substantial evidence that the Saco River is the main source of sediment to the region (Woods Hole Group and Aubrey Consulting, Inc., 2006).

The majority of the Saco embayment just eastward of the beaches is covered by Holocene sand with large ripple fields or narrow linear bands (Kelley et al. (1995) Woods Hole Group and Aubrey Consulting, Inc., 2006). The Holocene period is the name for the last 10,000± years of the Earth's history, the time since the end of the last major glacial epoch, or "ice age" (University of California Berkley, 2005). Seaward of these sand bedforms, bedrock and gravel is predominant north of Biddeford Pool and Wood Island, rippled gravel is prevalent south of Prouts Neck, and the center of the bay is dominated by muddy sand and bedrock outcrops (Woods Hole Group and Aubrey Consulting, Inc., 2006; Kelley et al., 1995).
A total of 20 borings collected from both onshore and offshore locations in the project area between December 2004 and November 2005 confirm the above observation. Boring logs are included in Appendix D, Geotechnical Design. The purpose of these borings was to obtain information on subsurface conditions to aid in the design of structural alternatives to protect Camp Ellis Beach from further erosion.

All borings encountered a sand layer at or near the mud line or ground surface. This layer was 2 to 5 feet thick in offshore areas in the northern portion of the study area, 10 to 18 feet thick near the north jetty, and about 20 feet thick along Camp Ellis Beach. Fifteen of the twenty borings encountered a layer of lean clay under this layer of poorly sorted sand. Offshore borings towards the northern portion of the project site encountered thicker layers of the clay, whereas borings toward the south of the study area had much less lean clay. A layer of sandy silt/clay was encountered below 9 to 13 feet of sand at three borings performed near the north jetty. Layers of well or poorly graded sand with silt, ranging in thickness from 2 to 45 feet, was encountered below the layers of lean clay or organic silt. Refusal (possible bedrock) was encountered in ten of the twenty borings at depths ranging from 25 to 50 feet.

2.4 Water Resources

2.4.1 Saco River

The Saco River watershed covers an area of about 1,700 square miles: 863 in Eastern New Hampshire and 837 square miles in Western Maine. The basin encompasses all or parts of 63 municipalities within the two states. Elevations in the basin range from 6,288 feet at the summit of Mount Washington in New Hampshire to sea level at the mouth of the river in Saco and

Biddeford, Maine. The lower 6 miles of the river are tidal up to Cataract Falls in Saco where a dam was constructed as early as 1682. The Saco River enters into the Gulf of Maine at the project site.

2.4.2 Coastal Processes (Erosion History and Coastal Modeling)

Since the last several series of extensions of the Saco River jetties, sand has accreted on the south side of the southern jetty and erosion has occurred at Camp Ellis Beach north of the northern jetty. Camp Ellis Beach has experienced significant erosion for a distance of approximately 2,500 to 3,000 feet north of the northern jetty since the 1950s. Placement of rock revetments along some sections of this shoreline in response to erosion caused by the Federal navigation project have slowed the rate of erosion, but since Maine State law prevents shore attached structures, additional rock cannot be placed along the shore. As erosion continues, it is expected that these structures will be undermined and will fail. This was the case in 2007, when a section of rock revetment was undermined and collapsed, and significant section of Surf Street and two adjacent residences were lost. The unprotected shoreline north of this revetment also experienced considerable erosion during this event. As net sediment transport along the beach is south to north, erosion in this area is possibly due to the relative lack of sand along Camp Ellis Beach south of this area.

To establish a historic perspective of shoreline change, historical shoreline change along the Saco Bay shoreline was developed for the 1864-1998 time period. Analysis of historic shoreline positions showed accretion south of the south jetty, significant erosion along Camp Ellis Beach, relative stability north of Camp Ellis at Ferry Beach, and accretion north of this area. Most of these historic shoreline changes at Camp Ellis coincide with the construction of navigation project features that began in 1827 with the construction of a commercial navigation channel on the Saco River and the original stone-filled timber crib jetties. Persistent inlet instability and shoaling resulted in the construction of a more permanent rubblestone north jetty between 1868 and 1873. Shoaling continued as sediment continued to collect in the navigation channel and areas south of the inlet. This prompted construction of a rubblestone south jetty that was initiated in 1891. Since its construction, the south jetty has served to contain the sand that is present in areas to the south. Over time, wave forces in this area have redistributed these sediments, and formed a typical crescent shaped beach south of the jetty and accretion on the south side of the jetty. In response to severe erosion on the north side of the north jetty and to prevent flanking of the jetty, a 400 feet spur jetty was constructed in 1912. Continued erosion in this area overwhelmed this jetty which can now be seen as a dispersed ribbon of rocks about 300 feet from shore. Channel instability also continued and resulted in north jetty extensions in 1927 and 1938, and jetty raising and tightening in 1968. In addition, to mitigate for continued erosion north of the north jetty, sand that has been dredged to maintain the Saco River channels and anchorages has been placed on Camp Ellis Beach since 1969.

Although the area north of Camp Ellis Beach had been relatively stable, the rate of erosion at the north end of Camp Ellis Beach and Ferry Beach has increased substantially in recent years. Although shoreline mapping was not updated, the project area has continued to experience shoreline loss since 1998 and the erosion problem has migrated further north into areas that had been stable or accretionary. Significant shoreline losses were experienced during the spring storms of 2005 and 2007 at the northern end of the study area, possibly due to the lack of sediment in the active beach profile south of this area. Initially, erosion at Camp Ellis Beach provided nourishment to areas to the north, replacing in part the source materials from the river that were channeled offshore by the jetties. However, in response to this erosion, the City and others attempted to stabilize the shoreline with stone or other measures. Although these structures are only marginally successful in completely controlling shoreline losses, they have reduced the amount of sand that is eroded from areas along Camp Ellis Beach. Since present volumes of sand reaching these northern areas is significantly less than those that occurred prior to construction of the jetty, erosion is expected to continue to move north due to a lack of sediment supply and the net northerly movement of sand. A comparison of the dune/vegetation line in this area based on 1998 and 2010 Google Earth photos show that the dune has retreated about 40 feet in these 12 years. This is an erosion rate of about 3.3 feet per year which is comparable to the historic loss rate in the southern portion of the project area (see Section 4.1.3 of Appendix B). Pine Point in Scarborough, Maine, at the northern end of the bay, has shown significant accretion, where the maintenance needs of the Scarborough River entrance channel have increased. The most notable changes over time have occurred at the mouth of the Saco River with a localized erosion rate of -3.41 feet per year at Camp Ellis on the north side of the jetty, and at Pine Point in Scarborough with an accretion rate of nearly +4.0 feet per year Extensive modeling studies completed by the Woods Hole Group, Environmental Laboratories of Raynham, Massachusetts (See Appendix C) indicate net sediment transport in the project area is from south to north. However, magnitude of the transport varies along the shore. The region just north of the navigational structures has a strong transport rate to the north, the middle section of the bay exhibits a smaller net northerly transport, and the northern most section has an increased net sediment transport rate to the north. Waves were determined to be the primary mechanism for sand movement in Saco Bay. The hydrodynamics of Saco River has had little influence on the sediment transport dynamics at Camp Ellis Beach; although the Saco River is a significant sand contributor to the southern section of Saco Bay. With the construction of the jetties, sand transported by the Saco River is carried out past the effective littoral system, thereby eliminating the primary source of sand for nourishment of Camp Ellis Beach and the Saco Bay shoreline. Prior to construction of the navigation channel and jetties, there was an extensive ebb shoal complex at the mouth of the river. With net northerly sediment transport, these shoals created wide beaches at Camp Ellis and areas to the north. These beaches, which were stable to accretionary, absorbed wave energy and protected the shoreline.

Modeling of the waves in the project area showed several factors affect erosion of the Camp Ellis Beach. One factor is that nearshore waves propagate directly towards the Camp Ellis Beach region and the northern jetty, irrespective of the offshore direction. The complex bathymetry between Eagle and Ram Islands, and the islands themselves, resulted in a nearly uniform approach towards the area of highest erosion and reflection. Waves approaching the jetty are reflected back towards Camp Ellis Beach. In addition, Mach-Stem waves (waves that travel along a structure) spread along the northern jetty in response to most of the offshore waves approaching the structure. Although this does not represent a large amount of energy, it does produce an additional wave process that impacts the coastline, specifically the corner where the shoreline and northern jetty meet. Therefore, for a portion of the shoreline directly adjacent to the northern jetty, the beach is impacted not only by incident (natural) wave energy, but also by the reflected wave energy off the jetty and Mach-Stem waves. This increased wave energy, combined with the loss of natural beach nourishment from the Saco River, has resulted in continuous shoreline erosion along Camp Ellis Beach.

2.4.3 Marine Water Quality

The tidal waters of the Saco River and its tidal tributaries and the coastal waters of Saco Bay Beach area are classified as SC waters by the State of Maine. Class SC waters are suitable for recreation in and on the water, fishing, aquaculture, propagation of shellfish, industrial process and cooling water supply, hydroelectric power generation, navigation, and as habitat for fish and other estuarine and marine life. Shellfish harvesting is restricted (Maine Revised Statutes Annotated, Title 38, Section 465-B).

2.5 Biological Resources

2.5.1 General

Biological resources in the Camp Ellis Beach project area, including populations of benthos, fish resources, essential fish habitats, marine and coastal birds, and upland/terrestrial wildlife, are typical of southeastern Maine coastal and marine habitats. A team of environmental researchers from the U.S. Army Corps of Engineers collected data on benthic resources and habitats from Camp Ellis Beach and subtidal area in May of 2002. The team returned in August 2004 to collect additional data on benthic resources and habitats, eelgrass, and surf clam populations. Data collection methods included a series of strategically placed benthic grab samples to document the existing benthic infaunal community and the presence of eelgrass within the project area. In addition, a surf clam survey in the intertidal area parallel to Camp Ellis Beach was also conducted. This information as well as information from other data sources is used to describe the natural resources below in the project area.

2.5.2 Eelgrass

Eelgrass is a saltwater angiosperm found in estuaries and shallow coastal areas. It produces organic material that becomes part of the marine food web; helps cycle nutrients; stabilizes marine sediments; and provides important habitat including breeding areas and protective nurseries for fish, shellfish, and crustaceans. Eelgrass is particularly susceptible to sedimentation and human activity.

During the period of 1992-2005, eelgrass bed locations were mapped along the coast of Maine by the Maine Department of Marine Resources (ME DMR). Verification was carried out by boat, on foot, and by plane. Dense patches of eelgrass approximately six meters in diameter and less could be identified under good conditions and in some cases were mapped. However, a conservative estimate by ME DMR of the minimum eelgrass mapping unit is 150 square meters. This represents a stand of approximately 14 meters in diameter (ME DMR website). Based on this mapping effort, the closest patches of eelgrass in the project area are to the southeast of the Saco River near Wood Island. A small patch is also noted north of Camp Ellis Beach near Eagle Island.

In addition to the eelgrass mapping effort of the ME DMR, benthic grab samples were also checked for the presence of eelgrass upon collection in 2002, 2004, and 2005. Except for grab samples collected in 2004 from the proposed breakwater BW2, BW3, and BW4 sample locations, no eelgrass was observed during the collection of benthic samples within the project area. See the Benthic Resources Section below for locations.

2.5.3 Benthic Resources

Benthic population samples were collected in the project area by Corps biologists in May 2002, August 2004, and August 2005. Samples were taken either intertidally with a beach core at random locations within or near initially proposed T-groins, and subtidally (nearshore and offshore) with a VanVeen grab at the initial, and subsequent locations, for the offshore breakwaters, potential tombolo/salient features, and the jetty spur.

Benthic organisms are good indicators of environmental disturbances, as their sessile nature precludes them from fleeing areas with declining environmental quality. Benthic communities can therefore provide a useful environmental monitoring tool to evaluate estuarine systems. The benthic samples collected in the project area show benthic communities dominated by a typical assemblage of sandy nearshore and intertidal beach species.

A detailed list of the benthic species collected and identified in the project area is included in Attachment A to the Environmental Assessment. Seventy-nine species were identified in the samples collected in 2002. This is a relatively high number considering the small number of samples. Naturally, the highest diversity occurred in the subtidal samples. These samples contained between 10 and 54 species with a mean number of 29 species. Likewise, these stations exhibited a fairly high density on a per square meter basis with a mean of over sixteen thousand. By contrast the intertidal samples were sparsely populated by a very few species. Beach sediments are characteristically colonized by few species. Whereas abundances can reach high numbers in many cases, the low densities encountered here are not considered unusual. Dominant species in the subtidal zone are the arthropod *Photis macrocoxa*, and the polychaetes *Aricidea jeffreysii*, *Pygospio elegans*, and *Paraonis fulgens*. In the intertidal zone, again the polychaetes *Pygospio elegans* and *Paraonis fulgens,* as well as the arthropod *Pseudoleptocuma minor*.

Thirty-nine benthic species were identified in the 2004 benthic collection in the intertidal and subtidal ranges of the project area with the dominant species including the arthropod *Haustorius canadensis* and the polychaetes *Pygospio elegans* and *Paraonis fulgens*. Intertidal samples are dominated by nematodes and oligochaetes. Dominant subtidal species includes the polychaetes *Pygospio elegans* and *Paraonis fulgens*. Subtidal samples are dominated by oligochaetes and nematodes.

2.5.4 Shellfish

Soft-shelled clams are known to exist throughout the tidal areas of the Saco River estuary. However, the Camp Ellis/Ferry Beach is characteristic of a high energy area which means high mobility of sediments resulting in high shellfish mortality and slow growth. Blue mussels occur in the river, mainly near the mouth. Atlantic surf clams and ocean quahogs are found near the mouth in offshore areas (U.S. Army Corps of Engineers, New England Division, 1992).

Atlantic surf clams are typically found to a depth of three feet below the water/sediment interface. They generally occur from the beach zone to a depth of about 200 feet, but beyond about 125 feet abundance is low. The Atlantic surf clam fishery is currently managed pursuant to the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) of 1976, as amended by the Sustainable Fisheries Act in October 1996.

An Atlantic surf clam survey was conducted within the project area in August 2005. This involved sampling at random locations along two transects parallel to Camp Ellis Beach. At each location, a one foot square area was excavated and examined for the presence of surf clams. Any individuals found were measured and then returned to their previous location. Overall findings suggest a dispersed incidental surf clam population within the project area.

Lobsters are widely distributed over the continental shelf of the western North Atlantic Ocean and are most abundant from Maine to New Jersey in inshore waters out to a depth of 40 meters. Post-larval lobsters have been observed settling into rock or gravel often covered with algae, salt-marsh peat, eelgrass, seaweed substrates, and firm mud. The preferred habitat for settlement of post-larval lobster appears to be any area with three-dimensional structure where they can build and maintain burrows for shelter from predators. Adult lobsters have been found in waters from the intertidal zone to as deep as 700 meters. Coastal populations concentrate in areas where shelter is readily available. When inactive, lobsters find shelter in burrows under rocks or, less frequently, in mud tunnels. In winter, especially when the water temperature is below 5°C, lobsters have been found close to the mouth of their burrow with sediment and debris, and remain in their burrow for weeks.

Although a lobster survey was not conducted by Corps of Engineers biologists for this proposed project, other surveys have noted lobster in the area (Reynolds and Casterlin, 1985; Sherman, et.al., 2003). Lobster would be expected to find some shelter in nearby rocky outcrops and possibly the jetties.

2.5.5 Fisheries Resources

The Saco River and Bay provide excellent recreational and commercial fishing opportunities for striped bass. The Saco River is one of the busiest sport fishing rivers in the State. American shad, blueback herring, alewife, and Atlantic salmon are known to reproduce in the Saco River. Anadromous fish run counts for Atlantic salmon, American shad, and blueback herring and alewife in 2007 were 24, 1,428, and 16,084 respectively (Saco River Salmon Club website). Twenty-one Atlantic salmon were counted at the Cataract Dam in 2010 (Maine Atlantic Salmon Commission website). Striped bass enter the river early to mid-May and remain through November. Fishing activity for stripers peaks during August and extends through October. Atlantic mackerel enter the Saco River during July and August. This species provides the second most important recreational fishery. Mackerel are generally concentrated in the lower two miles of the estuary with the majority of the fishing activity taking place at Camp Ellis and off the Saco River jetties. American eels are present throughout the estuary and provide an incidental fishery. Pollock and winter flounder are also caught by sport fishermen in the lower to mid-estuarine reaches. White perch are in the upper reaches of the estuary.

The Saco River estuary is also important as a nursery for a number of fish species. Twenty-four fish species were caught between April and October in 2007 and 2008 at the mouth of the river; nearly all were juvenile (Furey and Sulikowski, in press). At least ten species of planktonic fish larvae were collected at the mouth of the Saco River and nearby estuarine areas in the summer of 2007 (Wargo, et. al., 2009).

Ferry Beach, adjacent to Camp Ellis offers excellent open beach fishing (Maine Department of Marine Resources, 2005a). The commercial fishery for finfish and shrimp is located offshore principally near Jeffreys Ledge.

2.5.6 Essential Fish Habitat

The National Marine Fisheries Service (NMFS) has designated specific areas as Essential Fish Habitat (EFH) in accordance with the Magnuson-Stevens Fishery Conservation Act, as amended by the Sustainable Fisheries Act of 1996. The project occurs in designated EFH habitat areas managed by the New England Fishery Management Council. Appendix C lists life history profiles for the 14 EFH designated fisheries. The fisheries in Saco Bay are: Atlantic salmon, Atlantic cod, pollock, red hake, white hake, winter flounder, yellowtail flounder, windowpane flounder, American plaice, ocean pout, Atlantic halibut, Atlantic sea herring, bluefish, and Atlantic mackerel.

2.6 Wildlife Resources

2.6.1 General Wildlife Species

The nearshore habitat supports a variety of wildlife species typical in southern Maine. While-tailed deer, gray squirrels, raccoons, red fox, cottontails, skunks, and small mammals (mice, chipmunks, voles, etc) are frequently observed in the Saco River-Camp Ellis area. The islands off the coast of Camp Ellis support harbor and gray seals.

2.6.2 Birds

The sandy shores and salt marsh estuaries in this area offer breeding habitats for a number of species. The area supports concentrations of shore and sea birds, such as terns, plovers, gulls, turnstones, and American oystercatchers, and the Double-crested cormorant. The area supports several species of wading birds. Glossy ibis, snowy egrets, little blue herons, great blue herons, tri-colored herons, green herons, black-crowned night herons, blue-winged teals, mallards, black ducks, willets, snipes, savannah, and sharp-tailed sparrows reside in salt marsh estuaries nearby.

2.7 Endangered and Threatened Species

2.7.1 Federally Listed or Proposed Endangered or Threatened Species

The Federally-threatened piping plover occurs in the project area, with nesting pairs to the north at Goosefare Brook in Saco and to the south at Fortunes Rocks Beach in Biddeford, Maine (FWS, 2002).

One Federally endangered species of fish, the shortnose sturgeon (*Acipenser brevirostrom*), has been caught in the Saco River. Shortnose sturgeon have a range that extends from the St John River in New Brunswick, Canada to the St. Johns River in Florida. Shortnose sturgeon are anadromous, spending a portion of their lives in salt water, but returning to fresh water to spawn. In the Saco River, the shortnose sturgeons have been observed leaving the Saco River in December and traveling to Massachusetts to overwinter.

On February 6, 2012, NMFS listed the Gulf of Maine distinct population segments (GOM DPS) of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) as a threatened species under Section 7 of the Endangered Species Act. Atlantic sturgeon are found along the eastern seaboard from Cape Canaveral, FL to Labrador, Canada. Within the Gulf of Maine, Atlantic sturgeons have been documented from the following rivers: Penobscot, Kennebec, Androscoggin, Sheepscot, Saco, Piscataqua, Presumpscott, and Merrimack. Like the shortnose sturgeon, the Atlantic sturgeon is anadromous. Atlantic sturgeon have been captured during routine trawl sampling in the river during 2008 and 2009 as part of a two-year monitoring project for the Saco River and estuary. Tagging and tracking of the captured fish has shown that Atlantic sturgeon are making use of the river from the mouth up to Cataract Dam, the first dam on the Saco River. They have been observed in the river between December and April with the highest concentrations in June and July. Atlantic sturgeon are omnivorous benthic feeders and filter quantities of mud along with their food. The diets of adult sturgeon include mollusks, gastropods, amphipods, isopods and fish. Juvenile sturgeon feed on aquatic insects and other invertebrates. Sand lance make-up a large portion of the diet for Atlantic sturgeon caught in the Saco Bay estuary.

