Coastal Storm Damage Reduction Report

DRAFT
Feasibility Report and
Environmental Assessment

NANTASKET BEACH
DCR Reservation
Hull, Massachusetts

US ARMY CORPS
OF ENGINEERS
New England District

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EXECUTIVE SUMMARY

This Feasibility Report and Environmental Assessment for the Nantasket Beach Coastal Storm Damage Reduction Project has been prepared under Section 103 of the1962 River and Harbor Act, as amended, which authorizes the Corps of Engineers to participate in the cost of projects and antecedent studies for reducing coastal storm damages. Study funds have also been made available through Public Law 113–2—January 29, 2013, which made resources available to deal with the consequences of Hurricane Sandy in the Northeast. The effects of Hurricane Sandy in October 2012 were experienced at Nantasket Beach in the form of high winds and water level (surge plus tide) about 7.41 ft NAVD88 based on data recorded at the Boston Harbor NOAA station, north of Weymouth, MA. This report was prepared in response to a request from the Commonwealth of Massachusetts, Department of Conservation and Recreation (DCR), for a study to investigate the flooding and erosion problem at Nantasket Beach and its causes and to present feasible solutions for reducing damages in the Nantasket Beach back shore. The study is the product of detailed investigations conducted by the New England District of the Corps of Engineers in cooperation with the DCR and other state and Federal agencies.

The study area for the Nantasket Beach Coastal Storm Damage Reduction Project consists of the DCR's Nantasket Beach Reservation and the adjoining back shore area. It is located in the town of Hull, Plymouth County, Massachusetts, approximately 4 and 12 miles southeast, respectively, of the main entrance to Boston Harbor and the city of Boston. See Figure 1. The study area is the southerly 6,800 foot long portion of an elongated spit extending along a SE-NW axis into Massachusetts Bay from the Atlantic Hill section of Hull to Point Allerton. Beginning at its southern end, the back shore is protected by an approximately 5,400-foot long sea wall and its 1,400-foot long northerly end by a combination of sand fill and rip rap revetment and/or jersey barriers.

Coastal storms cause extensive damages to the publicly owned Nantasket Beach, its protective works and back shore public, commercial and residential properties. Storm driven waves from the east are responsible for the removal of sand in front of the concrete sea wall and the consequent lowering of the beach. The sea wall footings have been exposed and undermined in some places. By December 1992, the conditions had deteriorated to such an extent that a coastal storm with an approximately 10-year recurrence interval caused the failure and weakening of about 650 feet of sea wall at its northern end. The lowering of the beach and the sea wall breach increased ocean overtopping during coastal storms and the flooding of the back shore.

DCR reconstructed the portion of the sea wall lost in 1992 storm as a new structure called the Northern Revetment and placed a stone revetment known as the Temporary Seawall Fortification (TSF) at the south end of the Reservation, improving protection to those areas of Hull Shore Drive and Nantasket Avenue, the only roadway links between the mainland and portions of the town to the north. The central portion of the DCR reservation, historic seawall and commercial properties in the backshore have no similar protection, and suffer from greater seasonal material losses and higher storm wave overtopping volumes. The portion of the town north of this area contains an estimated two-thirds of the town's land area and 80 percent of the population of approximately 10,500 persons, in addition to elementary and high schools, the Pemberton Coast Guard Station and a number of commercial and public properties.

If a plan to reduce flooding and erosion is not implemented, the Nantasket shoreline, fronted by its older sea wall, would be vulnerable to storm damage from wave overtopping or wall failure. The DCR has invested an estimated $2 million to restore the bathhouse. This investment would be at risk if a project were not undertaken to protect the sea wall. An initial screening process eliminated an offshore breakwater as a possible solution for reducing damages due to coastal storms at Nantasket Beach due to economic reasons. Three plans were found to warrant further consideration: elevating 13 structures above the 100-year floodplain, sand fill nourishment and a stone revetment might reduce recurring storm damages and be economically feasible. Our analysis indicated that, although a plan to elevate 13 structures is feasible, a high level of residual damages to properties (about 75 percent) would remain if this plan were implemented. Two beach fill nourishment plans to protect Zone 2, the 2,200-foot middle portion of the DCR reservation, were economically feasible, however their cost was far in excess of what is allowed under Section 103. Two stone revetment plans to protect Zone 2 were also found to be economically feasible. A revetment plan for 10-year level of protection was shown to have a higher benefit-to-cost ratio than a plan offering 25-year level of protection, so that is the recommended plan.