2.7.2 Other Special Status Species

Due to the developed nature of the beach, no known State rare botanical features are expected to occur at Camp Ellis Beach.

2.8 Land Use, Recreation and Public Use Areas

The Camp Ellis section of the city of Saco is a predominantly residential community located at the junction of the Saco River and the beaches that extend northerly along Saco Bay. The area is characterized by relatively small one and two story homes on relatively small lots. Most lots are less than a quarter acre, with the average less than one fifth of an acre. Many of the homes are seasonal and are rented during the summer months. Property sales in the area are relatively stable with sales ranging from three and six sales per year in the past 5 years. Other properties at Camp Ellis include a city owned pier, fire station, restaurants, churches, gift shops, convenience stores, a boat yard and marine supplies store. This coastal beach community has a moderate to high population density. In many ways, Camp Ellis is typical of turn of the twentieth century seaside vacation communities up and down the southern Maine coast from York Beach to Pine Point Beach.

The coastal environment at Camp Ellis supports both commercial and recreational uses. Commercial activities include fishing, lobstering and charter boating that is supported by facilities at the Camp Ellis pier, and anchorages provided by the Federal navigation project. Recreational activities include boating, kayaking, surf casting, swimming, sunbathing, sailboarding, surfing, sailing, and fishing. A public boat landing, with parking, is located on the Saco River at the Camp Ellis pier. Erosion along Camp Ellis Beach has impacted recreational usage as the amount of beach available for sunbathing and other recreational uses has been reduced.

The Saco River is protected by the State of Maine as a designated special region through the Saco River Watershed and Saco River Corridor Commission because of its diverse natural resources, particularly the water quality. The Commission serves as a regulatory agency that provides coordinated, basin-wide land use regulation that is run by the affected communities. The Saco River area hosts an abundance of recreational activity, such as sightseeing, wildlife observation, camping, hiking, photography, fishing, swimming, and boating.

2.9 Air Quality

Section 176 (c) of the Clean Air Act (CAA) requires that Federal agencies assure that their activities are in conformance with Federally-approved CAA State Implementation Plans (SIP) for geographic areas designated as non-attainment and maintenance areas under the CAA. Also, Section 309 of the CAA, authorizes the U.S. Environmental Protection Agency (EPA) to review certain proposed actions of other Federal agencies in accordance with the National Environmental Policy Act (NEPA).

EPA has developed National Ambient Air Quality Standards (NAAQS) for six principal pollutants. The NAAQS sets primary (public health) and secondary (decreased visibility, damage to animals, crops, ecosystems, etc.) concentration limits to determine the attainment status for each criteria pollutant. The six criteria air pollutants are carbon monoxide, lead, nitrogen dioxide, particulate matter (PM_{10} and $PM_{2.5}$), ozone, and sulfur dioxide.

As of April 30, 2012, all of Maine, including York County and the Town of Saco, was designated as an attainment area for the 2008 8-hour ozone standard. This signifies that the State of Maine is currently in attainment status (meets the NAAQS) for all six criteria pollutants.

2.10 Cultural Resources

2.10.1 Pre-Contact (Native American) Archaeology

No previously documented Native American sites are recorded in the Camp Ellis Beach project survey area, or in the immediate adjacent onshore area. However, site files at the Maine Historic Preservation Commission (MHPC) indicated that 6 recorded archaeological sites, dating from the late Ceramic (3,000-450 Before Present (BP)) to Contact (circa 450 BP) periods, were located less than one mile from the project area. This was consistent with the location of the study area and its proximity to a major river, the river’s mouth and confluence with the ocean.

A review of environmental data and sea level rise curves for coastal Maine indicates that the entire Camp Ellis Beach project area was likely exposed land available for human occupation from the beginning of the Paleoindian period (circa 11,500 BP) up until the start of the Late Archaic Period (circa 6,000 BP). Between about 6,000 and 3,000 BP (roughly the beginning of the Late Archaic period to the start of the Ceramic Period, the area was gradually inundated by what likely would have been a destructive marine transgressive process of shore-face retreat, as rising sea level caused the shoreline and surf zone to migrate landward across the project survey area. By the beginning of the Ceramic Period (3,000 BP), the Camp Ellis Beach area would have been entirely underwater.

However, due to the combined effects of the area's inundation through shore-face retreat processes, its exposure to high-energy impacts from wind-driven oceanic waves and tidal currents and the recent erosion that Camp Ellis Beach has been experiencing, any archaeologically sensitive paleosols and Native American sites that may have been present have most likely been eroded and destroyed. Therefore, there is a low potential for formerly terrestrial and/or maritime Native American archaeological sites within the project area.

2.10.2 History and Historical Archaeology

A review of shipwreck databases and coordination with your office reported a total of 24 vessel casualties along the Saco and Biddeford coasts; however, none of these shipwrecks are recorded within the Camp Ellis Beach project area and adjacent shore. Most of the reported shipwrecks occurred in close proximity to land and were witnessed by shoreline observers. Given the project area's close proximity to shore, it seems unlikely that if a shipwreck occurred, it would have gone unnoticed and not been documented in the historic record. However, earlier and smaller vessels may have been grounded on the beach without being documented. Therefore, the project area was assessed as having a moderate potential for historic archaeological deposits, namely shipwrecks.

A systematic remote sensing archaeological survey was performed in November 2009 at the location of the Corps proposed construction of nearshore breakwaters and a spur jetty at the Camp Ellis Beach site. The investigation involved archival background research, field survey to record marine geophysical and geotechnical data, and analysis and synthesis of the research and survey results to assess the project study area's archaeological sensitivity and to determine the presence/absence of pre-contact and historic period submerged archaeological deposits within it.

A total of 22 side scan sonar anomalies and 9 separate magnetic anomalies were inventoried during the remote sensing survey. These anomalies were interpreted to be associated with a sunken modern core drilling barge and its associated steel boring tubes and debris, other pieces of isolated modern debris, or exposed and buried geological features. None of the targets or anomalies were interpreted to be archaeological deposits. Additionally, sub-bottom profile data produced no acoustic reflectors indicative of buried cultural or geological features.

A total of 20 geotechnical boring samples recovered in the Camp Ellis Beach project area under a separate contract were provided to Fathom for analysis and comparison with the sub-bottom profiler data for the presence of possible stratified paleosols. The stratigraphic sequence consisted primarily of sand mixed with silt and gravel overlying clay or, in some cases, compacted gravel or bedrock. None of the boring samples exhibited sediments that are characteristic of archaeologically sensitive paleosols.

Based on the results of this study, no remote sensing targets or anomalies or buried geological features indicative of archaeological deposits were identified. As a result, no further archaeological investigation of the proposed Camp Ellis Beach nearshore breakwaters and spur jetty project area is recommended. Additionally, the placement of sand on the beach in conjunction with the offshore structures is unlikely to impact significant historic properties due to the high energy impacts from waves and tidal currents and recent erosion discussed above.

Therefore, in summary, the Corps feels that the proposed shoreline protection measures at Camp Ellis Beach should have no effect upon any structure or site of historic, architectural or archaeological significance as defined by Section 106 of the National Historic Preservation Act of 1966, as amended, and implementing regulations 36 CFR 800. The Maine State Historic Preservation Officer, in a letter dated October 6, 2010, has concurred with this determination (see Appendix A).

2.11 Socioeconomics

The 2010 population of Saco, Maine was 18,482, and the median household income was $54,175. Based on the U.S. Census Bureau, 2005-2009 American Community Survey, the average annual labor force was 10,250, of which 9,768 were employed, and 482 were unemployed. The unemployment rate was 4.7 percent. Major sources of employment include management, professional and related occupations, service occupations, and sales and office occupations.

The Saco River Federal Navigation Project makes important contributions to local economy, particularly in regards to the fishing and service occupations. The city pier and adjacent anchorages support a fishing fleet of nearly 40 vessels, and several charter and sport fishing boats operate out of Camp Ellis. Three marinas along the river provide berths or moorings for about 290 recreational boats, and three public boat ramps provide additional access to the river. A commercial boat yard, situated further upstream on the Biddeford side of the river, manufactures and services commercial and pleasure craft. Visits to this picturesque area during the summer months support two sizable restaurants that are situated near the pier. Marine programs at the University of New England in Biddeford, kayak rentals, and other related activities are also supported or enhanced by the project.

2.12 Expected Future Conditions Without a Project

The inlet control structures at the river's mouth, principally the north jetty, have altered the Saco River delta (ebb shoal complex) and littoral system, and its ability to absorb and compensate for wave action at the mouth of the river. River-borne sands that were available to nourish the beach have been diverted by the jetties and navigation channel to areas offshore and seaward of the littoral system. Former ebb shoal deposits at the mouth of the river were relatively shallow and extensive, and created a stable to accretional shoreline north of the river. Over the years, these deposits have eroded, and, as net sediment transport is south to north, deposits located north of the north jetty have been carried north. Loss of these deposits has caused increased wave energy at the shoreline as waves break closer to or on the shore. These impacts are magnified as the north jetty intercepts and reflects wave energy into and northward along the beach accelerating the loss of beach material. The north jetty also sets up currents along its face that remove material from the shore to offshore areas. The zone of influence for structure induced sand loss and shoreline retreat extends the full 2,500 feet of Camp Ellis Beach, and as sand is depleted from this area, shoreline retreat has steadily extended northward along the beach over the past several decades. The total area presently impacted by reflected wave energy and diversion of riverine sediment supply currently extends beyond the primary zone of impact. With the lack of sand at Camp Ellis to nourish areas to the north, the area of erosion will most likely continue to move northerly.

Coastal erosion caused by the Saco River Federal Navigation Project will continue to affect properties along Camp Ellis Beach, and, as erosion moves north due to the lack of sand to nourish these areas, to properties abutting Ferry Beach. As sand is continuously eroded from the shoreline, the ability of the beach to absorb storm driven waves can be severely compromised. In the case of Camp Ellis Beach, a large percentage of the beach has been lost to erosion and sediment transport to the north. This leaves the shoreline susceptible to major losses in the event of a coastal storm event. The Patriots Day storm of April 2007 clearly demonstrated that single events can have a catastrophic effect on properties along the shore. This storm resulted in the loss of two residences, damage to many structures along the coast and the loss of a significant section of Surf Street, along with public utilities (see Figures 5 and 6). The north jetty will continue to affect waves along the Camp Ellis shoreline. The jetty will also continue to restrict the movement of sand from the Saco River that previously nourished the beach and areas to the north.

Coastal erosion will continue to degrade the human environment and impact people that live and work in the Camp Ellis area. The Camp Ellis area contains well over 200 properties, which includes residences, restaurants, and local variety stores. Camp Ellis also contains the City's pier that supports commercial fishing, boat charter operations, and recreational boating activities. As specified in EC 1165-2-211, three rates of potential sea level change have been considered in defining expected future without project conditions. These three rates of sea level change are the historic or “low” rate of change, and an “intermediate” and a “high” rate of expected change. As presented in Section 11.3 of Appendix B, projected sea level change over 50 years is a rise of 0.3 feet for the historic rate, a rise of 1.5 feet for the intermediate rate, and a rise of 2.2 feet for the high rate. As increased sea level rise rates will accelerate beach erosion, the annual erosion rate was calculated for each rate of sea level rise (see Section 11.4, Appendix B). Figure 7 shows the projected shoreline after 50 years for the three sea level rise scenarios. As shown on this figure, projected erosion will impact a significant number of properties in the study area. Total number of properties impacted by future erosion under the without project condition are: 62 for the historic rate of sea level rise, 86 for the intermediate rate of sea level rise, and 101 for the high rate of sea level rise. In addition, as shown on Figure 7, erosion associated with the intermediate and high rates of sea level rise could cut through a narrow section of Camp Ellis and isolate all property south of Fore Street. Without action by the City to prevent or close this breach between Saco Bay and the Saco River, the City pier and residences on Bay Avenue and the south end of North Avenue would have no vehicular access to the mainland. This breach would also result in serious impacts to the commercial fishing industry and the Federal navigation project on the Saco River. If access to the pier was not restored, the fishing fleet would have to relocate to another site, possibly to an area further upstream as nearby harbors are at capacity. Impacts to the navigation project include significant shoaling of the navigation channel and anchorages located near the breach, and the development of cross currents through the breach due to the nine foot tide range in this area. These effects would impact access to the upper five miles of navigation channel, and the feasibility of relocating the fishing fleet to an upstream location. Other expected future conditions include the following:

- Coastal sand dune habitat and aesthetics will remain degraded by continued erosion.
- Loss of usable beach area will continue to impact recreational usage.

Figure 5 – Damage along Surf Street, Patriot's Day storm of 2007

Figure 6 – Damage along Surf Street, Patriot's Day storm of 2007

Figure 7 – Projected Shorelines in 2061 based on Sea Level Rise over 50-years

3.0 PROBLEMS AND OPPORTUNITIES

3.1 Summary of Erosion Problem and Problem Identification

The cause of erosion at Camp Ellis Beach has been the subject of both speculation and study. The following paragraphs summarize the history surrounding the construction of the Saco River Navigation Project and the results of studies concerning erosion at Camp Ellis Beach.

Historically, navigation of the Saco River was difficult due to the presence of a significant tidal delta at the inlet. A navigation channel to support commercial navigation on the Saco River was authorized in 1827, but inlet instability and shoaling persisted. To stabilize the channel, a jetty on the north side of the inlet was authorized and construction began in 1867. At that time, there was an extensive ebb tide delta at the mouth of the Saco River, and a fairly deep single entrance channel forked into two shallow channels just east of the inlet across the entrance bars. One channel was 4-6 feet deep and oriented to the east-northeast, and the other was 4-5 feet deep and oriented to the east. Construction of the north jetty closed the east-northeast channel, and paralleled the northern edge of the easterly channel. Due to continuing problems with channel stability, the jetty was raised between 1885 and 1897, and a south jetty was constructed from 1891 to 1894. Entrance channel shoaling continued and the north jetty was extended to its current length of about 6,600 feet in the 1930's, and the shoreward 850 feet of the jetty was raised, resurfaced and tightened in 1968.

When the north jetty was constructed, it was thought that net sediment transport was from the north to the south, and that this movement was responsible for constant shoaling at the inlet. In addition, a riverine sediment source was not considered for shoaling at the inlet although the Corps acknowledged that a large amount of sand traveled down the river to the estuary. Since that time, numerous studies that address sediment sources and movement were conducted. The results of these studies are presented in Appendix B, Coastal Engineering Appendix, and Appendix C, Data Collection and Modeling Report prepared by the Woods Hole Group. All of these studies, conducted by the Corps and others, indicate that the Saco River has been the primary sediment source for the Saco Bay beaches. The most recent study concerning sediment sources, "Sand Budgets at Geological, Historical and Contemporary Time Scales for a Developed Beach System, Saco Bay, Maine, USA", developed a sediment budget for Saco Bay. This report concluded that the Saco River contributed, or should contribute, between 13,000 and 22,000 cubic yards of sand per year to the Saco Bay beaches. In addition, based on numerous studies, including grain size analysis and the Corps 1995 Model Study of Beach Erosion, it has been determined that the primary direction of sediment movement is south to north.

Prior to construction of the north jetty, beach nourishment material was provided by the Saco River and net sediment transport to the north distributed the sand along the shoreline. Based on the extensive ebb tide delta that existed in the 1860's, the Camp Ellis shoreline was most likely stable or accretionary as sediment was continuously deposited at the inlet. This accretionary nature continued after the original construction and reconstruction of the structures in the 1800s. However, with further extension of the north jetty through the mid-1900s, sands from the Saco River were retained in the channel or transported offshore into deeper waters where they were no longer available to the littoral system and the beach.

The other major impact to the area is significant wave reflection off of the northern jetty. Upon impacting the structure, waves are reflected back towards Camp Ellis Beach. Therefore, a portion of shoreline directly adjacent to the jetty is impacted not only by incident wave energy, but also by reflected wave energy. Modeling studies indicate that between 2,000 and 3,000 feet of shoreline experience a significant increase in wave energy. This increase ranges from 40 percent directly north of the north jetty to about 20 percent at the north end of the project. Waves propagating along the structure produce an additional wave process that impacts the shoreline, particularly at the corner where the shoreline and the jetty meet. The net effect of the lack of natural beach nourishment and increased wave energy has been significant shoreline regression at Camp Ellis (see shoreline regression analysis, Appendix C, Chapter 3).

In summary, the destabilization of Camp Ellis Beach and the resultant high erosion rate can be attributed to several factors directly related to construction of the Federal navigation project, specifically the north jetty. These include interruption of natural riverine sediment supply to the downdrift beach, diversion of riverine sediment farther offshore, and wave focusing along the beach due to reflection of waves by the jetty. Mitigating for these effects are the primary goals of the study.

3.2 Public Concerns

The city of Saco, state of Maine, local interest groups and residents were actively involved in all studies concerning shoreline erosion at Camp Ellis Beach. This involvement and coordination resulted in the formation of the Saco Bay Implementation Team (SBIT), which is comprised of property owners, municipal officials, and state and federal organizations (including the Corps of Engineers). The lead State agency for the effort has been the Maine Geological Survey. The City has been represented by numerous departments including the Mayor, City Council, City Administrator, Public Works Department and Assessor's Department. Numerous public information meetings have been held in the study to present and discuss study efforts and solicit public input. The most common concerns are listed below.

Loss of land and property due to erosion
Loss of recreational beach
Too much time since initial studies without positive results
Concern over constructing hard onshore structures (revetments, "T" groins, etc.)

3.3 Problems and Opportunities

3.3.1 **Problems**

As stated previously, the greatest problem along Camp Ellis Beach is continued erosion caused by the effects of the northern jetty at the entrance to the Saco River. The jetty has diverted riverine sediments from reaching the beach and detailed coastal studies determined that reflection of waves off of the jetty has caused a significant increase in wave energy at Camp Ellis Beach. The combined impact of these changes has destabilized Camp Ellis Beach and resulted in a high erosion rate and loss of land and property.

3.3.2 **Opportunities**

Opportunities are positive conditions that may result from management measures. There is an opportunity to prevent further shoreline erosion by implementing a variety of management measures. Reducing wave energy along the beach with off-shore structures would help stabilize the beach and improve the beach habitat. Shoreline stabilization measures also provide an opportunity to improve the overall social well being of residents of Camp Ellis.

3.4 Planning Objectives

3.4.1 Federal Objectives

The Federal objective is to develop the most cost effective plan to prevent or mitigate for erosion caused by the Saco River Federal Navigation Project consistent with protecting the Nation's environment and pursuant to national environmental statutes, applicable executive orders and other federal planning requirements. Since the Camp Ellis shoreline was stable to accreting prior to construction of the Federal navigation project, the primary goal of the study is to mitigate for the project's effects by preventing further erosion, but not restoring the area to any particular historic size or condition. The existing north jetty has caused significant increases in reflected wave energy that is directed along Camp Ellis Beach. Mach-stem waves that travel along the structure produce an additional wave process that impacts the shoreline, particularly in the corner where the jetty meets the shoreline. As both of these increases in wave energy contribute to the loss of sand, mitigating for these effects is also a goal of the study. The study will focus on mitigating long term (normal) erosion, and alternatives will not target a particular storm erosion risk reduction. Federal participation must also be warranted based on existing laws and statutes, primarily Section 111 of the 1968 Rivers and Harbors Act, as amended. In keeping with this authority, the mitigation objective is to prevent further shoreline erosion caused by the Federal navigation project and not to restore the shoreline at Camp Ellis Beach.