Since the stone revetment plan for protecting 2,200 feet of sea wall (Zone 2) is economically feasible, maximizes coastal storm damage reduction benefits (annual benefits minus annual costs) and meets pertinent environmental and cultural resources criteria, it is the National Economic Development (NED) Plan and therefore qualifies for further Federal participation. The NED Plan calls for construction of a stone revetment approximately 2,200 feet long in front of the sea wall with an 8.25 foot wide crest at elevation 10 feet NGVD and a lV:3H slope to meet the existing beach.

The Section 103 authority, under which this present study has been conducted, provides for Federal participation of 65 percent of first costs, including construction, contingencies, Engineering and Design (E&D), and Construction Management (CM) up to $5,000,000 in Federal costs, including the Federal share of reconnaissance and feasibility studies, which amount to $869,194.48. The project first cost of $6,353,300 would be cost shared. A projected annual maintenance cost of $1,100 per year during the 50-year life of the project would be a non-Federal responsibility.

The project was economically justified at the 2013 Price Level with an annual net benefit of $812,300 and a benefit to cost ratio (BCR) of 4.09. Project costs were updated to the January 2014 price level using the FY14 Federal interest rate of 3.5% and the Civil Works Construction Cost Index for Breakwaters and Seawalls (EGM 1110-2-1304, 31 March 2014). The economic cost of the project in 2014, including interest during 4 months of construction, amounts to $6,382,200. Annual Cost over the 50-year project life is $273,200 with Net Benefits of $827,000. The resulting BCR of 3.03 supports the recommended project.

The New England District Engineer recommends construction of 2,200 foot long stone revetment project in front of the sea wall in Zone 2. It was found to be technically (engineering) and economically feasible and environmentally and culturally acceptable project for reducing storm damages due to flooding and erosion in the Nantasket Beach back shore. The DCR intends to repair and rehabilitate the seawall in front of which the recommended Federal project would be built.

NANTASKET BEACH DCR RESERVATION
HULL, MASSACHUSETTS

Coastal Storm Damage Reduction Report

Photo source: http://www.flickr.com/photos/jeffcutler/8135566996/in/photostream/

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ABBREVIATIONS

ARA	Abbreviated Risk Analysis
BCR	Benefit-Cost Ratio
CENAE	Corps of Engineers, New England District
CM	Construction Management
cfs	cubic feet per second
cy	cubic yards
E&D	Engineering and Design
EOEA	Executive Office of Environmental Affairs
FCSA	Feasibility Cost Sharing Agreement
ft	feet (foot)
FY	Fiscal Year
GPM	gallons per minute
H	Horizontal
HRA	Hull Redevelopment Authority
LERRD	Lands, Easements, Rights-of-Way, Relocation, Disposal
LF	Linear Feet
MHW	Mean High Water
MLW	Mean Low Water
NED	National Economic Development
NGVD	National Geodetic Vertical Datum
RC	Reinforced Concrete
S&A	Construction Management
SF	Square Feet
SY	Square Yard
TPCS	Total Project Cost Summary
V	Vertical

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MAIN REPORT

1: INTRODUCTION

BACKGROUND

The study area for the Nantasket Beach Coastal Storm Damage Reduction Project consists of the Massachusetts Department of Conservation and Recreation's (DCR) Nantasket Beach Reservation and the adjoining back shore area. It is located in the town of Hull, Plymouth County, Massachusetts, approximately 4 and 12 miles southeast, respectively, of the main entrance to Boston Harbor and the city of Boston. See Figure 1. The study area is the southerly 6,800 foot long portion of an elongated spit extending along a SE-NW axis into Massachusetts Bay from the Atlantic Hill section of Hull to Point Allerton. Beginning at its southern end, the back shore is protected by a sea wall approximately 5400-foot long and at its northern end by a combination of sand fill and rip rap revetment. The open ocean borders the study area to the east and Sagamore Hill and Hingham Bay to the west.

Figure 1 – Nantasket Beach Study Area Location Map

Nantasket Beach's location on the Atlantic Ocean and close proximity to the urban areas of greater Boston results in a substantial increase in local population and usage of the DCR reservation and beach during the summer months.