3.4.2 State and Local Objectives

The State of Maine is empowered by the Federal Coastal Zone Management Act and its implementing regulations at 15 CFR 930 to review activities within and adjacent to its coastal zone to determine whether the activity complies with the requirements of the State's approved management plan. The State's Coastal Sand Dune Rules (Title 38 M.R.S.A., Section 480, and Chapter 355 of Maine's Natural Resources Protection Act) also govern work along the Maine coastline. The Maine Geological Survey, Department of Conservation, is the lead State agency for the implementation of these regulations and has been actively involved throughout the study. The Maine Department of Environmental Protection is the State's lead agency in regulating activities pursuant to the Clean Water Act and would review the project upon the Corps request for Water Quality Certification. The Maine Office of State Planning is the State's lead agency in regulating projects under the Coastal Zone Management Act and would review any Coastal Zone Management Consistency Determination made by the Corps. All of these agencies have participated in the Saco Bay Team throughout the study process.

The City of Saco's objectives center of stabilizing the shoreline to minimize coastal losses and community disruption. The City has been very vigilant in responding to erosion losses, including significant loss of public infrastructure and feel that the solution to the problem should be undertaken primarily by the Federal Government as a Federal navigation project has caused the erosion problem. The City is also concerned with long-term project maintenance costs, which are a cost shared for Section 111 projects.

3.5 Planning Constraints

Planning constraints specific to the study area consist of the following:

- Alternative plans must be consistent with Federal and State laws including Maine's Natural Resources Protection Act (Title 38 M.R.S.A., Section 480 et. seq. and Chapter 355, Coastal Sand Dune Rules).
- A piping plover management plan will be required for alternatives that include placement of beach fill. This is required by the Endangered Species Act.
- The integrity of the existing Federal navigation project must be maintained.
- The study will not include an assessment of the viability of existing Federal navigation project.

4.0 PLAN FORMULATION

This section describes the plan evaluation and selection process. The goal of the process was to develop the most cost effective method of mitigating for shoreline damages caused by the Saco River Federal Navigation Project. Shoreline erosion has resulted in the loss of over 30 homes, City streets and public infrastructure, and, based on historic erosion rates, will impact over 60 homes and numerous City streets over the next 50 years assuming the historic rate of sea level change. The following paragraphs describe the iterative process used to develop and assess measures to prevent or mitigate for shoreline erosion.

4.1 Measures to Prevent or Mitigate for Shoreline Erosion

Measures to prevent or mitigate for shoreline erosion were developed by collecting and reviewing historic shoreline change information related to the navigation project, and collecting and analyzing data on existing conditions. Field data collection included waves, currents, tides and bathymetry of Saco Bay to develop an understanding of the coastal processes that shape the Camp Ellis shoreline. A detailed data collection and modeling report (See Appendix C), was completed to both develop and evaluate the performance of erosion mitigation alternatives.

Measures typically considered to prevent or mitigate for shoreline erosion include both structural and non-structural features. Structural measures involve partial jetty removal, beach nourishment and construction of breakwaters, spur jetties, “T” groins, seawalls, or other structures along or adjacent to the coastline. Partial jetty removal reduces the amount of wave energy that is reflected from the jetty toward the beach, and beach nourishment reduces shoreline erosion by providing sacrificial fill that erodes during storm events. Coastal structures reduce shoreline erosion by reducing wave energy or minimizing damage due to wave action. Sand dredged from the Saco River navigation channel during maintenance operations has been placed on Camp Ellis Beach on several occasions in an attempt to stabilize the beach, but positive impacts were temporary as the sand was quickly eroded from the beach. Sand from the navigation channel represents the primary source of offshore sand for beach nourishment. Studies in the vicinity of Camp Ellis Beach have determined that offshore sources within a reasonable distance tend to occur in thin layers and would not be sufficient for beach nourishment. However, upland sand sources are plentiful in the Saco area.

The only applicable non-structural measure evaluated during the study was a buyout alternative that consists of purchasing and demolishing homes and businesses within the zone of expected erosion.

4.2 Plan Formulation Process

The Corps of Engineers developed and refined potential alternatives through a series of meetings and discussions with key stakeholders. These stakeholders include the city of Saco, the state of

Maine, and the Saco Bay Implementation Team (SBIT). The SBIT includes interested representatives and individuals concerned with or impacted by erosion at Camp Ellis. Considerable Congressional interest and involvement was also evident throughout the study. State agencies including the Maine Geological Survey, Maine Department of Environmental Protection, Maine Office of State Planning, and Maine Division of Marine Resources were all participants in the SBIT. Through this public involvement process, stakeholders actively participated in the development and evaluation of alternatives under study. Considerations during the evaluation process concentrated on preventing further loss of homes and businesses by stabilizing the shoreline, and minimizing impacts to the coastal dune and marine ecosystems. Specific evaluation factors included, but were not limited to, engineering feasibility, effectiveness in stabilizing the shoreline to prevent further losses caused by the navigation project, environmental impacts, and the likelihood of resource agency acceptance.

There have been numerous previous studies and reports of the Camp Ellis Beach area, but with no resolution to the ongoing erosion. The highly irregular offshore bathymetry, nearby islands, tidal shoals, tidal range, mile-long coastal structures, and the overall shape of Saco Bay all influence wave propagation and resulting sediment transport in the vicinity of Camp Ellis Beach and the Saco River Jetties. To provide a better understanding of coastal processes at this site, a detailed modeling study, including extensive data collection program and more rigorous numerical modeling, was conducted to evaluate potential solutions to the erosion problem. This study, conducted under contract with Woods Hole Group Environmental Services, is presented as Appendix C.

The overall purpose of this study was to evaluate the likely success of potential alternative solutions to the ongoing shoreline erosion at Camp Ellis Beach that is caused by the Federal navigation project. The study focused on evaluating the physical processes (concentrating on the wave environment) occurring within the vicinity of Saco Bay, and specifically the Camp Ellis Beach region, to assess potential structural alternatives that would prevent erosion along the shoreline. The two main components of the study were a field data collection component, and a numerical modeling component. The field data collection component consisted of collecting data on site-specific conditions (e.g., waves, currents, tides, bathymetry, etc.) and the historic environment (e.g., shoreline change, offshore wave data, existing studies, etc.) to develop an initial understanding of the ongoing coastal processes that shape the Camp Ellis shoreline. The field effort provided data for development of predictive models of the Camp Ellis region. More specifically, the data collected during the field program provided the information needed to both drive and verify the numerical models to assure that they accurately represented the coastal processes occurring at Camp Ellis. The numerical modeling component of the study consisted of simulating the existing conditions within the vicinity of Camp Ellis, verifying the models' performance with observed data, and subsequently, utilizing the verified models to simulate various alternatives for shoreline protection. The numerical modeling portion of the study was ultimately used to evaluate the performance of each considered alternative. The Contractor's report was essentially complete in 2006 and changes in shoreline regression and other updates to this report are presented in Appendix B which summarizes and expands on the results of this study.

4.3 Development of Alternatives

The primary goal of the specific alternative plans that were developed as part of the coastal modeling effort was to prevent further erosion and property loss along the Camp Ellis shoreline that is caused by the navigation project, specifically the north jetty. Overall flood damage reduction along the coastline was not a goal of the study. Alternatives were developed based on the professional experience of study participants and suggestions made by stakeholders. Alternative development was constrained by Federal and State laws, regulations and policy concerning coastal development and structures. Based on existing state regulations, seawalls or coastal revetments were not considered to be permittable structures and were therefore not considered as viable alternatives. Based on these goals and constraints, over 30 alternatives were developed during the modeling study. In addition to these structural measures that would prevent further shoreline erosion, a non-structural buy-out plan consisting of the purchase of all property projected to be impacted by erosion over the next 50-years was also evaluated. Under this plan, purchased property would be demolished, existing roads and utilities would be removed, and the area restored to a natural state. This plan was discussed and developed in coordination with the Saco Bay Implementation Team (SBIT) and other stakeholders even though a buy-out plan was generally not favored by the community.

Development of structural alternatives to prevent further shoreline losses was an iterative process that involved the development and evaluation of an initial set of alternatives. These alternatives were evaluated and discussed which lead to the development of additional potential alternatives or the combination of alternatives. Site investigations conducted during the study also played a significant role in the evaluation of alternatives and the development of additional alternatives.

Table 1 provides a summary of all alternatives that were developed and evaluated as part of the modeling effort. The Alt. ID column lists the identification number of the alternative, the second column provides a brief description of the alternative and the last column provides information concerning when or why the alternative was developed. Alternative development is discussed in Chapter 10.0 of the Data Collection and Modeling Report (Appendix C), and initial screening is presented in Chapter11.0 of this report.

The initial analysis of each alternative was accomplished by simulating an eastern (90-110 degree) average annual wave approach bin, and a 10-year return period storm. The 90 – 110 degree wave approach bin represents those waves that emanate from this 20 degree sector. Since 90 degrees is east, these waves emanate from an east to east southeast direction. Waves from this sector create some of the most damaging waves along the Camp Ellis Beach shoreline. If an alternative performed well under these scenarios, it was likely that it would perform well under more energetic storm scenarios. Similarly, if it did not perform well, further study was not undertaken as it was likely that it would be ineffective under other scenarios. Wave height changes caused by proposed project features were developed for each alternative, and areas of increased and decreased wave energy were determined. To determine and alternative's effectiveness, wave energy reduction was evaluated in specific zones in the vicinity of Camp Ellis and the existing structures. In most cases, a base beach nourishment profile was included with structural features such as spur jetties or breakwaters to ensure that further shoreline losses caused by the navigation project were controlled. The following section provides a more detailed description of alternatives and the results of the initial screening analysis.

Table 1 - Alternatives considered in the alternative analysis procedure

Alt. ID	Description	Origin
	No Action	Without Project Condition
	Buyout (demolish and remove properties)	Initial alternative set
Base	Beach Nourishment Only	Initial alternative set
0	Jetty removal (segments 1, 2, and 3)	Initial alternative set
1	Northern jetty extension (segment 3) removal	Initial alternative set
2	Northern jetty extension (segment 3) removal and additional lowering of 600 m (1,970 ft)	Initial alternative set
3	Seaward location of a 750 foot spur jetty	Initial alternative set
4	Optimized location of a 500 foot spur jetty	Initial alternative set
5	Optimized location of dual 500 foot spur jetties	Initial alternative set
6	Inshore location of a 750 foot spur jetty	Initial alternative set
7	Inshore location of a 750 foot spur jetty coupled with northern jetty extension (segment 3) removal	Initial alternative set
8	Inshore location of a 750 foot spur jetty coupled with shore-based terminal groin	Initial alternative set
9	1st configuration of T-Head Groins	Initial alternative set
10	2nd configuration of T-Head Groins	Initial alternative set
11	Offshore Breakwater (seaward location)	Secondary alternative set
11A	Offshore Breakwater (nearshore location)	Secondary alternative set
11B	Offshore Breakwater (intermediate location)	Secondary alternative set
12	Offshore Breakwater (landward location) coupled with seaward location of a 500 foot spur jetty	Secondary alternative set
13	Comb configuration of 50 foot spur jetties	Secondary alternative set
14	Offshore borrow pit	Secondary alternative set
15	Seaward location of a 750 foot spur jetty with an angled orientation	Secondary alternative set
16	Northern jetty roughening (segments 1, 2, and 3)	Secondary alternative set
17	Submerged shoal/rock outcrop	Secondary alternative set
18	Offshore Breakwater (landward location) coupled with landward location of a 500 foot spur jetty	Developed based on highest performing previous alternatives
19	Seaward location of a 750 foot spur jetty, northern jetty extension removal, and jetty roughening	Developed based on highest performing previous alternatives
20	Alt. 11a with estimated full salient formation	Estimated based on expected shoreline response
21	Alt. 11a with estimated partial salient formation	Estimated based on expected shoreline response
22	Combination of 750 foot spur jetty with two nearshore 375 foot segmented breakwater components	Developed based on results of initial geotechnical work
23	Combination of 500 foot spur jetty with three 325 foot segmented breakwater components	Developed based on results of initial geotechnical work
24	Alt. 23 with additional northern breakwater segment of 325 feet	Developed based on results of initial geotechnical work
25	Secondary configuration of 500 foot spur jetty with three segmented breakwater components with lengths of 395feet, 410 feet and 325 feet	Developed based on results of initial geotechnical work
26	Alt. 24 moving the northern most breakwater segment further north	Developed based on results of initial geotechnical work
25A	Modification of Alt. 25, removing northernmost segmented 325 foot breakwater	Developed based on concern of nearshore proximity of northernmost breakwater

4.4 Description of Alternatives and Results of Initial Screening

Even though 32 alternatives were evaluated during the study, these alternatives were not evaluated as a complete set of alternatives. Alternative development was an iterative process whereby plans were developed and assessed based on their potential to prevent or mitigate for erosion occurring at Camp Ellis, and additional plans were developed based on the results of these earlier studies. The initial group of alternatives that was screened was the alternatives that were referred to as the initial and a secondary set of alternatives. These alternatives were developed based on wave modeling studies, professional experience, and input and coordination from study stakeholders. These alternatives (the base alternative through alternative 21) are described below along with the results of initial screening. To simulate the effects these alternatives, the existing conditions model was numerically modified to include the proposed layouts. Figure 8 shows the zones that were used to evaluate changes in wave energy in the vicinity of Camp Ellis Beach and the Saco River Jetties.

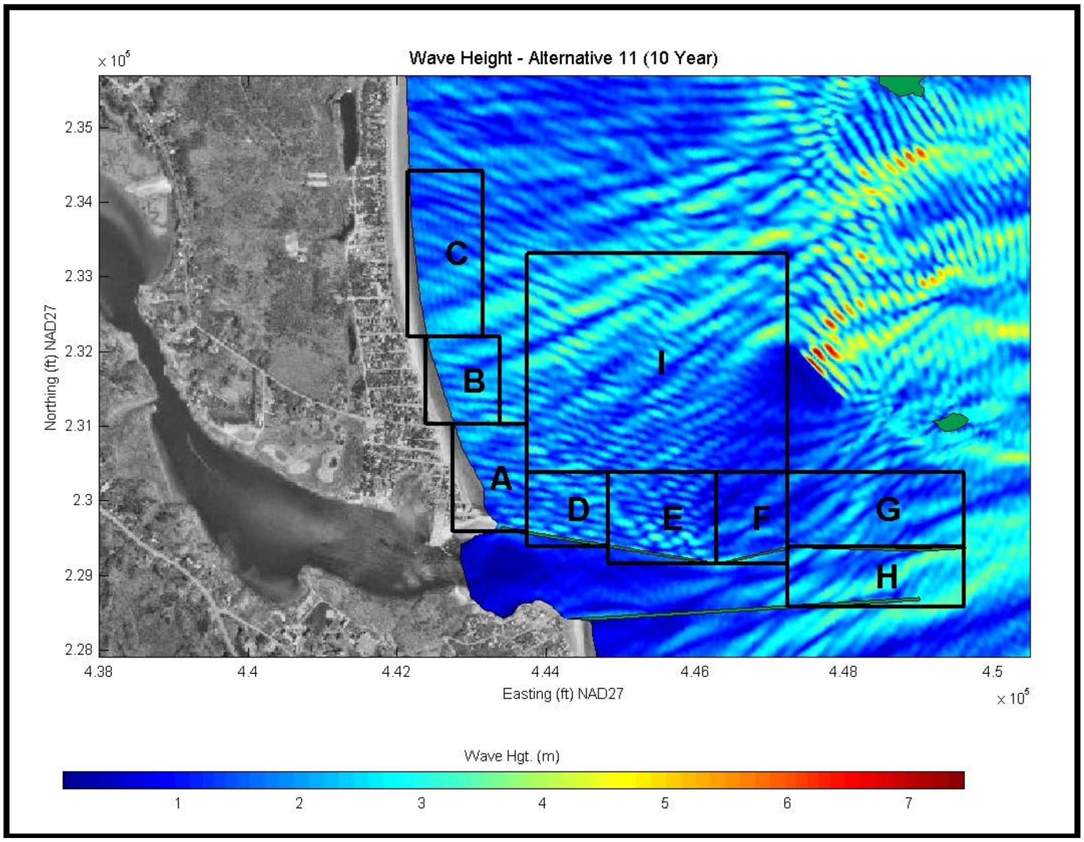


Figure 8 – Wave Energy Zones

No Action Alternative

The no action alternative or without project condition assumes that there would be no change to the present conditions at Camp Ellis Beach. The shorefront would continue to erode and the State and local government and shorefront property owners would be the only proponents of shoreline erosion mitigation. It is expected that some shoreline protection activity may be initiated as erosion continues. For example, following the Patriots Day storm of April 2007, the State approved the installation of geotubes and sandfill in an attempt to stabilize a section of shoreline that experienced severe erosion. However, State regulations prohibiting hard structures along the shoreline will minimize the extent of these activities. The geotubes provided only temporary relief This alternative would not address the required mitigation purview of the Section 111 Authority, but is retained as it represents the without project condition.

Buyout Alternative
The buyout alternative includes the purchase and demolition of all residential and commercial property within the zone of expected erosion. All utilities and roadways within this area would also be removed and the area restored. This alternative was developed based on projected erosion rates in the study area and retained throughout the plan formulation process as a viable non-structural alternative.

Beach Nourishment Only
This alternative consists of placement of sand on the beach area fronting Camp Ellis Beach. The initial nourishment design consisted of approximately 300,000 cubic yards of material placed along approximately 3,000 feet of shoreline with the southern end of the project located at the northern jetty. Beach fill must be placed along 3,000 feet of shoreline to allow the northern end of the fill to taper and tie into an existing healthy beach profile. However, with continued erosion, it is likely that the beach nourishment design volume will increase. Beach nourishment is also a necessary component of every structural alternative. Structural measures can reduce the amount of wave energy reaching the shoreline, but a beach is still necessary to absorb remaining wave energy.

This alternative poses a significant risk of failure during repeat storms and does not mitigate for the north jetty's effect on the wave field. Although this alternative does not address all the causes of erosion at the project site, it was included in further analysis as the potential lifetime of beach nourishment alone can be used to assess the relative performance of other alternatives.

Alternative 0: Jetty Removal
This alternative evaluates complete removal of the northern jetty adjacent to the Saco River and would attempt to restore the beach system by removing the jetty. This alternative would also remove the southern jetty at Saco River inlet. The goal of this alternative would be to eliminate reflected wave energy from the structure that impacts Camp Ellis Beach, as well as to potentially restore a natural sediment supply to the beaches from river sediment.

Removing structures would eliminate reflected wave energy, but there are significant wave height and energy increases in the navigation channel and along the Biddeford shore at Hills Beach. So while this alternative does eliminate reflected wave energy from the structure, there are some significant negative impacts associated with this alternative, including a plausible increase to the erosion at Camp Ellis Beach.

The increased wave energy at the entrance to the Saco River will result in significant navigation and maintenance concerns related to the navigational channel. Presently the structures assist in keeping the needed maintenance frequency for the lower river channels and anchorage areas at about a ten year cycle. Removal of the structures would compromise navigation safety in the inlet and significantly increase the frequency and cost of maintenance dredging requirements. Exposing the inner harbor and inlet at Camp Ellis to increased sea states would also increase maintenance requirements for shore structures, including the fish pier and result in a greater incidence of damages to the commercial fishing fleet of nearly 40 vessels and the large number of recreational boats that use the river. Decreased channel depths would result in grounding damages and result in delays as commercial vessels wait for favorable tides to unload their catch. Anchorage areas would shoal more frequently, severely impacting mooring capacity. It is expected that the combined effect of increases in wave energy and susceptibility to shoaling would compromise the safety and usefulness of existing navigation facilities and result in a significant reduction is the number of boats using the lower Saco River.

Wave energy would also increase significantly in areas south of the Saco River such as Hills Beach in Biddeford, Maine under all wave approach scenarios.

The removal of all existing structures would also remove some protection that is afforded Camp Ellis Beach from the easterly and southeasterly wave approach directions and hurricanes. Removal of the northern structure would destabilize the Camp Ellis shoreline. The northern jetty has been in place for over 150 years, and although the structure has blocked sediment supply to Camp Ellis Beach by directing the sediment laden Saco River discharge much further offshore, the shoreline has had the structures in place for 150 years and re-adjusted to their presence. It is likely that complete removal of the northern jetty may actually exacerbate erosion at Camp Ellis Beach through destabilization of the shoreline (communications with MGS, 2005). The southern terminus of the beach would be exposed to significant tidal currents, and due to the lack of sediment supplied over the last 150 years, it is very likely the entire southern portion of Camp Ellis Beach would be flooded, eroded, or completely severed, isolating the fish pier and other shore infrastructure on which the harbor and its fishing fleet depends.