Storm driven waves from the east have caused extensive loss of beach material in front of the concrete sea wall and the consequent lowering of the beach. In turn, this has left the existing sea wall vulnerable to damage and undermining as a result of tidal and wave action. In addition, the sea wall has been subject to increased risk of overtopping during coastal storms, which has increased the flood risk to public, commercial and residential properties in the back shore.

The DCR maintains Nantasket Beach Reservation and its facilities, including the sea wall and revetment, the pavilion, a bathhouse, parking areas, etc. in the Nantasket Beach back shore. Nantasket Beach faces east and is exposed to direct attack from Atlantic storms, in particular New England' s famed Nor'easters. The erosion of sand from the beach has exposed the footings of the sea wall over most of its length, and in some areas the footings are undermined. The October 1991 storm, an approximately 17-year recurrence event (based on still water elevation), caused extensive damage to the sea wall including stairways and ramps. By December of 1992, the sea wall had deteriorated to such an extent that a less severe 10-year storm event caused the failure and weakening of approximately 650 linear feet of sea wall at its northern end.

DCR recognized the wall failure greatly increased the risk of storm damage to several backshore properties and public infrastructure. They asked the Corps to provide design assistance for a wall/revetment to replace the failed and severely damaged wall sections. The result of the work was the Northern Revetment, which DCR constructed in 2006.

The land west of the DCR reservation includes Hull Shore Drive and Nantasket Avenue, arterial streets that provide the only links between the mainland and the portion of the town to the north, which contains an estimated two thirds of the town's land area and 80 percent of the population of approximately 10,500 persons. Many commercial properties, public schools, a fire station, and the United States Coast Guard Station at Pemberton are located north of the beach and rely on the roadway links that run parallel to the Nantasket shoreline.

STUDY AUTHORITY

This investigation has been prepared under the Continuing Authorities Program and authorized in Section 103 of the 1962 River and Harbor Act, as amended. The maximum Federal cost for planning, design, and construction of any one economically justified project is $5,000,000. Study funds have also been made available through Public Law 113–2—January 29, 2013, which made resources available to deal with the consequences of Hurricane Sandy in the Northeast.

STUDY OBJECTIVE AND SCOPE

The purpose of this Feasibility Study is to determine the most technically and economically feasible, and socially, environmentally and culturally acceptable project, if any, to control damages to the sea wall and the storm driven ocean flooding of back shore properties due to overtopping of the seawall.

Figure 2 – Nantasket Beach Study Area Map

Photo 1 A view of the south end of the sea wall in Zone 2 with the DCR bath house and other public infrastructure behind it.

Photo 2 A view of the sea wall at the north end of Zone 2 with commercial properties lining Hull Shore Drive beyond.

Photo 3 This view of the sea wall taken after a storm shows the portion of the wall footing is exposed.

PRIOR STUDIES, REPORTS, AND PROJECTS

- Cooperative beach erosion control studies for Nantasket Beach have been conducted by the Corps of Engineers with the Metropolitan District Commission.

The first report, Beach Erosion Control Report on Cooperative Study of Metropolitan District Commission Beaches, Massachusetts, Part D Nantasket Beach, was submitted to the Chief of Engineers on 1 June 1949. The report concluded that Nantasket Beach was stable and recommended that the problem of maintenance of the beach for recreational use be accomplished entirely by local interests at their expense by burying and covering stone deposits or by the removal of stones and replacing them with equal volumes of sand.

The second report, Beach Erosion Control Report on Cooperative Study of Revere and Nantasket Beaches, Massachusetts was submitted to the Chief of Engineers in March 1968. The report recommended the direct placement of suitable sand fill along 6,800 feet fronting the Metropolitan District Commission Reservation to a berm width of 75 feet and an elevation of 12 feet above NGVD, thus furnishing a protective and recreational beach averaging 190 feet wide above the mean high water line. The project was subsequently authorized by Congress in 1970. Due to a lack of local cooperation, the project was never constructed and was subsequently deauthorized in January 1990.

- New England Division, Corps of Engineers, Blizzard of '78, Coastal Storm Damage Study, February 1979 covered the New England coastline between Orleans, Massachusetts and New Castle, New Hampshire. It compiled the estimated costs and losses, attributable to water related damage, from the Blizzard of 1978.

- Federal Emergency Management Agency, Flood Insurance Study, Town of Hull, 1980.