Removal of the structures would also allow the Saco River Inlet to migrate (i.e., shift its position to either north of south) and could result in the loss of a significant portion of Camp Ellis Beach.

Detailed consideration of this alternative was not recommended for further consideration by the project team (SBIT, MGS, USACE, and WHG).

Alternative 1: Northern Jetty Extension Removal

This alternative would remove the outer 2,300 feet of the northern jetty (segment 3), which comprises the half-tide portion of the structure. These were the last sections added during the history of the project's construction. The goal of this alternative would be to reduce a minor portion of the wave energy that reflects off the jetty and impacts Camp Ellis Beach.

This alternative causes no major changes in much of the region, with the exception of wave energy increases in the entrance channel and a small increase in energy at the new outer portion of the structure. Overall, this alternative does not warrant further study or consideration. Wave energy and heights were increasesed in the navigational channel or along the remaining structure length, but wave energy decreases at the beach were not observed by the model. The key problem with this alternative is that the primary goal of reducing reflected wave energy does not occur. This alternative was not recommended for further consideration.

Alternative 2: Northern Jetty Extension Removal and Lowering

This alternative adds to Alternative 1 by lowering 1,970 feet of the remaining length of the northern jetty to a crest elevation of 1.1 feet Mean Tide Level. By lowering this length of jetty, the seaward extent of the exposed portion of the northern jetty at Mean High Water (MHW) would be equivalent with the seaward extent of the exposed portion of the southern jetty at MHW. The intent of this alternative was to further reduce reflected wave energy, while creating a somewhat equivalent structure length on both sides of the Saco River Inlet.

Similar to Alternative 1, there are wave energy increases in the entrance channel. There are two locations that indicate wave energy reduction for the eastern approach direction. The first is the actual area of the lowering (zone E) on the northern jetty, which was expected due to reduced wave reflection off the structure in this region. The second area that indicates a decrease is zone B along the shoreline. Waves from this approach direction that were reflected off the structure onto the beach in this region were eliminated. For northeast prevalent storm cases, there are similar reductions in zone E, but less improvement in zone B. Overall, this alternative warranted little further study or consideration. This alternative would increase wave energy and heights in the entrance channel during both annual and storm conditions. There was some benefit to the shoreline regions for the eastern average annual wave approach direction, but little to no benefit for other directional approaches and storm cases. This alternative was not recommended for further consideration.

Alternative 3: Seaward Placement of 750-foot Spur Jetty

This alternative would consist of the construction of a 750 foot spur jetty that would be attached to the existing northern jetty. The spur would be located approximately 2,000 feet from the shoreline (approximately two-thirds the length of segment 1). The spur would be oriented in a shore parallel (jetty perpendicular) orientation. This alternative would attempt to intercept the reflected wave energy, break a portion of the incident wave energy, and block Mach-Stem wave effects from transferring energy along the structure. Mach-Stem waves refer to waves traveling along the structure. These higher than normal waves are generated when waves strike a structure at an oblique angle.

For average annual eastern approach scenario – Zone D, which lies directly landward of the spur experiences significant energy reductions while critical zones A and B indicate minor energy reductions. Increased wave energy occurs in zone F on the order of approximately 20 percent. For this approach simulation, the alternative is minimally effective.

For the 10-year storm case, wave height reduction is significant directly landward of the structure, but wave height reduction is small for zones A and B along the coast. The position of the spur jetty does not intercept a majority of the waves that are reflected back towards Camp Ellis Beach. A significant increase in wave energy is also visible in zone F which may result in some structural maintenance concerns during storm events.

Although this alternative does intercept a portion of the wave energy that is reflected off of the northern jetty, its layout and location does not significantly reduce the wave energy acting on zones A and B. Therefore, this alternative warranted little further study or consideration, and further evaluation was not recommended.

Alternative 4: Optimized Location of a 500-foot Spur Jetty

This alternative would consist of the construction of a 500 foot spur jetty that would be attached to the existing northern jetty. During the modeling process, an iterative methodology was used to determine the optimal location for the spur. This included evaluation of the existing condition wave energy, and a logical placement of the 500-foot spur. Through this process, the optimal spur would be located at approximately 1,475 feet from the shoreline (approximately one-half the length of segment 1). The spur would be oriented in a shore parallel (jetty perpendicular) orientation. As in the case of the Alternative 3, the goal of this alternative would be to intercept the reflected wave energy, break a portion of the incident wave energy, and block Mach-Stem wave effects from transferring energy along the structure. Therefore, this alternative would potentially reduce the overall wave energy arriving at Camp Ellis Beach. In addition, the spur jetty should assist in reducing cross-shore sediment transport from the beach seaward along the existing northern jetty.

For the average annual eastern approach scenario, the results for this alternative were similar to those for Alternative 3. There was a significant energy decrease in zone D, moderate increases in zones E and F, and minimal decreases in energy in zones A and B. There was a slight increase in wave energy in zone C for this approach scenario, as well.

The results for the 10-year storm case were similar to the average annual eastern approach scenario. The length of the spur jetty does not intercept a majority of the waves that are reflected back towards Camp Ellis Beach. Overall, results for this alternative are similar to Alternative 3, with a slight improvement during storm events. This alternative indicates that the location is far improved over alternative 3, but the reduction in the length of the structure (from 750 to 500 feet) decreases the effectiveness of Alternative 4. Although an improvement, this alternative warranted little further study or consideration, and was not recommended for further evaluation.

Alternative 5: Optimized Location of Dual 500-foot Spur Jetties

This alternative would consist of the construction of two 500 foot spur jetties that would be attached to the existing northern jetty. This alternative would attempt to improve the performance of Alternative 4 by adding a second spur. During the modeling process, an iterative methodology was used to determine the optimal location for the spurs. Through this process it was determined that the optimal spurs would be located at approximately 1,475 feet from the shoreline (approximately one-half the length of segment 1) and approximately 4,035 feet from shore (at the seaward end of segment 2). The spurs would be oriented in a shore parallel (jetty perpendicular) orientation. As is previous spur alternatives, the goal was to intercept the reflected wave energy, break a portion of the incident wave energy, and block Mach-Stem wave effects from transferring energy along the structure. Therefore, this alternative would potentially reduce the overall wave energy arriving at Camp Ellis Beach. In addition, the spur jetty should assist in reducing cross-shore sediment transport from the beach seaward along the existing northern jetty.

For average annual eastern approach scenario, the results for this alternative were similar to Alternative 4, but with increased energy reduction within zone F due to the shadow zone caused by the second spur jetty. For the 10-year storm case, the reflected wave energy reduction was approximately the same as Alternative 4. The only significant differences between the wave energy and wave height differences between Alternatives 4 and 5 occur along the northern jetty, where the dual spur jetties create a complex wave interaction.

Overall, the dual spur option shows little improvement over a single spur alternative, and also creates a region of significant wave turbulence in between the two spurs, along the length of the northern jetty. Although this alternative eliminates the Mach-Stem wave and reduces a portion of the reflected wave energy, it doesn't offer significant improvement over the single spur cases, nor does it result in a significant energy reduction in zones A and B. Further evaluation of this alternative was not recommended.

Alternative 6: Inshore Location of a 750-foot Spur Jetty

This alternative would consist of the construction of a 750 foot spur jetty that would be attached to the existing northern jetty. The spur would be located approximately 1,475 feet from the shoreline (approximately one-half the length of segment 1). This location was determined by optimizing the location through multiple simulations. The spur would be oriented in a shore parallel (jetty perpendicular) orientation. This alternative would attempt to intercept the reflected wave energy, break a portion of the incident wave energy, and block Mach-Stem wave effects from transferring energy along the structure. Therefore, this alternative would potentially reduce the overall wave energy arriving at Camp Ellis Beach and seaward removal of material from the beach. In addition, the spur jetty should assist in reducing cross-shore sediment transport from the beach seaward along the existing northern jetty. This alternative was build off of the success of Alternative 4 and attempted to take advantage of an increased spur length at an optimized location.

This was the first alternative that showed significant wave energy reduction in zone A for the average annual eastern approach scenario, as well as wave energy reduction in both zones B and C. The large reduction in wave energy in zone D also makes this alternative the best performing spur alternative that was simulated. As expected, zones E and F show moderate energy increases seaward of the spur. There also was no change in wave energy at the entrance to the navigational channel (zone H). Figure 9 clearly shows the interception of a good portion of the reflected wave energy throughout the directional array. Waves are intercepted that would propagate to a significant stretch of Camp Ellis Beach.

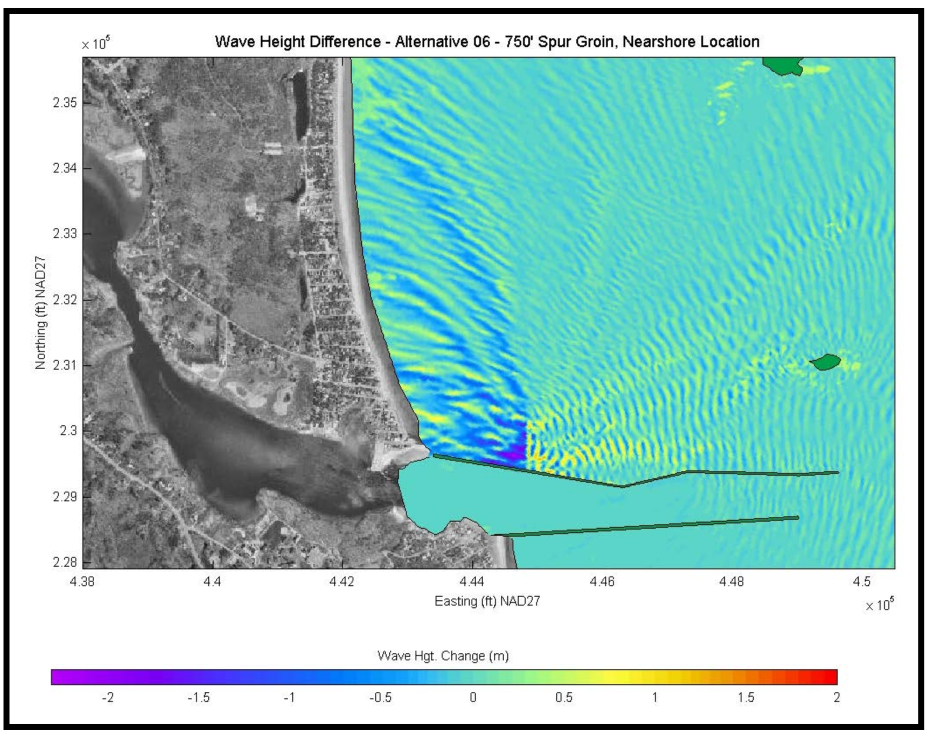


Figure 9 - Wave height changes for Alternative 6 for an eastern (90-110 degree) wave approach scenario

Alternative 6 also reduces wave energy within the same zones during the 10-year return period storm scenario. The percentage of reduction is not as great, but the overall wave height reduction is still significant. Overall, Alternative 6 was the best performing spur alternative. A significant amount of reflected wave energy is intercepted and wave energy was reduced in critical zones A, B, and D without negative impacts in zone C or the entrance to the navigational channel (zone H). It is recommended that Alternative 6 be considered for further detailed assessment, including simulation of all wave approach directions and assessment of sediment transport.

Alternative 7: Alternative 6 with Northern Jetty Extension Removal

This alternative would consist of a combination of Alternative 6 and removal of a portion of the existing northern jetty. 750 feet of segment 3 would be removed for potential beneficial re-use in the construction of the spur jetty. As in other spur alternatives, this alternative would potentially reduce the overall wave energy arriving at Camp Ellis Beach by intercepting reflected wave energy, breaking a portion of the incident wave energy, and blocking Mach-Stem wave effects from transferring energy along the structure. The spur jetty should also assist in reducing cross-shore sediment transport from the beach seaward along the existing northern jetty.

This alternative combined the best performing spur alternative (Alternative 6) with removal of the northern jetty extension. The results of this alternative were the same as Alternative 6 except that there was a wave energy increase of approximately 20 percent at the entrance to the navigational channel (zone H). Additionally, no significant improvement on shoreline protection is added by removing the northern jetty extension. This alternative warranted little further study or consideration, and was not recommended.

Alternative 8: Alternative 6 with Terminal Groin

This alternative would consist of a combination of Alternative 6 and construction of a terminal groin positioned at the approximate location of the northern terminus of the beach nourishment template. The terminal groin would be located approximately 3,000 feet north of the existing northern jetty and would extend approximately 250 feet offshore. In addition to the potential benefits of the spur jetty, the terminal groin would attempt to prevent the beach nourishment material from being transported to the north and away from the most critical erosion areas of Camp Ellis.

The terminal groin does not have any significant influence on the wave transformation in the vicinity of Camp Ellis Beach. Its primary purpose was to help contain sand within the beach nourishment footprint by minimizing northward movement of sand. The terminal groin would also likely have a negative influence on the adjacent northerly coastline by cutting off a sediment source and not allowing sand to be transported into the area. Alternative 8 was not recommended for further consideration.

Alternatives 9 and 10: Primary and Secondary Configurations of T-Head Groins

These alternatives would consist of the construction shore-attached T-head groin structures and a single spur jetty. T-head groins are comprised of a standard shore perpendicular groin fitted with a shore-parallel T-head at their seaward end. The T-head is often built to interrupt the seaward flow of water and sand in rip currents that often develop along a groin's axis. The T-head may also act as a breakwater and shelter a sizeable stretch of beach behind it. Alternative 9 consists of five (5) shore-attached T-head groin structures and a single spur jetty. Alternative 10 is a variation of Alternative 9 and includes seven (7) shore-attached T-head groins along a longer stretch of shoreline. The gap spacing and structure lengths for these alternatives are presented in Tables 10-2 and 10-3 in Appendix C. These alternatives would attempt to hold the beach nourishment in place by preventing losses in both the seaward and alongshore directions. In addition, the T-heads would afford additional wave protection by breaking wave energy.

Alternatives 9 and 10 represent cases with shore-attached structures that are difficult to directly assess in terms of wave energy reduction. The primary purpose of the T-head groins is to contain sand in the nearshore region fronting Camp Ellis Beach. The wave energy changes show some reduction in wave energy in zones A and B for Alternative 9, located behind the head of the structures. Wave energy changes for Alternative 10 are local only, behind each individual structure. Comparing Alternative 9 and 10, Alternative 9 clearly has the better layout configuration. No additional wave changes occur throughout the entire domain. The T-head groins would likely be effective at holding sand in place from a beach nourishment scenario, but are likely to have significant impacts on neighboring beaches by only allowing minimal sand movement. Based on an assessment of their influence on sediment transport processes, the best T-head groin alternative was Alternative 9. Further study of this alternative was recommended to assess its impact on beaches to the north.

Alternative 11: Offshore Breakwater, Seaward Location

This alternative would consist of the construction of a breakwater located offshore of Camp Ellis Beach and detached from the existing northern jetty. The breakwater would be 920 feet in length and set in approximately 32 feet of water, relative to MHW. The breakwater would be located approximately 4,755 feet from the shoreline, with the southern end of the breakwater located approximately 1,968 feet north of segment 3 of the northern jetty. The breakwater would be oriented at approximately 45 degrees west of true north. This alternative would attempt to reduce the energy of the incident waves reaching the north jetty and also minimize the amount of incoming and reflected wave energy assaulting Camp Ellis Beach. The breakwater was specifically sited to intercept a wave train that passes between Eagle and Ram Islands.

This is one of three alternatives that were evaluated to assess the feasibility of using an offshore breakwater to prevent continued erosion at Camp Ellis Beach. This offshore breakwater, located at the seaward position, produces a significant reduction in wave energy throughout the local area for the average annual eastern approach scenario. Wave energy is reduced in almost all zones, and significantly in zone B. However, for this approach direction, the offshore breakwater fails to reduce the wave energy in zone A. This is due to the wave train that propagates nearly parallel to the northern jetty and is able to bypass the influence of the offshore breakwater. Although the breakwater is able to reduce a significant amount of wave energy arriving from between Eagle and Ram Islands, this alternative misses the wave propagating along the structure.

For the 10-year storm case, which has a more northeastern approach, this alternative intercepts a majority of the wave energy. Wave heights are reduced in the shadow zone of the breakwater and for a significant region behind the structure. The wave energy is reduced in every zone, with significant reductions in zones A, D and E. Zones B and C also experience reduced wave energy for the 10-year storm.

Overall, the Alternative 11 breakwater performs well, but it has significant limitations under the average annual eastern approach conditions and does not produce consistent wave energy reduction in the critical regions. The increased water depth also adds significant difficulty in construction and maintenance. Based on these factors, combined with the improved performance of another offshore breakwater alternative (see Alternative 11A below), Alternative 11 was not recommended for further consideration.

Alternative 11A: Offshore Breakwater, Inshore Location

This alternative would consist of the construction of a breakwater located offshore of Camp Ellis Beach and detached from the existing northern jetty. This alternative varies from Alternative 11 in that it was shifted landward and oriented to provide direct protection to zones A and B along Camp Ellis Beach. The breakwater would be 935 feet in length and set in approximately 18 feet of water, relative to MHW. The breakwater would be located approximately 2,200 feet from the shoreline, with the southern end of the breakwater located approximately 1,968 feet north of segment 1 of the northern jetty. The breakwater would be oriented at approximately 20 degrees west of true north. This alternative would attempt to reduce the incident waves reaching the shoreline, as well as a portion of the reflected wave energy advancing along the northern jetty.

This alternative, located at the inshore position, focuses on wave energy reduction in zones A and B. For the average annual approach scenario wave energy is reduced by zones A and B, and there is no negative impact on zone C. Insignificant wave energy changes occur throughout the rest of the local domain. For the 10-year storm case wave energy is also reduced in zones A and B, and there are significant reductions in wave heights in the shadow zone of the structure. Figure 10 shows wave height changes for Alternative 11A for the 10-year return frequency storm.

Overall, Alternative 11A is the best performing offshore breakwater alternative. It consistently reduced wave energy in the most critical areas, without negative influence on adjacent shores.

The breakwater is also located in shallower water thereby reducing construction and maintenance concerns. Alternative 11A was recommended for further detailed assessment.

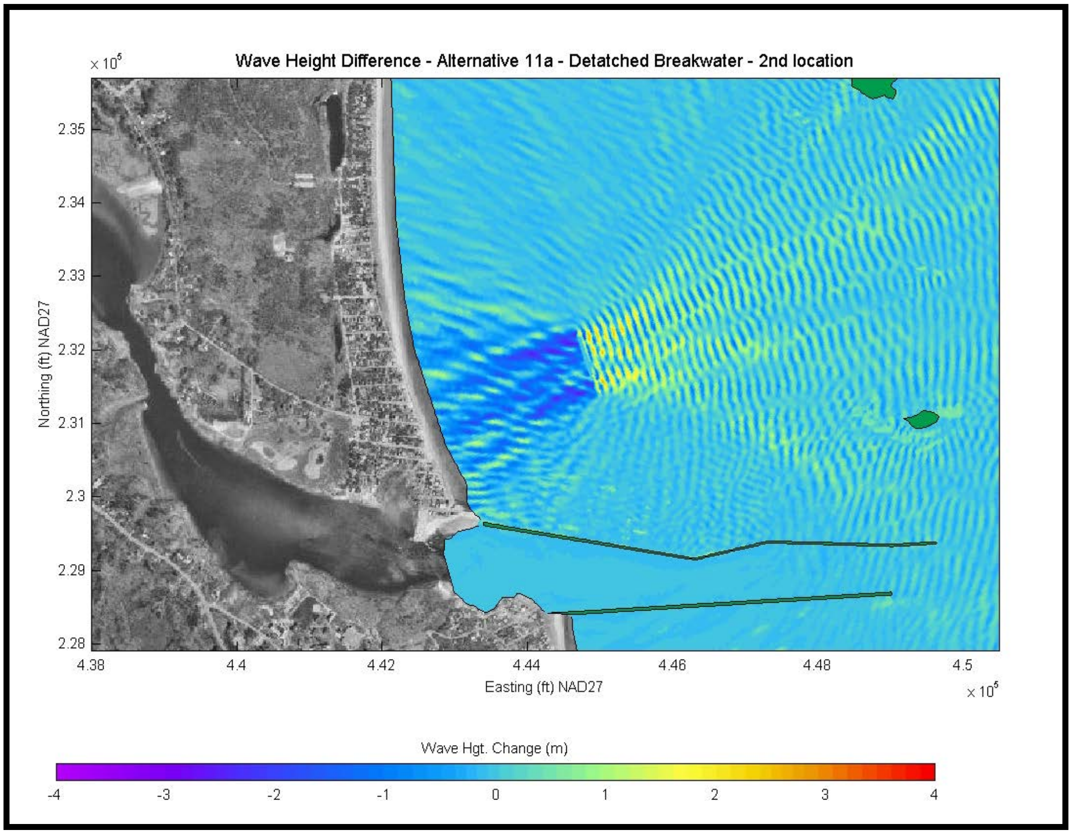


Figure 10 – Wave Height Changes for Alternative 11A for a 10-year storm

Alternative 11B: Offshore Breakwater, Intermediate Location

This alternative would consist of the construction of a breakwater located offshore of Camp Ellis Beach and detached from the existing northern jetty. The location of the breakwater for this alternative was selected as an intermediate water depth between Alternative 11 and 11A. The breakwater would be 935 feet in length and set in approximately 23 feet of water, relative to MHW. The breakwater would be located approximately 3,690 feet from the shoreline, with the southern end of the breakwater located approximately 2,067 feet from segment 2 of the northern jetty. The breakwater would be oriented at approximately 35 degrees west of true north.

The Alternative 11B breakwater did not perform as well as Alternative 11A. The reduction in wave energy was significantly less for every zone in both scenarios simulated. Therefore, this alternative did not warrant further study or consideration, and it was not recommended since there was a better performing offshore breakwater alternative.

Alternative 12: Alternative 11a and Seaward Location of 500-Foot Spur Jetty

This alternative would be a combination of the breakwater configuration presented in alternative 11A and a 500 foot spur jetty positioned 2,000 feet from shore. The gap between the breakwater and the northern end of the spur jetty would be about 1,607 feet. The goal of this alternative would be to combine the beneficial effects on wave energy reduction of both the spur jetty and the breakwater. The breakwater would reduce the incident wave energy reaching the shoreline, as well as a portion of the reflected wave energy advancing from the northern jetty. The spur jetty would reduce reflected wave energy, intercept Mach-Stem effects, and help retain sediment that now advances seaward along the existing northern jetty.

This alternative, and Alternative 18, represent combinations of the best performing offshore breakwater configuration and a spur jetty. Alternative 12 improves on Alternative 11a by eliminating a portion of the reflected wave energy from the nearshore region through use of a spur jetty. Energy is reduced in all critical zones, but Alternative 18 performs better than Alternative 12 because the spur jetty is repositioned to the optimal location. Therefore, although Alternative 12 performs effectively, it is not recommended for further analysis since Alternative 18 outperformed it.

Alternative 13: Comb Configuration of Spur Jetties

In an effort to cut down on the reflected wave energy and Mach-Stem effect, a configuration of a series of smaller spur jetties was considered. This alternative would consist of 19 small spur jetties attached to the northern jetty. Each spur jetty would be approximately 50 feet in length and extend perpendicular to the existing northern jetty. The spurs would be spaced about 200 feet apart and would extend along segments 1 and 2 of the northern jetty. This alternative would attempt to prevent Mach Stem effects and break the reflected wave energy.

Alternative 13 was effective at diminishing the reflective wave energy and Mach-Stem effects, but only to a minimal to moderate level and was only effective for zones along the structure. When compared to some of the better performing alternatives, and considering the logistical hurdles associated with installing 19 small individual structures, Alternative 13 was not recommended for further analysis.

Alternative 14: Offshore Borrow Pit

This alternative would consist of the dredging of an offshore borrow pit in a strategic location offshore of Camp Ellis Beach. The location of the proposed borrow site was sited to intercept the primary wave train advancing between Eagle and Ram Islands. The dredged region would be deepened by approximately 8 feet to a maximum depth of 45 feet relative to MHW. This alternative would cause wave energy to diverge from the Camp Ellis Beach area, while also serving to provide nourishment material. A borrow site, with increased water depth, would create a zone of decreased wave energy behind the sand borrow site and increased energy in areas adjacent to the borrow site. Waves propagating over the borrow site are deflected outward, the opposite of what occurs when waves converge over a shoal.

The offshore borrow pit had minimal influence on the wave field and transformation. Wave height changes were minimal during the 10-year return period storm case, and there were no significant wave energy changes within the entire region. The net result is that an offshore borrow site, at least one of reasonable depth and dimensions, would not improve conditions at Camp Ellis Beach over existing conditions. Based on these minimal changes and underperformance, the offshore borrow pit was not recommended for further consideration.

Alternative 15: Alternative 3 with Angled Orientation

Although various orientations of spur jetties were simulated in the optimization approach, this alternative focused on a specific angled orientation of a spur jetty. The orientation was identified in the existing conditions assessment and was positioned to intercept a primary wave train impacting the northern jetty and Camp Ellis region. This alternative would consist of the construction of a 750 foot spur jetty that would be attached to the existing northern jetty. The spur would be located approximately 2,000 feet from the shoreline (approximately two-thirds the length of segment 1). The spur would be oriented approximately 10 degrees west of north. This alternative would intercept reflected wave energy, break a portion of the incident wave energy, and block Mach-Stem wave effects that transfer energy along the structure. Performance of the angled orientation would be compared to other spur jetty alternatives.

In the 10-year return period storm scenario, maximum wave height decreases were located directly in the shadow of the angled spur. Wave energy reduction was most significant in zone D, while zone B showed a minor reduction. There was a significant increase in wave energy in zone F. Alternative 15 showed no change in wave energy in zone A, and it did not perform as well as Alternative 6, which was the best performing straight spur jetty alternative. In the wave transformation animation, it was evident that the angled spur was not as effective at intercepting the important wave trains that were reflected off of the northern jetty and directed at Camp Ellis Beach. Therefore, this alternative warranted little further study or consideration, and was not recommended for further analysis.

Alternative 16: Northern Jetty Roughening

This alternative would consist of roughening the northern jetty by repositioning existing armor units in a loose configuration and/or “points out” orientation. Currently, a significant portion of the northern jetty is comprised of well-placed armor units forming a relatively smooth face which increases its reflectivity. This alternative would reduce the reflectivity of the structure through roughening of the northern face of the jetty. Jetty roughening was included in a plan recommended in the Corps August 2001 feasibility report update. However, subsequent modeling by the Corps (Model Study of Beach Erosion, dated August 1995) determined that better wave height reductions could be achieved with other alternatives.

The northern jetty was numerically roughened by reducing the reflection coefficient for the northern jetty by approximately 40 percent. It is debatable if the jetty could potentially be roughened to that extent, considering the existing size and length of the structure. It would likely require a nearly complete reconstruction of a significant portion of the jetty. However, this level of roughening was simulated in the model to determine if Alternative 16 was viable even under the best roughening conditions.

The jetty roughening alternative indicated moderate wave height and energy reductions throughout the domain. Jetty roughening does impact the amount of reflected wave energy that is directed back toward the Camp Ellis Beach shoreline and the development of the Mach-stem effects. Although indicating moderate success at reducing wave energy for the critical zones along the shoreline, jetty roughening did not produce the same level of energy loss as some of the other alternatives. Therefore, further study or consideration of this alternative was not recommended.

Alternative 17: Submerged Breakwater / Rock Outcrop

This alternative would consist of the construction of a submerged detached breakwater, and/or random placement of rocks to form an offshore shoal/outcrop. This is the submerged version of Alternative 11. The submerged feature would have a crest elevation equivalent to mean tide level (MTL) and would be approximately 920 feet in length and located in approximately 33 feet of water at MHW. The structure would be located approximately 4,760 feet from the shoreline and approximately 1830 feet north of segment 3. The crest width of the submerged breakwater was set to 10 feet. This alternative would mimic the protection afforded by typical rock outcrops and submerged features throughout the coastal region of Maine. Therefore, waves would break at this structure prior to reaching the northern jetty and/or Camp Ellis Beach.

The submerged breakwater/rock outcrop alternative performed similar to the offshore borrow pit alternative. The amount of wave energy reduction was minimal and wave height reduction was less than three feet, even in areas directly adjacent to the submerged feature. The submerged feature does have some benefits, but it lags behind the emergent structures in terms of performance. The potential significant maintenance requirements and difficulties associated with maintaining a submerged structure, as well as the hindrance to navigation, are also significant concerns when considering a submerged solution at this location. Although beneficial, it does not perform well enough to solve the problem at Camp Ellis Beach. Therefore, this alternative does not warrant further study or consideration, and was not recommended for further analysis.

Alternative 18: Alternative 11A and Inshore Location of 500-Foot Spur Jetty

For the average annual eastern approach scenario Alternative 18 provides significant wave height reductions in the regions landward of the proposed structures. Wave energy reductions for the average annual eastern approach case are also significant in the three most critical zones (A, B and C), and zone D energy is also reduced.

Figure 11 presents the wave height difference plot for Alternative 18 under a 10-year return period storm scenario. For the 10-year storm case, Alternative 18 shows similar performance to the average annual eastern approach scenario. The wave heights are decreased landward of the proposed structures, and in zones along the shoreline (A and B). There are no negative impacts in zone C and a decrease in wave energy in zone D. There are some increases in wave energy seaward of the proposed structures.

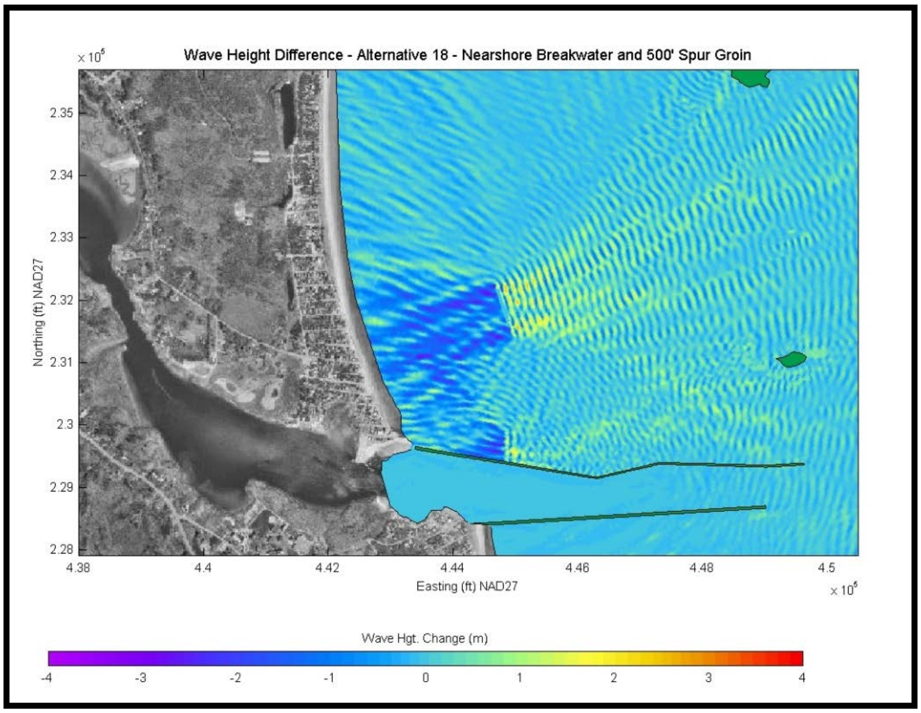


Figure 11 – Wave Height Changes for Alternative 18 for a 10-year return period storm

Overall, Alternative 18 is the best performing breakwater/spur alternative. The animations of wave propagation show the scenario intercepts a majority of the wave energy, missing only a single wave train that passes between the two structures. Alternative 18 consistently reduced wave energy in the most critical areas, without negative influence on adjacent shores. Alternative 18 was recommended for further detailed assessment.

Alternative 19: 750 foot Spur Jetty, Jetty Roughening and Jetty Removal

This alternative would be a combination of the best performing 750 foot spur jetty, roughening of the existing northern jetty, and removal of the seaward end of the existing northern jetty. The spur jetty would be located 1,475 feet from shore. This alternative would combine a number of potential alternatives to develop cumulative reductions in wave energy.

Alternative 19 shows minimal performance gains over Alternative 6. Wave energy reductions for the 10-year return period storm remain under 10 percent for the shoreline areas, while the average annual eastern directional approach performs significantly better due to the spur jetty's ability to intercept the wave train propagating directly parallel to the northern jetty. Although there are some improvements over Alternative 6, they are not great enough to warrant the significant construction component of the added roughening and removal. In addition, as is the case for any removal option, there is an increase in wave energy at the entrance to the navigational channel, impacting both vessel traffic and maintenance requirements. Alternative 19 was not recommended for further analysis.

Alternatives 20 and 21: Alternative 11A with Estimated Salient Formations

Alternatives 20 and 21 do not represent specific alternatives, but rather are a subset of expected shoreline response simulations in relation to Alternative 11A. Estimates of salient formation were developed to determine the impact of salient formations on wave energy. A salient is a coastal formation of beach material developed by wave refraction, wave diffraction, and longshore drift producing a bulge in the coastline behind an offshore island of breakwater. Figure 12 presents an example of the expected shoreline response to Alternative 11A and 18. These alternatives (20 and 21) helped to gauge the wave changes occurring due to expected shoreline response.

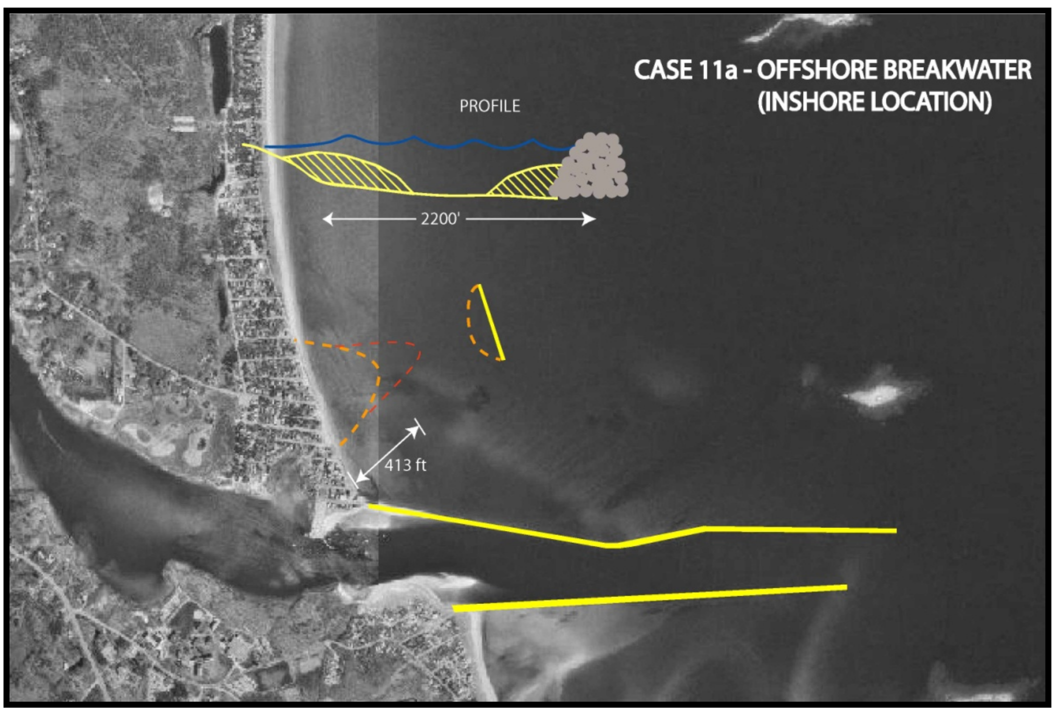


Figure 12 - Expected shoreline response behind offshore breakwater of Alternative 11A (broken red line) and Alternative 18 (broken orange line)

4.5 Results of Initial Alternative Screening

Evaluation of the alternatives presented in the previous section resulted in the selection of five (5) alternatives that warranted further study. One was the base alternative of beach nourishment only while the others involved the construction of coastal structures along with beach nourishment. These alternatives are shown in Table 2.

Table 2 – Alternatives Recommended for Further Study based on Initial Screening

Alternative ID	Description
	No Action
	Beach Nourishment Only
6	750 foot Spur Jetty
9	T-Head Groins
11A	Offshore Breakwater – Nearshore Location
18	Offshore Breakwater (Nearshore Location) Combined with 500 Foot Spur Jetty

4.6 Secondary Screening of Preferred Alternatives

Once these alternatives were selected for further study, field investigations were initiated to provide the basis for more detailed design and cost estimating. Field work included subsurface borings to determine foundation conditions in the study area. Borings along and adjacent to the centerline of the offshore breakwater determined that there was a thick layer of lean clay (see Appendix D) under the majority of the structure. Only the south end of the structure had acceptable foundation conditions. This compressible layer of clay was overlain by a very thin layer of sand (2-5 feet) that would provide very little support for a stone structure. Since a breakwater at this location would have a total height of 25 feet, the weight of the structure would cause significant settlement along the majority of the structure. The breakwater could be overbuilt to compensate for settlement, but as one end of the structure would be situated on less compressible substrate, differential settlement would be an additional concern. Based on these concerns and the high costs of constructing a stable breakwater at this location, the feasibility of placing breakwaters closer to the shoreline was discussed with key study stakeholders. These discussions resulted in the development of five (5) additional alternatives.

The following alternatives (22 – 26) comprise a series of segmented breakwater configurations designed in response to geotechnical investigations that identified the foundation conditions underlying previously proposed alternatives. Of particular concern was the presence of soft compressible clay under a thin layer of sand in several areas. Breakwater segments and structures for these alternatives were placed in nearshore locations thought to have adequate soil/sediment bearing capacity. Considerations in the development of these plans included potential reductions in wave energy in the nearshore zone, reducing reflected wave energy and extending beach nourishment life. Since the construction of breakwaters closer to the shore could result on salient development and impacts to littoral transport, these factors were also considered. Plans of these alternatives are presented in Appendix C, pages 150-156.

Alternative 22: Segmented Breakwater Configuration 1
This alternative would consist of two (2) detached breakwater segments and a spur jetty. The spur jetty would be 750 feet in length, 1,475 feet from shore, and extend perpendicular to the existing northern jetty. Included would be two (2) segmented breakwater segments 375 feet long, located north of the spur and about 1080 feet from the shoreline.

Alternative 23: Segmented Breakwater Configuration 2
This alternative would consist of 3 detached breakwater segments and a spur jetty. The spur jetty is 500 feet in length, 1,475 feet from shore, and extends perpendicular to the existing northern jetty. The breakwater segments are 325 feet long and located about 1,100 feet from shore.

Alternative 24: Segmented Breakwater Configuration 3
This alternative would consist of 4 detached breakwater segments and a spur jetty. The spur jetty would be 750 feet in length, 1,475 feet from shore, and extends perpendicular to the existing northern jetty. The location of the first 3 breakwater segments is the same as Alternative 23. A fourth 325 foot breakwater, about 425 feet from shore, was added north of the third breakwater.

Alternative 25: Segmented Breakwater Configuration 4
This alternative would consist of 3 detached breakwater segments and a spur jetty. The spur jetty would be 500 feet in length, 985 feet from shore, and extend perpendicular to the existing northern jetty. The three segmented breakwaters would have lengths of 395 feet, 410 feet, and 325 feet. The first two breakwaters would be about 900 feet from shore and the third segment would be about 425 feet from shore. Wave height changes for Alternative 25 for a 10-year return period storm are shown in Figure 13 below.

Alternative 26: Segmented Breakwater Configuration 5
This alternative would consist of 4 detached breakwater segments and a spur jetty. The spur jetty would be 500 feet in length, 1,475 feet from shore, and extend perpendicular to the existing northern jetty. All breakwaters are 325 feet long and placed in the same location as those in Alternative 24 except that the north breakwater was moved 50 feet further north.