- Camp Dresser and McKee, Inc. (CDM) Evaluation of Coastal Protection Measures at Nantasket in Hull, Massachusetts, June 1980. This report summarizes damages from the Blizzard of February 1978 for both the North Nantasket Beach Study Area and the Metropolitan District Commission's (DCR) Nantasket Beach located south of North Nantasket Beach. No measures for protecting Nantasket Beach were recommended.

- New England Division, Corps of Engineers, Reconnaissance Report, Nantasket Beach Shore Protection Study, Hull, Massachusetts, August 1993. With the continuing loss of sand in front of the reinforced concrete sea wall and lowering of the beach, significant damage to and undermining of the sea wall and back shore flooding due to the overtopping of the sea wall, the Reconnaissance Report found that a sand fill nourishment project constructed seaward of the sea wall was economically justified and that a Feasibility Study was warranted.

2: EXISTING CONDITIONS

PHYSICAL SETTING

The study area for the Nantasket Beach Coastal Storm Damage Reduction Project consists of the DCR reservation and the adjoining back shore area. See Figure 2. The open ocean borders the study area on the east and Sagamore Hill and Hingham Bay on the west. The study area is the southerly approximately 6,800-foot long portion of an elongated spit averaging about 500 feet in width and extending along a SE-NW axis into Massachusetts Bay from the Atlantic Hill section of Hull to Point Allerton. Since approximately 1915, the back shore has been protected on the east by a 5,400-foot long reinforced concrete sea wall, whose crest ranges in elevation between 14.4 and 17.0 feet above the National Geodetic Vertical Datum (NGVD).

From the south end of the reservation, the sea wall is fronted by a 2,000 foot-long stone revetment known as the Temporary Seawall Fortification, or TSF. The TSF was placed in 2004 as an emergency action in response to beach erosion that had reached a point where no dry beach in front of the sea wall existed at high tide. At the northernmost end of the sea wall, a 650 foot-long portion of the sea wall failed or was weakened, including a segment that collapsed seaward, as a result of a December 1992 storm. DCR rebuilt that portion of the sea wall in 2008 as the 900 foot-long Northern Revetment. Beyond the Northern Revetment to the north, shoreline protection is provided by sand fill in combination with stone riprap revetment or jersey barriers.

In addition to these protective works, the DCR reservation includes property in the immediate back shore. The agency maintains a pavilion, a bath house, restrooms and parking areas. Further back, Nantasket Avenue provides the sole link between the mainland and the northerly portion of Hull comprising more than two-thirds of the town of Hull's land area and about 80 percent of its population. Further west into the back shore are primarily commercial establishments serving the recreational interests and residential structures, including a high-rise condominium development.

The relatively flat study area has been divided into three hydrologic zones that are shown on Figure 2. A further description of the three zones is provided below.

- Zone 1 is located between the south end of the sea wall the end of the TSF near Wharf Avenue. When high volume overtopping occurs, ocean water first ponds in the area adjacent to the sea wall and then flows into the parking lot of Horizon Condominiums on Park Avenue and then over the George Washington Boulevard into Hingham Bay.

- Zone 2 is located between the end of the TSF near Wharf Avenue and the end of the Northern Revetment near Water Street. When coastal storm waves overtop the sea wall, ponding occurs in the DCR parking lot, and between Nantasket Avenue and the George Washington Boulevard.

- Zone 3, located between the end of the Northern Revetment near Water Street and Phipps Street, is partially protected from ocean overtopping by sand fill, stone rubble revetment, jersey barriers at the northern end and further south by the Northern Revetment. Overtopping in this zone has been observed to flow through Bay Street and into Hingham Bay.

Photo 4 The Nantasket Beach Resort Hotel complex is situated at the north end of Zone 2, directly across Hull Shore Drive from the sea wall.

GEOLOGICAL SETTING

Nantasket Beach was formed primarily from materials eroded from drumlin islands located north of Atlantic Hill. It has been postulated that five (or more) drumlins located east of the existing beach have been partially or completely destroyed as a result of erosion. Based on a slight variation in grain size, it appears that a small amount of material is still being added to Nantasket Beach from the continuing erosion of the remnant drumlins offshore. The presence of coarse material on the beach adjacent to Allerton Hill, and the fining of beach materials to the south indicate that Point Allerton and Allerton Hill were also contributing material to the beach until sea walls were built to protect them from erosion. Recent beach profiles conducted for the study indicate that the shoreline is moving inland. At high tide the entire beach in front of the sea wall is inundated. The Corps conducted a study to characterize the profiles and material distribution in 2006. That study is presented as Appendix A. The geology of the study area is discussed in detail in Appendix D.

ENVIRONMENTAL SETTING

The large intertidal sand flat grades seaward from the beach along the length of the study area. Site visits were undertaken in preparation of the 1993 Reconnaissance Report and this feasibility report to determine the benthic community of the intertidal and sub tidal area. No dunes, beach grass, or other ecologically significant natural resources were observed. Benthic investigations conducted in May 1996 indicated a low number of species and individuals along the beach. No commercial shellfish were observed except for blue mussel spat, and one recently dead surf clam spat. A low density would be expected considering current, wave conditions and human disturbances. An inventory of surf clams was prepared in 2007 to better understand what impacts implementation of a beachfill alternative might have on their population. The waters offshore from Nantasket Beach support a viable lobster Homarus americanus population. No eel grass Zostera marina was found in the project area. No threatened or endangered species are known to inhabit the study area.

HISTORICAL/CULTURAL SETTING

The town of Hull, Massachusetts, originally called Nantascot by the Wampanoag Indians, dates from 1644, when the town was named for a seaport town in Yorkshire, England. Although initially a fishing and agricultural town, the town became a popular big hotel summer resort beginning in the early 1880's and continuing until the First World War. Concurrent with the genesis of the hotel industry was the construction of private summer homes ranging in size from bungalows to mansions. Typically, oceanfront lots contained larger homes than those further inland. In 1905 Paragon Park (amusement center) was constructed in the southern part of the town. The old inns and hotels have since disappeared along with Paragon Park. The Metropolitan District Commission, now DCR, assumed control of the Nantasket Beach Reservation in 1899 and has managed the popular beach since that time. The DCR bathing facilities located on Nantasket Avenue were built in a variation of the Spanish Mission Style circa 1905-1915.

Between 1915 and 1940, bungalow style homes were predominant in the area surrounding the beach. There was widespread alteration and demolition of existing commercial structures after World War II as other resorts became popular. The rise of strip development along Nantasket Avenue also became prevalent during this period.

The Hull Redevelopment Authority (HRA) acquired properties by eminent domain in the 1970’s that had been occupied by cottages and small businesses. Located in the study area between Water and Phipps Streets, a parcel of 33 acres, of which some 14 acres are buildable, is zoned for office, retail and residential use. Although there have been development proposals, this land remains undeveloped. The implementation of a plan to protect the Nantasket Beach back shore could reduce the risk of damages to the future development of this parcel.

Photo 5 The DCR bath house is located very close to the sea wall in Zone 2.

3: PROBLEM IDENTIFICATION AND OPPORTUNITIES

STATEMENT OF PROBLEM

Coastal storms cause extensive damages to the publicly owned Nantasket Beach, its protective works and back shore recreational, commercial and residential properties. Protection of the back shore is provided by a 5,400-foot long sea wall and a combination of revetment, sand fill and jersey barriers along the northerly 1,400 feet portion of the Beach. Storm driven waves from the east are responsible for the removal of sand in front of the concrete sea wall and the consequent lowering of the beach. The sea wall footings have been exposed and undermined in some places. By December 1992 the conditions had deteriorated to such an extent that an approximately 10-year recurrence event caused the weakening and failure of about 650 feet of sea wall at its northern end. In addition, the lowering of the beach and the sea wall breach has increased the risk of ocean overtopping during coastal storms and the flooding of properties in the back shore.

For the purpose of formulating plans to protect the back shore, Nantasket Beach has been divided into three zones: Zone 1 includes the shoreline occupied by a 2,000-foot long portion of the sea wall from Atlantic Hill to Wharf Avenue, Zone 2 includes the shoreline occupied by a 2,200-foot long portion of the sea wall from Wharf Avenue to the south end of the Northern Revetment near Water Street and Zone 3 extends 1,400 feet from the south end of the Northern Revetment to Phipps Street. The Northern Revetment is the result of the reconstruction of the portion of the sea wall damaged in the December 1992 storm, restoring some protection to the Nantasket Beach back shore. The remainder of Zone 3, between the Northern Revetment and Phipps Street, has little or no backshore development. The presence of the TSF since 2005 has bolstered another critical section of the old sea wall in Zone 1. The likelihood of sea wall failure in Zone 1 and Zone 3 is reduced by the newer works in front of the old sea wall, and only wave overtopping will contribute to backshore flooding for most postulated storms. The risk of wall failure in Zone 2 is greater, and, in the event of wall failure, areas within the two adjacent zones would be affected by flooding.