After Alternatives 22-26 were developed, initial evaluation of their performance determined that Alternatives 25 and 26 provided the highest level of energy reduction along the shoreline. Both alternatives provided significant reductions in wave energy along the shoreline and intercepted a large portion of wave energy reflected off of the northern jetty. Wave height changes for these alternatives for a 10-year return frequency storm are shown in Figures 13 and 14.

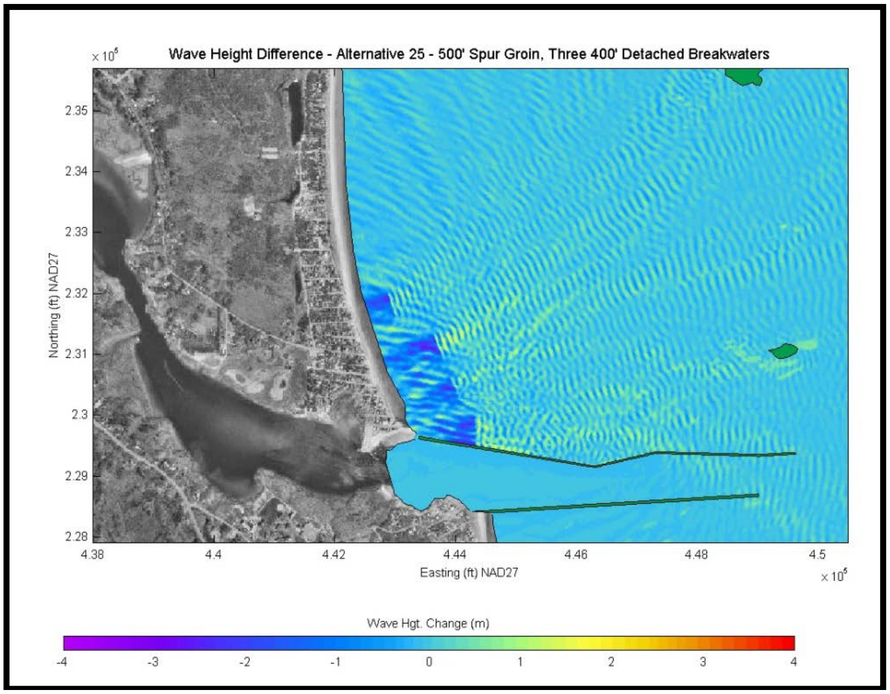


Figure 13 - Wave height changes for Alternative 25 for a 10-year return period storm

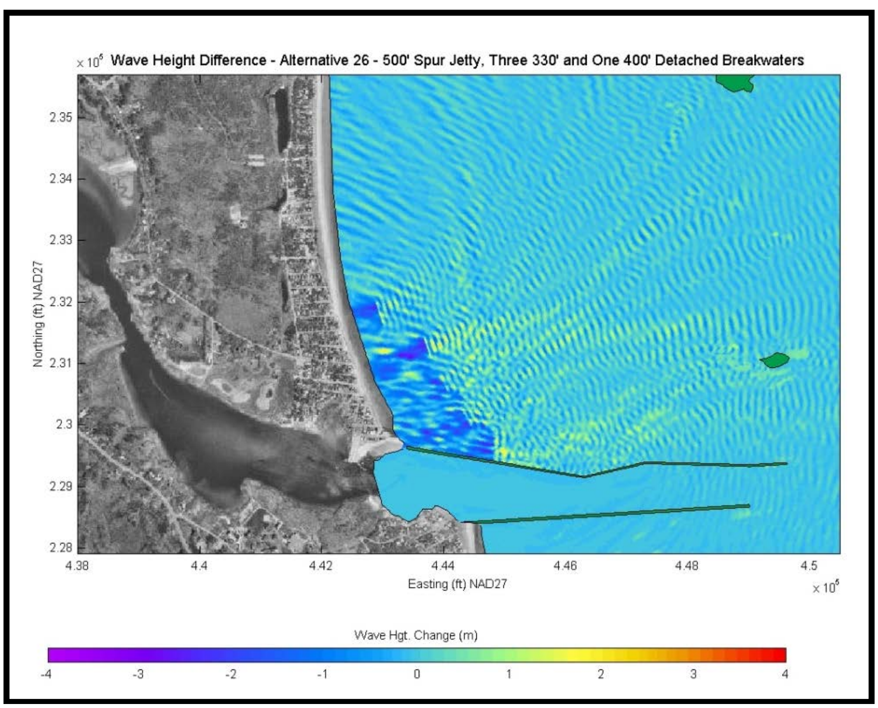


Figure 14 - Wave height changes for Alternative 26 for a 10-year return period storm.

To assess the constructability of these alternatives, additional subsurface investigations were conducted along the centerline of proposed structures. These investigations determined that a thick (51-55 foot) layer of lean compressible clay was found under a thin (4-5 foot) layer of sand was located beneath the northernmost breakwater for both alternatives. As constructing a breakwater at this location would be difficult and expensive, the feasibility of deleting the northern-most breakwater was discussed. In addition to structural stability issues, there was the possibility of a well formed salient developing landward of this northern breakwater that would interrupt littoral drift. Due to these potential problems, Alternative 25 was modified by deleting the northern breakwater. This new alternative became known as Alternative 25A

Alternative 25A: Segmented Breakwater Configuration 6

This alternative would consist of Alternative 25 minus the northern breakwater. The spur jetty would be 500 feet long, located 985 feet from shore, and extend perpendicular to the existing northern jetty. The two segmented breakwaters would have lengths of 395 feet and 410 feet, and would be about 900 feet from shore. This alternative would provide wave energy reductions similar to Alternatives 25 and 26 near the breakwater, but less reduction along the northern section of Camp Ellis Beach. The wave height changes for Alternative 25A for a 10-year return frequency storm are shown in Figure 15.

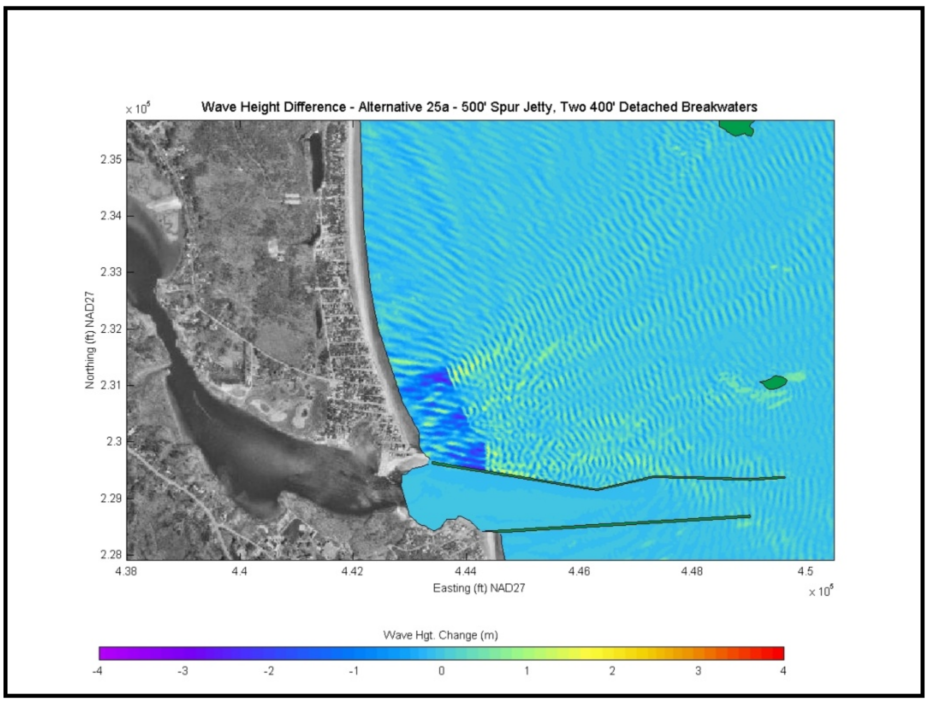


Figure 15 - Wave height changes for Alternative 25A for a 10-year return period storm.

4.7 Summary of Modeling Results

From a wave energy reduction standpoint, the modeling study resulted in the selection of eight alternatives that warranted further study. These alternatives are presented in Table 3 below. Beach nourishment alone was retained as it provided a baseline to evaluate alternatives.

Table 3 – Alternatives Selected for Further Study Based on Wave Energy Reduction

Alternative ID	Description
	No Action
	Beach Nourishment Only
6	750 foot Spur Jetty
9	T-Head Groins
11A	Offshore Breakwater – Nearshore Location
18	Offshore Breakwater (Nearshore Location) Combined with 500 Foot Spur Jetty
25	Segmented Breakwater – Configuration 4
26	Segmented Breakwater – Configuration 5
25A	Segmented Breakwater – Configuration 6

To further evaluate these alternatives, which was done to some extent in the previous section, these alternatives were then assessed based on other parameters such as impacts to adjacent areas, constructability, and overall cost. This additional analysis is presented in the following paragraphs.

Alternative 9, T-Head groins, represents an alternative that is fundamentally different than the other alternatives. While the other alternatives focus on wave energy reduction and the subsequent reduction in the ability of waves to move sediment, the T-Head groins primary function is to hold sand in place by eliminating nearly all alongshore sediment transport. Analysis of the alternative assumed that the region downdrift of the groin field would be nourished and minimal bypassing would occur around the groin field. This analysis determined that the area north of the T-Head groins would require renourishment approximately every six years. Construction costs of the T-Head groins would be high as each groin would involve construction of about 450 feet of structure, a 250 foot groin with a 200 foot T section. This plan was not favored by the state of Maine as it involved construction of permanent structures along an active beach profile. Based on these concerns and cost, this alternative was eliminated from further consideration.

Alternatives 11A and 18 included construction of a 935 foot long breakwater in fairly deep water about 2,200 feet from shore. Although these plans were supported by study participants, these alternatives were eliminated due to the high cost of constructing a stable breakwater in an area of highly compressible substrate.

Alternatives 25 and 26 were among the best performing alternatives evaluated during the study. However, each of these alternatives has the same weakness; the northern most breakwater segment is located in an area underlain by very compressible lean clay. Construction of a stable breakwater under these conditions would require overbuilding or a foundation support system resulting in high costs. The proximity of the breakwater to the shoreline would also result in the formation of a strong salient shoreward of this breakwater. Although these alternatives would have the lowest beach renourishment costs, they were eliminated based on high initial costs and potential impacts on littoral drift.

4.8 Alternatives Carried Forward

The previous assessment of alternatives eliminated five (5) of the seven (7) structural alternatives from further consideration. In addition to the two (2) structural alternatives retained for study (Alternatives 6 and 25A), the non-structural buy-out plan was included in the final array of alternatives. In addition, even though the beach nourishment only alternative has some serious drawbacks, it was included in the final array. These drawbacks include very short lifespan of previous sand placement in the project area, and the complex wave environment and reflected waves from the north jetty. These final alternatives are presented and described in Table 4.

Table 4 – Final Array of Alternatives

Alternative	Description
No Action	Represents the Without Project Condition
Beach Fill Only	Beach nourishment only
Alternative 6	750 foot spur jetty and beach nourishment
Alternative 25A	500 foot spur jetty, 2 nearshore breakwaters and beach nourishment
Buy-Out Plan	Purchase of all property and demolition of buildings within the 50-year erosion zone, shoreward extension of the north jetty and relocation of North Street

Design Considerations - Previous analysis of structural alternatives was accomplished based on an estimated volume of beach fill that was the same for all alternatives. However, as the beach response to storms would vary with the alternative, additional analysis was undertaken to size the beach fill to each alternative under study. Section 9.0 of Appendix B presents this analysis. As the intent of a Section 111 project is to prevent or mitigate for shoreline erosion problems caused by the navigation project, the beach fill was designed to prevent further shoreline erosion and not to reduce wave attack damage or to reduce the risk of tidal inundation. The model SBEACH was used to model cross shore performance of various beach fill designs. However, since the SBEACH model does not consider mach stem currents, reflected waves or the complicated current regime of the existing beach condition, the model would over-predict the performance of the beach fill only alternative, and under-predict the performance of alternative 25A due to the presence of shore parallel breakwaters. Since placement of beach fills in other high erosion down drift areas similar to this project have shown underperformance, and beach fills that were placed on Camp Ellis Beach have essentially disappeared with no appreciable longevity, the renourishment frequency for the beach fill only alternative was doubled to account factors not considered in the SBEACH model. Fill placed along Camp Ellis Beach as part of the Corps 1982 maintenance dredging of the Saco River channel and anchorages was washed off shore as fast as it was placed on the beach. Although the beach fill for alternative 25A would be expected to last longer than expected, no adjustment was made to the renourishment frequency. Section 10.0 and 12.0 of Appendix B discuss this longevity and risk analysis.

Design of the beach cross section was accomplished in three increments. The first step was the selection of an appropriate beach slope and berm elevation. A healthy, relatively stable beach profile from an area north of the study area was used as a template for the beach fill profile. This stable beach profile was extended by merging it with the off shore portions of eroded sections based on equilibrium beach theory and the strong likelihood that sub aerial profiles were similar. Through SBEACH modeling the top elevation of the berm was increased slightly based on performance and set at 12 feet NAVD88 (approximately 17.4 feet MLLW). The second and third steps in the beach design process were to determine the non sacrificial and sacrificial components of the beach berm. The non sacrificial component of the berm was defined as the minimum beach berm width required for each alternative to prevent shoreline erosion during a 10-year storm. As the intent of this project is to prevent shoreline erosion and not to provide storm damage reduction, the use of a 10-year storm to evaluate the performance of the beach fill should not be interpreted as this project providing storm damage protection from this event. The 10-year storm was selected to evaluate beach fill performance under storm conditions. Since northeast storms are very frequent in this area, there isn't a major difference between the water levels, wave heights and wave period between a 1-year and 10-year storm. However, selection and use of the 10-year storm added conservatism to the design. The width of this non sacrificial berm, which varied between 20 and 30 feet, was developed for wave energy zones A and B along the Camp Ellis Beach coastline. For details concerning this analysis see section 9.12.1 in Appendix B. To determine the width of the sacrificial portion of the beach, berm widths of 20, 30 and 40 feet were evaluated based on performance. During this evaluation, it was concluded that beach fills that have short renourishment intervals were not feasible based on resiliency and risk of failure. This removed the 20-foot berm from further consideration. It was also determined that the Beach Fill Only alternative required much more frequent renourishments when compared to Alternatives 6 and 25A for all berm widths evaluated. Based on discussions concerning comparability and effectiveness, it was determined that the beach fill volume for the Beach Fill Only alternative should be increased to a level that would result in a renourishment interval that more closely approximated Alternatives 6 and 25A. Based on the performance of Alternatives 6 and 25A for 30 and 40 foot berm widths, a 10-year renourishment interval was chosen for the Beach Fill Only alternative and fill volumes were calculated based on this interval. In addition, based on the time required between renourishment fills, a 40 foot sacrificial berm width was selected for alternatives 6 and 25A. A detailed analysis of beach widths and volumes is presented in Sections 9 and 10 of Appendix B.

The next step in the design process was to determine renourishment volumes required under the three sea level change scenarios as required under EC 1165-2-211. These sea level rise scenarios are “low” or historic, “intermediate” and “high”. Projected sea level change over 50 years is a rise of 0.3 feet for the historic rate, a rise of 1.5 feet for the intermediate rate, and a rise of 2.2 feet for the high rate. As increased sea level rise rates will accelerate beach erosion, renourishment volumes were calculated for each rate of sea level rise for each alternative. These renourishment volumes are shown in Tables 11-2 and 11-3 in Appendix B.

Detailed hydraulic and geotechnical design was necessary to size the spur jetties and breakwaters included in Alternatives 6 and 25A. Detailed design information and cross sections of these structures are included in Section 8 of Appendix B, the Geotechnical Design Appendix (Appendix D) and the Design Appendix (Appendix E). Specific design information concerning project features (beach fill, spur jetty and/or breakwaters) of each final alternative was then combined with bathymetric and upland survey data to develop detailed drawings of each alternative. Plans and cross sections of each alternative are presented in Appendix E. The following paragraphs provide detailed information concerning the final alternatives.

Real Estate Considerations - The beach nourishment only alternative, and alternatives 6 and 25A have similar real estate requirements. The landward limit and linear extent of the beach fill is the same for these three alternatives. These alternatives would require perpetual beach storm damage reduction easements on 28 properties, temporary work area easements on 11 properties, and permanent and temporary easements on public roads and rights of way. Construction of the jetty spurs and breakwaters in alternatives 6 and 25A will be in areas below mean sea level (within navigable waters of the United States). The buy-out alternative will require the purchase of all property and improvements within the area expected to be eroded over the next 50 years. As three level of potential sea level change scenarios were evaluated, the number of properties required varied with each rate of change as higher rates of sea level rise would increase the erosion rate and result in erosion moving further inland. The number of properties that would be acquired under the low (historic), intermediate and high rates of sea level change are 62, 86 and 101 respectively. Under these scenarios, the property would be purchased, all improvements removed, and the land returned to a natural state. The Uniform Relocation and Assistance and Real Property Acquisitions Policies Act of 1970 would provide uniform and equitable treatment of persons displaced from their home, business or farm. Benefits include moving expenses and relocation allowances for owner occupants impacted by the project. Further information concerning real estate requirements is contained in Appendix G, the Real Estate Planning Report.

No Action Alternative - This alternative assumes that there would be no change to the present conditions at Camp Ellis Beach. The shoreline would continue to erode, no protective action would be taken, and shorefront homes and structures would face potential loss due to erosion.

Beach Fill Only - This alternative would consist of the placement of beach fill along Camp Ellis Beach from the existing north jetty to a point about 3,250 feet to the north. Initial studies indicated that beach fill would be required along 3,000 feet of beach, but recent severe erosion at the northern end of the study area and more detailed modeling indicate that fill will be required along 3,250 feet of coastline to tie into a healthy beach profile at Ferry Beach. SBEACH modeling determined that the beach berm should have an elevation of 17.4 feet MLLW. In addition, based on studies concerning effectiveness and risk, it was determined that the required beach fill volume would be 712,000 cubic yards and the berm width would be about 150 feet. The seaward slope of the fill would be 1 vertical on 10 horizontal, approximately equivalent to the current beach slope. This slope is also suitable as piping plover habitat. To maintain a beach cross section that is effective in preventing further shoreline losses, this beach fill must be renourished approximately every 10 years. As this renourishment frequency is an average based on a range of storm events, actual renourishment events could occur more or less frequently. In addition, as this beach would be subject to wave forcing caused by reflected wave energy and mach stem waves, continuous monitoring would be required to insure an adequate beach profile. Renourishment volumes for each cycle for the historic (low), intermediate and high sea level change scenarios are approximately 432,000 cubic yards, 505,000 cubic yards, and 548,000 cubic yards respectively. Figure 16 shows the limits of the Beach Fill Only Alternative.

Figure 16 – Beach Fill Only

Alternative 6 – This alternative (see Figure 17) would consist of a jetty spur and beach fill. The jetty spur would be 750 feet long and would be attached to the existing north jetty approximately 1,475 feet from the shoreline. The spur jetty would have a top elevation of 14.5 feet MLLW and side slopes of 1 vertical on 2 horizontal. Since the spur and jetty junction will experience increased turbulence, about 400 feet of the existing jetty would require slope and toe reinforcement. This alternative includes the placement of beach fill along Camp Ellis Beach from the existing jetty to a point about 3,250 feet to the north. The beach berm would be at 17.4 feet MLLW and the minimum width of the berm would be 60 feet at the south end and 70 feet at the north end. The seaward slope of the beach would be 1 vertical on 10 horizontal. The total volume of sand required to construct this beach profile would be about 365,000 cubic yards. To maintain an effective beach width, the beach would require renourishment every 12 years. Renourishment volumes for each renourishment the three rates of sea level change are: 116,000 cubic yards for the historic rate; 192,000 cubic yards for the intermediate rate; and 236,000 cubic yards for the high rate.

Figure 17 – Alternative 6

Alternative 25A – This alternative consists of a spur jetty, two detached shore parallel breakwaters and beach fill (see Figure 18). The spur jetty would be 500 feet long and would be attached to the existing north jetty approximately 985 feet from the shoreline. The spur would have a top elevation of 14.5 feet MLLW and side slopes of 1 vertical on 2 horizontal. Due to increased turbulence at the spur and jetty junction, about 400 feet of the existing jetty would require slope and toe reinforcement. The two breakwaters would be placed about 900 feet from shore. The southern breakwater would be 395 feet long, and the northern breakwater would be 410 feet in length. Each breakwater would have a top elevation of 14.5 feet MLLW, a seaward slope of 1 vertical on 2 horizontal and landward slope of 1 vertical on 1.5 horizontal. This alternative also includes the placement of beach fill along Camp Ellis Beach from the existing jetty to a point about 3,250 feet to the north. The horizontal beach berm would be at 17.4 feet MLLW and have a minimum width of 50 feet at the south end and 60 feet at the north end. The seaward slope of the beach would be 1 vertical on 10 horizontal. The total volume of sand required to construct the beach is about 328,000 cubic yards. Beach renourishment would be required at 19 year intervals to maintain an effective beach width. Sand volumes for each renourishment for the three rates of sea level change are: 123,000 cubic yards for the historic rate; 226,000 cubic yards for the intermediate rate; and 286,000 cubic yards for the high rate.

Figure 18 – Alternative 25A

Buy-Out Plan – The buy-out plan consists of the purchase of all property within the 50-year erosion zone. All buildings would be demolished and the debris disposed of at an approved off site location. In addition, all public roads, utilities and other improvement will be removed within this area and disposed of at an appropriate location. After removal of all structures and improvements, the area would be restored to a natural condition. As erosion would be allowed to continue, north jetty would be extended landward to prevent flanking and impacts to the Saco River navigation project and Camp Ellis Harbor. This would be accomplished by stabilizing the north side of Bay Avenue with stone or other suitable material. Continued erosion would also wash out existing access roads and prevent access to the City pier and remaining properties on North and Bay Avenues. North Avenue would be relocated to provide continuous access. If North Avenue was not relocated and protected, all commercial and recreational activities at the pier would have to be relocated, the pier abandoned, and all remaining properties at the south end of Camp Ellis would need to be purchased. Figure 19 shows the geographical extent of the buy-out plan and other plan features for the historic sea level rise scenario. The 61 properties that would be purchased under the historic rate of sea level rise are highlighted on Figure 19. Under the intermediate rate of sea level change a total of 86 properties would be purchased, and under the high rate of sea level change 101 properties would be purchased.

4.9 Beach Fill Volumes for Structural Alternatives

Table 5 below summarizes initial beach fill and renourishment volumes required for each structural alternative.

Table 5-Beach Fill Volumes and Renourishment Frequency

Alternative	Initial Fill (cy)	Renourishment Fills		Number of Renourishments	Total Sand Volume (cy)*
		cy*	Interval (years)		
Beach Fill Only	712,000	432.000	10.0	5.0	2,873,000
6	365,000	116,000	11.6	4.3	865,000
25A	328,000	123,000	19.0	2.6	652,000

* The volumes shown are for the historic rate of sea level change

4.10 Costs of Final Alternatives

Costs of final alternatives were developed for all three potential sea level change scenarios. For the beach fill only alternative, and alternatives 6 and 25A, initial costs remain the same for all levels of sea level change. However, renourishment costs for these plans vary substantially with higher levels of sea level change. Since costs for the buy-out alternative are all up-front costs, initial costs for this alternative vary significantly depending in the level of sea level rise. Table 6 summarizes the first costs associated with each final alternative. These costs include engineering and design costs, costs for construction supervision and administration, and the cost to acquire the necessary real estate interests. For additional details concerning costs of these final alternatives see Appendix E, Design and Cost Estimates.

Table 6 –Costs of Final Alternatives

Alternative		Historic Rate of sea level change	Intermediate Rate of sea level change	High Rate of sea level change
	Initial Construction Cost	Renourishment Costs		
Beach Fill Only	$14,437,000	$9,700,000	$11,260,000	$12,175,000
Alternative 6	$23,835,000	$2,960,000	$4,575,000	$5,510,000
Alternative 25A	$29,685,000	$3,110,000	$5,295,000	$6,585,000
Buy-Out and Demolition	$38,220,000	Historic Rate of sea level change		
	$51,485,000	Intermediate Rate of sea level change		
	$59,480,000	High Rate of sea level change		

Figure 19 – Buy-Out Plan – Historic Sea Level Rise

4.11 Screening of Final Alternatives

As specified in the Planning Guidance Memorandum (PGM) for this study, dated 15 September 2011, the recommended alternative for this study will be based on the least costly, technically feasible, and environmentally acceptable alternative. In addition, as required by the PGM, the analysis of alternatives addressed sea level change per EC 1165-2-211. Since the No Action Alternative does not satisfy the Federal objective of mitigating for erosion caused by the Saco River Federal Navigation Project, it was eliminated from further consideration. The remaining four alternatives were then evaluated based on based on the four criteria established in the Principles and Guidelines. These criteria are completeness, effectiveness, efficiency and acceptability. Completeness is the extent to which the alternative plans provide and account for all necessary investments or other actions to ensure the realization of the planning objectives, including actions by other Federal and non-Federal entities. Effectiveness is the extent to which the alternative plans contribute to achieving the planning objectives. Efficiency is the extent to which an alternative plan is the most cost effective means of achieving the objectives. Acceptability is the extent to which the alternative plans are acceptable in terms of applicable laws, regulations and public policies. The following paragraphs describe how each alternative satisfies these four evaluation criteria.

Completeness – Completeness is the extent to which an alternative plan accounts for all necessary investments or other actions to ensure the realization of the planned effects. To address completeness, each alternative was evaluated based on the three rates of sea level change. For the study area, expected rates of sea level change for the next 50 years were 0.3 feet for the historic or "low" rate, 1.5 feet for the "intermediate" rate and 2.2 feet for the "high" rate. For the three alternatives that include beach fill, the initial fill volumes were developed based on existing conditions. However, as projected future sea level change occurred, different volumes of renourishment were developed for each sea level change scenario to provide beach profiles that would withstand future water levels. For the buy-out alternative, projected shoreline positions were developed for each sea level change scenario and the appropriate number of homes included on the buy-out list.

When assessing completeness, the ability of an alternative to prevent further erosion damages was the primary objective that was evaluated. Alternatives 6 and 25A reduce wave energy reflected off of the north jetty and require renourishment at intervals of about 12 and 19 years respectively. The beach fill only alternative, with its requirement for a significant initial placement of sand and renourishment about every 10 years, is also complete even though reflected wave energy remains unabated.. Each provides a complete and manageable solution to coastal erosion. An incidental benefit of all alternatives that include beach fill is the incidental beneficial effect on Ferry Beach and other areas to the north as the net amount of sand transported to the north would be greater than currently exists. These alternatives may also reduce storm damage forces as a byproduct of shoreline stabilization. The buy-out plan can also be considered complete, but as erosion progresses on an unprotected shoreline, unexpected property and infrastructure losses could occur.

Effectiveness – Effectiveness is the extent to which an alternative plan alleviates the specified problems and achieves the specified objectives. An effective plan is responsive to the identified needs and makes a significant contribution to the solution of the problem. Alternatives 6 and 25A are considered effective as they address wave energy increases caused by the north jetty and provide a beach profile that will prevent further shoreline losses. In addition, although beach fill only does not reduce wave energy increases it is an effective alternative as it prevents further shoreline losses. However, considering the high volume of sand that is necessary to provide effective shoreline stabilization, and the fact that reflected wave energy is not attenuated, this would introduce a large volume of sand into the littoral system north of the project. This may have unforeseen impacts on areas to the north, such as potential clogging of the Goosefare Brook outlet. The buy-out plan is effective in preventing property losses within the areas of projected erosion.

Efficiency – Efficiency is the extent to which an alternative is the most cost effective means of solving the identified problems and realizing specified opportunities. The following table (Table 5) presents the total annual cost of each alternative for each sea level rise scenario. In the case of the beach fill only alternative and alternatives 6 and 25A, costs of periodic renourishment are included. For a complete breakdown of these costs see the economic assessment in Appendix F. These costs were developed based on a 50-year project life and a Federal interest rate of 3-3/4 percent. Based on this table, beach fill only has the lowest life cycle annual costs and the buy-out plan has the highest costs.

Table 7 – Total Annual Costs

	Rate of Sea Level Change		
Alternative	**Historic**	**Intermediate**	**High**
Beach Fill Only	$1,481,900	$1,613,400	$1,690,500
Alternative 6	$1,325,600	$1,436,200	$1,500,300
Alternative 25A	$1,509,200	$1,581,600	$1,624,400
Buy-Out Plan	$1,703,600	$2,294,900	$2,651,300

Acceptability - Acceptability is the workability and viability of an alternative with respect to acceptance by Federal and non-Federal entities and the public and compatibility with existing laws, regulations and public policies. Two primary elements of acceptability are implementability and satisfaction. To be implementable, an alternative must be feasible from technical, environmental, financial, political, legal, institutional and social perspectives. The second element of acceptability is the satisfaction a plan brings to government agencies and the public. All alternatives are acceptable from technical and environmental perspectives, but the buy-out plan is not 100 percent acceptable when political and social perspectives are considered. The buy-out plan will cause major disruption to the Camp Ellis community as a large percentage of homes are purchased and demolished. It is also expected that condemnation procedures would be necessary to acquire all property within the 50-year erosion zone. When alternatives are evaluated regarding the satisfaction that they bring to government entities and the public, the buy-out plan is not considered an acceptable solution by all study stakeholders. The buy-out plan does nothing to mitigate for increased shoreline erosion, it simply purchases and demolishes those homes that would be lost over a 50-year period. Conversely, since the beach fill only plan and alternatives 6 and 25A prevent further shoreline losses, they offer a more satisfactory response to the erosion problem.

4.12 Selection of Recommended Plan

Table 7 below summarizes the results of the evaluation of alternatives under all four Principles and Guidelines criteria. Based on the results of this evaluation, Alternative 6 (750-foot long spur jetty plus beach fill), was selected as the recommended plan. It is the most cost effective plan and satisfies all other principles and Guidelines criteria. Alternative 6 also provides direct mitigation for the effects of the Federal navigation project. It substantially reduces increased wave energy caused by the north jetty, and provides continuous renourishment of Camp Ellis Beach. This renourishment mitigates for the north jetty's disruption of the natural sediment supply from the Saco River to Camp Ellis Beach.

Table 8 – Evaluation Criteria Ranking

Alternative	Completeness	Effectiveness	Efficiency Ranking	Acceptability
Beach Fill Only	Y	Y	2	Y
Alternative 6	Y	Y	1	Y
Alternative 25A	Y	Y	3	Y
Buy-Out Plan	P	Y	4	P

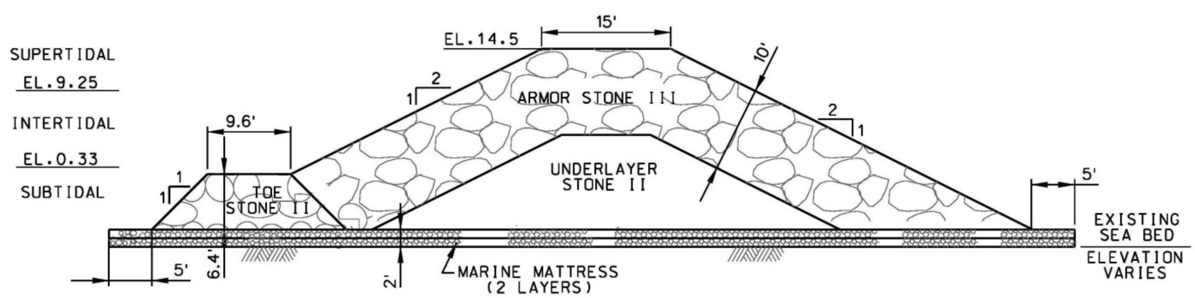
Y - Meets Criteria
P – Partially Meets Criteria

5.0 RECOMMENDED PLAN

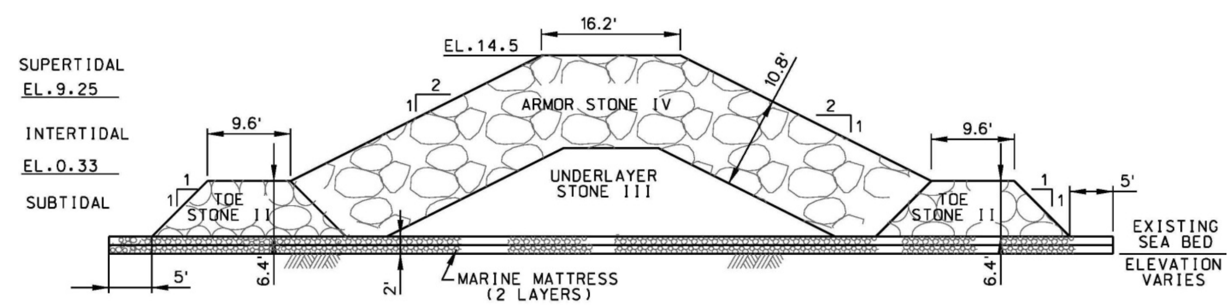
5.1 Description of Recommended Plan

The recommended plan, also referred to as Alternative 6, consists of a 750-foot long spur jetty and beach fill along Camp Ellis Beach to prevent further shoreline losses north of the existing northern jetty at the mouth of the Saco River. These two project features are described in the following paragraphs.

The spur jetty would be attached to the existing north jetty at a point about 1,475 feet from the shoreline (as measured from MLW). The top of the structure would be about 15 feet wide and at an elevation of 14.5 feet MLLW. Seaward and landward side slopes of the jetty would be 1 vertical on 2 horizontal. The spur consists of an outer layer of armor stone would be about 10 feet thick with average weight of 10 – 13 tons. This armor layer is underlain by smaller stone with an average weight of 2 tons that form the core of the structure. The seaward side and head section of the structure would include a layer of toe stone about 6 feet thick and 10 feet wide to prevent underscour. For overall stability, the stone structure would be placed on two layers of marine mattress. Marine mattresses are rock-filled containers constructed of high-strength geogrid (see Section 1.1.3 in Appendix D for further information). These mattresses would be laced together to form a stable foundation for the spur jetty. Cross sections of the spur jetty are shown below.



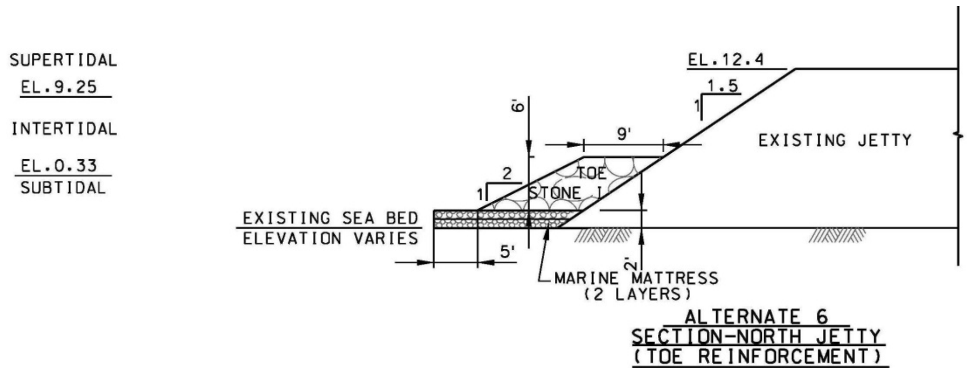
ALTERNATE 6
SECTION-(SPUR TRUNK)

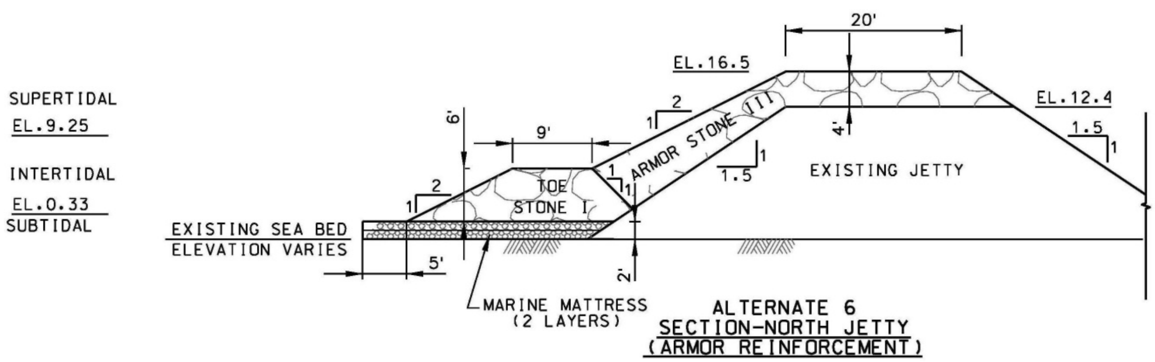


ALTERNATE 6
SECTION-(SPUR HEAD)

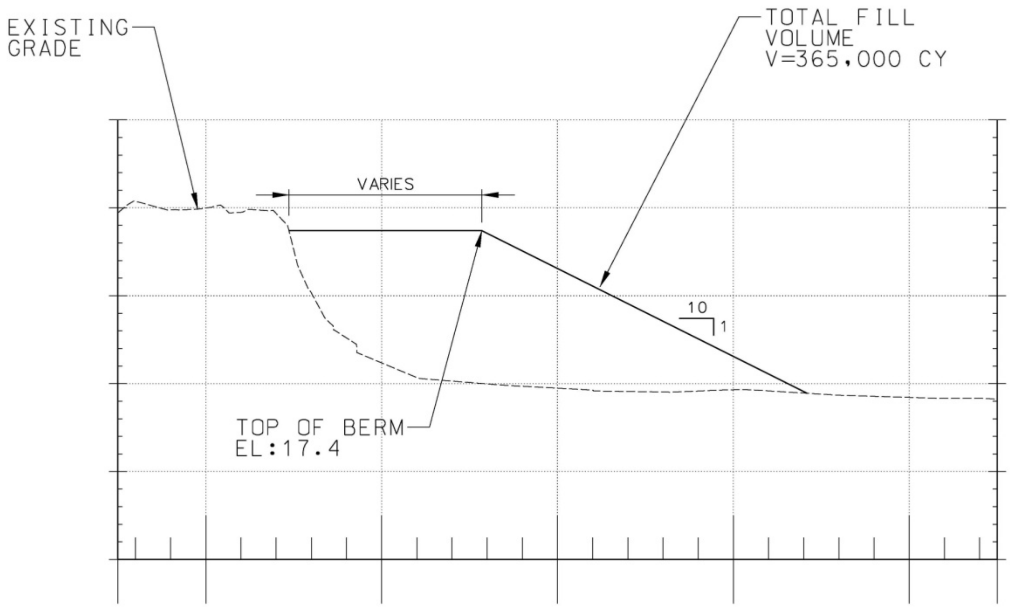
GRAPHIC SCALE:
10 0 10 20

Due to increased turbulence at the spur and jetty junction, and the potential for damage to the existing north jetty, about 400 feet of the existing jetty seaward on the spur jetty would require reinforcement. Modifications to the first 200 feet of the north jetty include raising the top elevation to prevent a large increase in overtopping, flattening the slope from 1 vertical on 1.5 horizontal to 1 vertical on 2 horizontal, adding armor stone, and reinforcing the toe to prevent scour. The toe of the existing structure would be reinforced an additional 200 feet for scour protection. North jetty reinforcement would also be placed on two layers of marine mattress for stability. Reinforcement cross sections are shown below.





Beach fill along Camp Ellis Beach would begin at the north jetty and extend about 3,250 feet to the north. The proposed beach berm elevation is 17.4 feet MLLW, which is roughly equivalent to the natural beach berm elevation in areas north of the study area. The berm width would vary based on topography, but the minimum beach berm required in the southern section is 60 feet and the minimum required in the north section is 70 feet. Sand placed on the beach will have a seaward slope of 1 vertical on 10 horizontal. Sand placed on the beach would have a gradation similar to the sand that is presently on the beach and the slope would be sufficient for shorebird access. The total estimated volume for sand required for initial beach-fill construction is 365,000 cubic yards. A typical cross section of the beach fill is shown below.