FUTURE CONDITIONS WITHOUT A FEDERAL PROJECT ESTABLISHED

Methodology

In a memorandum dated 23 March 1994 (see Appendix F), the Corps of Engineers Headquarters, Policy and Planning Division prescribed that the without project condition for determining the National Economic Development (NED) benefits of reducing damages in the Nantasket Beach back shore will 1) determine the condition, probability, and extent of failure of the sea wall based on engineering analysis, and 2) assume that the approximately 650 feet of failed and weakened seawall is repaired to its former design standards, but not further repaired during the period of analysis. After the initial reconstruction, the sea wall would, therefore, be permitted to lose its protection and eventually fail.

Without Project Condition

Without the benefit of a Federal project, it has been assumed that the DCR, with FEMA assistance, would continue to maintain the sea wall and other public infrastructure on its Nantasket Beach Reservation. Despite the DCR's efforts to seal cracks and perform other repairs to the sea wall, the position of the sea wall is fixed, and its stability is subject to change when storm waves remove sand and cobble to expose its footing.

Surveys have shown Nantasket Beach experiences significant seasonal erosion and accretion. Erosion of the beach in winter contributes to the vulnerability of the sea wall at the time of year when many significant storms occur. MACZM has concluded that the position of the sea wall at Nantasket Beach is more seaward of where the natural shoreline would be. That could be one reason why the high wave impacts associated with overtopping have been concentrated in this area during past storms. Consequently, high end losses are expected for any proposed beach fill project, and it is likely that the north end of the DCR seawall will continue to be a location where wave energy is focused after a project is constructed. DCR manages the 6,800 foot long beach reservation so that visitor safety and quality recreational experience are priorities.

The without project condition for Zone 2 encompasses two situations. The first is prior to sea wall failure but with the sea wall and the adjacent dune and concrete barriers north of the sea wall overtopped during storm conditions with their associated flooding and damages to the back shore properties. The second condition is after the failure of the sea wall has occurred. Based on the existing wall conditions and the high probability of failure, the estimated annual damages would be incurred from flood water flowing over the collapsed wall and reaching the backshore properties. Overtopping of the protective works in adjacent Zones 1 and 3 would continue to add some additional volume of water to the Zone 2 backshore. Sea wall failure in Zone 2, however, would increase associated backshore flood stages and damages. The 34 commercial structures and 31 residential structures within the FEMA-designated 100-year flood plain would experience flood damage. The 65 structures include homes, shops, restaurants, and a hotel. Land would also be lost to erosion as a result of sea wall failure. The DCR bathhouse, the sidewalk, parking areas and parts of Hull Shore Drive behind the wall are the most immediately vulnerable, along with the utilities that exist there.

The existing sea wall in Zone 2 is constructed out of concrete sections, and its design and functioning relies upon the existing beach providing scour protection for the structure. No toe stone was included in the original design because the width and height of the beach at that time was adequate to ensure no undermining of the structure would occur due to erosion. The structure functioned to protect against wave action and storm surge, but relied upon the existing beach for protection of its footings. Since its construction, there have been noticeable reductions in the beach width and height due to seasonal variations and the beach's response to storms. The beach conditions have eroded to the point where the existing beach is not of an adequate width to prevent the undermining of the wall. There are portions of the wall where the toe of the structure is exposed, and the wall is subject to attack from very frequent storms.

Based upon the fact that 1) the existing wall design depends upon a beach for scour protection, 2) that the beach under current conditions does not meet the design requirements, 3) that the beach conditions will continue to degrade, and 4) that under current conditions a relatively small storm event could result in the wall failure, it is reasonable to forecast that by the project base-year that the wall would fail. Since the existing structure is constructed of concrete segments, it is reasonable to expect that when the wall fails that there is no residual protection that is provided by the structure.

When the age and current condition of the wall in Zone 2 and the Corps prior inspection results for the adjacent segments are considered, the seawall in the study area cannot be depended on as a reliable flood risk reduction structure and should not be considered in the without project condition. The benefit analysis will assume existing ground elevations and should not assume a specific level of protection is afforded by the existing structure.