BEACH ALTERNATIVE 6
TYPICAL SECTION
NOT TO SCALE

5.2 Design Considerations

The following summarizes the design considerations developed for major project features. Although the majority of detailed design is complete, additional detailed surveys of the existing jetty and seabed at the location of the jetty spur and along the beach will be accomplished as required during continuation of the planning, engineering and design phase to refine construction quantities.

The spur jetty design consisted of the design of several elements of the structure. Key variables in sizing armor units were wave height and slope of the structure. Design wave heights used during design were developed during the modeling study of the study area. The base elevation of the structure was established based on bathymetric data at the site. Structure side slopes of 1 vertical on 2 horizontal were selected for both structural and stone stability. The crest elevation of 14.5 feet MLLW (9 feet NAVD88) was selected based primarily on wave transmission, tide range, storm duration, and potential for foundation settlement.

Reinforcement of the existing north jetty at the junction of the jetty spur will be necessary due to increased turbulence in the area caused by reflection of waves off both the existing jetty and the new spur. Reinforcement included adding larger armor stones, raising the crest elevation, and reinforcing the toe to prevent scour. Additional stability will also be provided by flattening the side slope of the existing jetty from a slope of 1 vertical on 1.5 horizontal to 1 vertical on 2 horizontal for a distance of about 400 feet seaward of the new spur jetty.

As previously discussed, the beach was designed in two increments; a non-sacrificial section and a sacrificial section. Providing this non-sacrificial section or minimum berm would restore the beach to a healthier profile. The volume associated with the minimum berm is the amount that the beach should not be allowed to go below and is considered the trigger point for when a beach should be renourished as soon as possible. To prevent the non-sacrificial fill from being eroded, additional beach fill would be placed that would be sacrificed to beach erosion. As the sacrificial fill erodes and the beach approaches the minimum volume, a renourishment project would be scheduled. A 40-foot sacrificial berm was selected as it results is less risk exposure through the life of the project. A smaller fill would result in more frequent renourishments, and more instances where the project will be near the minimum allowable beach fill width.

Since it would be unwise to allow the entire sacrificial portion of the fill to erode before renourishment, it was decided that renourishment should occur when the sacrificial fill volume reaches 10 cubic yards per linear foot of beach. This equates to about 32,500 cubic yards of sand or a beach berm width of about 10 feet. Using this estimate of the volume of sand remaining on the beach, additional beach fill would be required approximately every 12 years. The volume of renourishment fills would vary with each of the three levels of projected sea level change. Renourishment fills for the historic (low), intermediate and high rates of sea level change are 116,000 cubic yards, 192,000 cubic yards and 236,000 cubic yards respectively.

5.3 Cost Sharing of Beach Renouishment

As specified under Section 215 of Public Law 106-53 (Water Resources Development Act of 1999), the non-Federal share of costs for periodic beach renourishment of the project shall be 50 percent.

5.4 Operation, Maintenance, Repair, Replacement and Rehabilitation Requirements

Periodic local monitoring of the beach will be required to determine the condition of the beach fill. Seasonal or post-storm regrading may also be required between renourishment fills. Repairs to the stone spur jetty would also be required periodically. While the structure has been design to withstand severe Gulf of Maine North Atlantic storms, storm damage in the form of displaced armor stone and toe stone could occur. The spur jetty should be inspected after major storms and displaced stone reset or replaced as needed.

The non-Federal sponsor is responsible for 100 percent of OMRRR costs associated with beach monitoring and regrading, and spur jetty inspections and repair/rehabilitation. These costs are estimated to average about $30,000 per year, but, considering the size of armor stone that will be used for the spur jetty, resetting of stone is not expected to be required very often. Therefore, OMRRR expenses can be expected to vary from year to year.

5.5 Real Estate Requirements

The recommended plan will require permanent easements on 28 parcels and temporary work easements on 11 properties. Easements will also be required on public roads and ways. The cost for these easements, which include administrative costs, surveys, title fees, appraisal fees and closing are estimated at $397,000. Considering escalation to current values, these costs were increased to $400,000.

5.6 Summary of Project Costs, Accomplishments, Benefits and Impacts

5.6.1 Project Costs (Alternative 6)

Construction costs for the recommended plan were refined during the agency technical review process. Changes in cost assumptions resulted in reductions in the estimated costs for both the spur jetty and beach fill components of the project. Although these reductions in cost could be applied to the other two structural alternatives that were evaluated during the screening of final alternatives, updating these costs would not change the results of final plan selection. Therefore, costs used during final plan selection in the previous section were not revised.

Initial Project Costs - Total project costs for the recommended plan are shown in Table 8. These costs include: direct construction costs with escalation and contingencies; planning, engineering and design; construction supervision and administration; and real estate acquisition. A detailed breakdown of these costs is included in Appendix E.

Table 9 – Initial Project Costs
(October 2012 Price Level)

Work Item	Cost
Spur Jetty and Jetty Reinforcement	$12,057,000
Beach Fill	$5,425,000
Land Acquisition	$400,000
Planning, Engineering and Design	$942,000
Construction Management	$647,000
Total Initial Project Cost	$19,471,000

Renourishment Costs - Renourishment costs for the historic (low), intermediate and high rates of sea level change scenario are presented in Tables 10 -12 below to show the range of potential costs for renourishment. Beach performance will be monitored closely, and adaptive management will be utilized to adjust future renourishment volumes in response to sea level changes throughout the 50-year project life. Costs are March 2011 price levels and include three years of escalation.

Table 10 – Beach Renourishment Costs (Historic (low) Rate of Sea Level Change)
(October 2012 Price Level)

Work Item	Cost Historic (Low) Rate of Sea Level Change
Beach Fill	$1,734,000
Planning, Engineering and Design	$360,000
Construction Management	$110,000
Total Cost	$2,204,000

Table 11 – Beach Renourishment Costs (Intermediate Rate of Sea Level Change)
(October 2012 Price Level)

Work Item	Cost Intermediate Rate of Sea Level Change
Beach Fill	$2,858,000
Planning, Engineering and Design	$360,000
Construction Management	$110,000
Total Cost	$3,328,000

Table 12 – Beach Renourishment Costs (High Rate of Sea Level Change)
(October 2012 Price Level)

Work Item	Cost High Rate of Sea Level Change
Beach Fill	$3,514,000
Planning, Engineering and Design	$360,000
Construction Management	$110,000
Total Cost	$3,984,000

<u>Total Project Costs</u> - Total estimated project costs (Table 13) include all planning, engineering and design costs to date, initial costs to complete design and construct the project, and land acquisition costs. Costs for beach renourishment, based on the historic rate of sea level change, are included and have been discounted to the October 2012 price level. Beach renourishment is projected to be required at 12 year intervals following completion of construction.

Table 13 – Total Project Costs
(October 2012 Price Levels)

Work Item	Cost
Spur Jetty and Jetty Reinforcement	$12,057,000
Beach Fill	$5,425,000
Land Acquisition	$400,000
Planning, Engineering and Design	$942,000
Construction Management	$647,000
Planning, Engineering and Design Expenditures	$3,268,000
Beach Renourishment (Historic Rate of SLC)	$3,340,000
Total Initial Project Cost	$26,079,000

Cost Apportionment - Section 111 projects are cost shared with the non-Federal sponsor in the same proportion as they shared in the costs for the navigation project causing the damage. As all costs associated with the project causing the damage were 100 percent Federal, the Federal government will be responsible for 100 percent of the initial cost for mitigation. Section 111 further states that the Federal share of costs is limited to $5 million. However, Section 3085 of the Water resources Development Act of 2007 raised the maximum Federal limit to $26.9 million for mitigation of shore damages at Camp Ellis. Accordingly, all design and construction costs up to $26.9 million will be 100 percent Federal. In addition, based upon Section 215 of Public Law 106-53 (Water Resources Development Act of 1999), non-Federal interests are responsible for 50 percent of the costs for periodic beach renourishment.

5.6.2 Plan Accomplishments, Benefits and Impacts

The recommended plan is a comprehensive solution to shore damage caused by the Saco River Navigation Project. The spur jetty would reduce reflected wave energy that has contributed to the destabilization of Camp Ellis Beach, and beach nourishment would mitigate for the loss of natural beach nourishment sediments that have been blocked and redirected by the north jetty. Periodic beach renourishment to maintain an effective beach profile will ensure that these benefits are realized over the 50 year evaluation period for the project and that there are no with-project unmet needs north of the project. The plan would also have the incidental beneficial effect of increasing sediment supply to beaches to the north as the net amount of sand moving to these areas would be greater than currently occurs. Stabilization of the shoreline will prevent the loss of 61 properties under the historic sea level rise scenario. For intermediate and high sea level rise scenarios, property losses prevented would amount to 86 and 101 parcels respectively.

Significant improvement in the social well being of residents and businesses in the village of Camp Ellis would occur as a result of this project to prevent further shoreline losses. The stress and concern that is experienced before and during storm events would be significantly reduced or eliminated. Emergency management and recovery costs would also be minimized. Removal of existing revetments is not necessary for the placement of beach fill. Removal is also not advisable due to concerns regarding the stability of adjacent improvements such as Eastern Avenue.

Continued access to the southern end of Camp Ellis would be assured allowing continuation of commercial activities such as fishing, boat chartering, and operation of restaurants and stores in this area. The summer tourist industry would also benefit from shoreline stability as the general aesthetics of the area will be greatly improved.

Placement of sand on the beach would result in the initial loss of about 11 acres of subtidal habitat as supratidal areas are created. As the beach erodes, this loss will gradually decline to about 6 acres before the beach is renourished. There will be a small decrease in intertidal habitat after placement, but this is expected to change as waves and currents redistribute the sand. The impact would be relatively minor as the current benthic community in this area is representative of a highly dynamic environment, which is characterized by a low number of species and a low number of individuals. With a reduction in wave energy at Camp Ellis Beach, the benthic community along the beach may become more diverse and productive.

Construction of the jetty spur and jetty reinforcement will result in the permanent replacement of about 2.3 acres of sandy subtidal habitat with stones and rocks. About 1 acre will remain subtidal with the remainder split between intertidal and supratidal areas. The rocks used to construct the spur will serve as a reef and numerous species are expected to attach to these surfaces. These species include rockweed, knotted wrack, Irish moss, tufted red weed, and barnacles. Blue mussels may be found in the intertidal zone, with kelp and small red seaweeds located subtidally, especially on the protected side of the spur. These species will provide shelter for a number of invertebrates and fish.

The rock reef will attract finfish and shellfish species that favor this habitat. Blue mussels that attach to these structures are a favored food item for both the adult tautog and cunner. Other smaller finfish species could use the rock habitat for feeding and shelter. The rock structure will also provide shelter for another commercially important shellfish, the lobster.

Both shortnose sturgeon and Atlantic salmon are listed as Federally endangered species, and Atlantic sturgeon is listed as a threatened species. No critical habitat is listed for any of these species within the project area. However, it is possible that adult shortnose sturgeon and Atlantic sturgeon juveniles and adults could be present in Saco Bay to transit to other locations or to use the bay as a forage area. The proposed project could create minimal disturbance, if any, to either species. Sand will be placed on the beach as fill above the high water line and then graded to the lower levels during low tide. Rocks will be removed from a barge and placed on the seafloor with care. No direct impacts to the subject species from either disturbance are expected as the area of impact is relatively small when compared to the amount of foraging area present in Saco Bay. Therefore, although it is possible that shortnose sturgeon and Atlantic sturgeon could be present in the vicinity of the project, it is concluded that these activities are not likely to adversely affect Atlantic sturgeon or its critical habitat. NMFS concurred with this determination by letter dated March 12, 2013.

The loss of shallow subtidal habitat, and intertidal habitat to supratidal, will reduce the available food source for fisheries by an incremental amount. The reduced subtidal habitat is expected to be a minor impact considering the amount of habitat currently available in Saco Bay.

Piping plovers have been known to nest at Ferry Beach which is north of the project area. Although the last known nesting was in 2007, suitable piping plover nesting habitat is likely to be created along Camp Ellis Beach with the placement of a 60 to 70-foot wide beach. To mitigate for any potential adverse impacts on this endangered species, the City of Saco will prepare a beach management plan that is consistent with U.S. Fish and Wildlife Service guidelines outlined in the Northeast Region, April 15, 1994 document titled, Guidelines for Managing Recreational Activities in Piping Plover Breeding Habitat on the U.S. Atlantic Coast to Avoid Take Under Section 9 of the Endangered Species Act. This will insure that the project is not likely to significantly affect Piping plovers. The management plan shall include the following:

- Signed permission from all landowners to allow piping plovers to be managed on areas where sand fill is placed.
- Paths from residences to the beach should be consolidated and shared.
- The City's piping plover manager will assume responsibility for installing and removing stake and twine used to symbolically fence piping plover nesting areas. Suitable nesting habitat areas will be identified and fenced prior to April 1 of each year.
- Dogs can be present on the beach only on a leash during the piping plover nesting season (April 1 to September 1).

Additional details concerning the management plan are contained in the December 16, 2010 letter from the Fish and Wildlife Service that is included in Appendix A.

A systematic remote sensing archaeological survey was performed in November 2009 at the location of the proposed spur jetty. No remote sensing targets or anomalies or buried geological features indicative of archaeological deposits were identified during the study, and no further archaeological investigations were recommended. Based on this study, the Corps concluded that the proposed shoreline protection measures at Camp Ellis Beach should have no effect upon any structure or site of historic, architectural or archaeological significance as defined by Section 106 of the National Historic Preservation Act of 1966, as amended. The Maine State Historic Preservation Officer, in a letter dated October 6, 2010, concurred with this determination.

6.0 FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

6.1 Findings and Conclusions

Shoreline change at Camp Ellis has been the subject of numerous studies conducted by the Corps and others. These studies determined that the Saco River has been the primary sediment source for the Saco Bay beaches, and that the primary direction of sediment movement along the shoreline is south to north. However, with construction of the Saco River Navigation Project, sands from the Saco River were retained in the channel or transported offshore into deeper waters, making them unavailable as beach nourishment at Camp Ellis Beach. The other major impact to the area is significant wave reflection off of the north jetty. Upon impacting the structure, waves are reflected back towards Camp Ellis Beach and a portion of shoreline directly adjacent to the jetty is impacted not only by incident wave energy, but also by reflected wave energy. In summary, the destabilization of Camp Ellis Beach and the resultant high erosion rate can be attributed to several factors directly related to construction of the Federal navigation project. These include interruption of natural riverine sediment supply to the downdrift beach, diversion of riverine sediment farther offshore, and wave focusing along the beach due to reflection of waves by the jetty.

During evaluation of shoreline erosion problems at Camp Ellis Beach in Saco, Maine, all potentially feasible measures to solve these problems were evaluated. Shoreline erosion mitigation measures included wave attenuation measures such as jetty spurs and breakwaters, modification of existing structures, beach nourishment, and purchase and demolition of structures at risk from further erosion. These measures were coordinated with study participants at periodic coordination meetings.

Evaluation of alternatives was done in several phases. A detailed model of the Camp Ellis coastal area was developed and numerous alternatives were developed and evaluated for effectiveness. Other factors such as off shore subsurface foundation conditions also entered into evaluation and screening of alternatives. This analysis identified plans that would be effective in mitigating future shoreline erosion or removed potentially damageable property from the zone of future erosion.

A total of 32 plans were developed and evaluated during the plan formulation process. Through detailed modeling, off shore geotechnical investigations, and other studies concerning the effects and impacts of these alternatives, the list of potentially acceptable alternatives was reduced to four. These plans were: beach nourishment only, construction of a 750-foot-long spur off on the existing north jetty plus beach nourishment (alternative 6); construction of a 500-foot-long spur off the north jetty along with two shore parallel breakwaters and beach nourishment (alternative 25A); and the purchase and demolition of property within the 50-year erosion zone. Plans that included beach nourishment would also require periodic renourishment to sustain a beach profile that would prevent shoreline losses. All plans were evaluated based on the potential for sea level change. The three levels of sea level change that were evaluated are low (or historic), intermediate and high. Evaluation of these alternatives based on the four Principles and Guidelines (P&G) criteria of acceptability, completeness, effectiveness and efficiency resulted in the selection of the alternative that included a 750 foot spur jetty with beach nourishment. Of the alternatives that satisfied the four P&G evaluation criteria, this plan was the most cost effective. Specific contributions to these four evaluation criteria are presented below.

- Completeness – The recommended plan accounts for all investments and actions necessary to ensure that the plan meets the objective of preventing further shoreline loss. The plan is also consistent with the City's desire to stabilize the beach at Camp Ellis.

- Effectiveness – The selected plan responds to the identified shoreline erosion problem along Camp Ellis Beach, and will preclude further property loss at Camp Ellis caused by the Saco River Federal Navigation Project. Future monitoring and renourishment effects will ensure proper functioning of the plan over its projected 50-year life.

- Efficiency – The plan is the most cost effective means of providing complete and effective shoreline stabilization along Camp Ellis Beach. Depending on the future rate of sea level change, the project will prevent the loss of between 62 and 101 properties over the projected 50-year life of the project.

- Acceptability - The proposed plan to prevent further shoreline losses at Camp Ellis Beach is supported by the city of Saco and is compatible with existing Federal and State regulations. The plan has also received public support at numerous public information meetings in the study area.

In addition to the satisfying the specific study objective of mitigating for shore damage caused by the Federal navigation project, the recommended plan will also ensure that the navigation project will continue to provide commercial navigation benefits to the area. Without stabilization of this area, future erosion could impact access to the City pier that supports the fishing fleet and charter boat activities. Summer recreational activities in this area are also an important part of the local economy.

6.2 Recommendations

It is recommended that the plan selected herein (Alternative 6) to provide shore damage mitigation at Saco River and Camp Ellis Beach, be approved for implementation under Section 111, of the River and Harbor Act of 1968, as amended; at a total estimated initial cost of $19,471,000, plus costs for planning and design and future renourishment, up to a maximum cost of $26,900,000, as specified in Section 3085 of the Water Resources Development Act of 2007. As non-Federal sponsors must share in the initial cost of mitigation measures in the same proportion as they shared in the costs for the navigation project causing the damage, and the navigation project was 100 percent Federally funded, the non-Federal sponsor will not be required to share in initial construction costs up to this $26,900,000 limit. In addition, based upon Section 215 of Public Law 106-53 (Water Resources Development Act of 1999), non-Federal interests will be responsible for 50 percent of the costs for periodic beach renourishment.

This recommendation is subject to the provision that qualified non-Federal sponsors agree to the following items of local cooperation that will be included in a Project Partnership Agreement.

1. Assume responsibility for 50 percent of the costs of future periodic beach renourishment over the 50-year project life.

2. Assume responsibility for operating, maintaining, replacing, repairing, and rehabilitating (OMRR&R) the project or completed functional portions of the shore damage mitigation project, without cost to the Government, in a manner compatible with the project's authorized purpose and in accordance with applicable Federal and State laws and specific directions prescribed by the Government in the OMRR&R manual and any subsequent amendments thereto.

3. Give the Government a right to enter, at reasonable times and in a reasonable manner, upon land which the local sponsor owns or controls for access to the project for the purpose of inspection, and, if necessary, for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating the project.

4. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, and Section 103 of the Water Resources Development Act of 1986, Public Law 99-662, as amended, which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the non-Federal sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element.

5. Hold and save the Government free from all damages arising from the construction, operation, maintenance, repair, replacement, and rehabilitation of the project and any project-related betterments, except for damages due to the fault or negligence of the Government or the Government's contractors.

6. Prevent obstructions of or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) which might reduce the level of protection the project affords, hinder its operation and maintenance, or interfere with its proper function, such as any new development on project lands or the addition of facilities which would degrade the benefits of the project.

7. Promulgating and enforcing such beach and habitat management regulations as required for the project by Federal and State resource agencies, to include management and

monitoring of the beach and beach activities in the interest of critical species and public safety.

All significant aspects, including overall public interest, environmental, social and economic effects, and engineering and financial feasibility have been considered in concluding that the recommended plan meets the objectives of this study subject to the results of agency technical review and final review comments.