In the absence of a Federal project, the properties in the Nantasket Beach back shore are expected to incur significant average annual damages due to flooding, as well as losing some land to erosion. Failure to protect the sea wall will jeopardize DCR's investment of over $2 million for the pavilion restoration and bathhouse renovation as well as increasing future risk of damages to the infrastructure behind the wall segments that are most at risk. The key to

protecting the sea wall is to prevent instability by keeping material against the wall face to a critical height where the wall will not topple and the wall footing is not exposed.

Photo 6 Seasonal work performed at Nantasket Beach.

OPPORTUNITIES AND RESPONSE TO PROBLEMS

Problems and opportunities are derived from current areas of public concern and from future concerns that would be a consequence of predicted conditions in the study area in the absence of Federal measures to address these consequences. The following opportunity statements are in response to problems in the study area.

In the first instance, they define how the water and related land resource management needs can enhance the National Economic Development (NED) account for proposed corrective measures for protecting Nantasket Beach. NED increases the nation's output of goods and services by improving its economic efficiency as the result of corrective measures. A Federal project could:

- Alleviate damages due to coastal storms by reducing overtopping and subsequent flooding of back shore public, commercial and residential infrastructure and properties.

- Reduce erosion and the risk of erosion due to coastal storms. Protection of the sea wall will reduce the risk that a storm event will affect the Nantasket Beach back shore between Wharf and Water Streets to an extent that northern parts of Hull would be isolated from the mainland.

- Reduce damages, due to wave action, on the back shore and back shore structures such as the sea wall, the newly reconstructed bathhouse and other facilities.

In addition to the NED objective, other planning considerations are Environmental Quality, Regional Economic Development, and Other Social Effects. Opportunities in these respects are to:

- Contribute to enhancement of the well-being of people and physical, historical and cultural environments.

- Enhance the economic strength, recreational opportunities and well-being of the area.

- Minimize the negative impacts on residents of the study area.

PLANNING CONSTRAINTS

Planning constraints are limitations that are incorporated into the planning process. These limitations are based on a wide range of concerns such as natural conditions, social and environmental factors, economic limits, and legal and regulatory restrictions.

The following constraints were found to be relevant to the study. The formulated plans should be consistent with the geographic limitations of the study area and avoid or minimize negative effects on adjacent shores, on the environment, including plant and animal life, and on historical resources. They should address the concerns and desires of the sponsor and residents of the study area and be consistent with the requirements of local, state and Federal regulatory agencies.

The following knowledge and information became known during the course of the study, and influenced details of some of the alternatives that were considered:

- A characterization of Nantasket Beach material revealed it has a very bi-modal composition, consisting of very fine sand and cobbles. Such a mix results in a relatively flat beach. A protective beach berm of compatible material would require a very high volume of fill to construct. Prior to the characterization, use of coarser-grained sand for beach fill had been considered. Coarser-grained material would allow the construction of a stable berm with a steeper slope thereby needing lesser volumes to provide a given level of protection. However a coarser material mixture would not be compatible with the existing beach.

- Construction of the TSF in 2005 and the Northern Revetment in 2008 changed the level of protection afforded to the backshore in Zones 1 and 3 respectively. With the TSF in place the sea wall behind it is adequately protected for the higher frequency storms up to ten year return. The Northern Revetment affords a much higher level of protection due to its robust design and construction. With these remedies in place, the volume of water due wave overtopping and wall failure risk in Zone 1 and Zone 3 are significantly reduced. The focus of the study became how to reduce damages due to wave impacts and flooding in Zone 2 where the sea wall remains vulnerable.

4: PLAN FORMULATION

PRELIMINARY SCREENING

Significant actions taken by the DCR at the Nantasket Beach Reservation in the last ten years included construction of the TSF as an emergency measure in 2005 and construction of the new Northern Revetment in 2008. These measures changed the level of protection afforded to the backshore in Zones 1 and 3, as the volume of water due wave overtopping and wall failure risk in Zone 1 and Zone 3 are significantly reduced. The 2,200 foot-long Zone 2 and its sea wall remains most vulnerable to wave attack, overtopping and possible failure. Four alternative methods were considered for reducing flooding and erosion due to coastal storms in the Nantasket Beach's Zone 2.

- Offshore Breakwater
- Revetment
- Elevation of Structures
- Beachfill Nourishment

Offshore Breakwater

An offshore breakwater would provide protection to an area of shoreline located leeward of the structure. Breakwaters protect the shore by causing waves to break prior to reaching the shoreline. A seven thousand-foot long rubble-mound breakwater, placed in a depth of 5.5 feet of water about 900 feet offshore with a crest width of approximately 24 feet and a crest elevation of 10 feet (NGVD) for a 10-year level of protection was considered for reducing damages due to coastal storms at Nantasket Beach. The breakwater would be long enough to trip waves approaching the shore from directions from north to east and would offer protection for all three zones. A breakwater would impact the recreational surfing at the DCR Reservation and create deposition of material between it and the shore. Construction and annual costs for the breakwater have been estimated at $68.5 and $ 5.3 million respectively. These costs are far in excess of estimates of annual benefits. The breakwater is not economically feasible and, therefore, does not warrant further consideration.

Revetment

Seawalls are constructed for the purpose of protecting property immediately behind them from erosion, flooding and wave action and for separating ocean water from the land. They provide protection by deflecting wave energy but are poor dissipaters of wave energy. As a result, waves impacting sea walls cause scour as some of the wave energy is deflected downward. The loss of sand in front of the sea wall at Nantasket Beach has resulted in the lowering of the beach elevation, the exposure of footings, more frequent overtopping and the failure of a portion of the sea wall. Placing a rock revetment in front of the sea wall can be effective in breaking waves prior to their reaching the sea wall and reducing overtopping and scour.

The Corps had initially considered alternative plans, including a revetment, to protect the DCR reservation's entire 6,800-foot length. Loss of sand in front of the sea wall at the south end of the reservation created a critical condition that was addressed by the DCR in 2004 when the TSF was constructed. The TSF has provided reliable toe protection to the wall behind it and performed better than expected. Later, the DCR constructed the Northern Revetment to replace the failed seawall north of Water Street, leaving the 2,200 foot reach that comprises Zone 2 as the only segment of sea wall not protected by a revetment. A revetment could provide toe protection to the unprotected wall and reduce overtopping of the sea wall by breaking storm waves before they reach the face of the wall. For these reasons, a stone revetment will receive further consideration.

Elevation of Structures

Non-structural measures, such as the elevation of structures, reduce the vulnerability of private and public properties to flooding, but do not reduce the flooding itself. Flooding, beginning at the first floor, is responsible for a large part of the damages to structures. By elevating structures above flood waters some damages can be avoided. Corps experience indicates that elevating those structures receiving one foot or more of flooding above the first floor level is likely to be economically feasible.

Beachfill Nourishment Alternatives

Placement of beach fill nourishment on a beach can enlarge the existing beach berm profile so that storm waves will break before they reach the sea wall. Scour at the base of the wall and overtopping of the wall could be reduced by this measure. The area of dry beach would be increased for this alternative, so permissible recreational benefits would accrue

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RESULTS OF PRELIMINARY SCREENING

A preliminary analysis of the costs and benefits of a stone revetment, elevation of structures, and sand fill nourishment alternatives indicates that they warrant more detailed consideration for reducing damages in the Nantasket Beach back shore.

ALTERNATIVE PLANS

With Project Conditions

The with project condition is the most likely condition that is expected to exist in the study area during the 50-year planning horizon if a Federally-assisted project is undertaken. Our alternatives evaluation was driven by results of the Corps SBEACH model that are presented in Appendix B. There are as many with project conditions as there are alternative plans and options, which are presented below for each alternative.

Revetment

The sea wall along Zone 2 at Nantasket Beach has direct exposure to storm waves that can move material away from its footings, placing it at risk of failure similar to what occurred at Nantasket in 1992. Placing a rock revetment in front of the sea wall can be effective in breaking waves prior to their reaching the sea wall and reducing overtopping and scour. Two rock revetment plans offering 10-year and 25-year levels of protection were formulated. The two plans have similar layouts and dimensions with the principal difference being the size and weight of the armor stone that is specified. The TSF design was used as a practical starting point, since the Corps and DCR both agree its performance has met expectations. It has proved to be effective protection for the wall footing. The plans created have a deeper toe and a more robust cross section than the TSF with provisions to accommodate existing beach access stairs and ramps. Details of the concept design are found in Appendix E of this report.

Elevation of Structures

Non-structural measures, such as the elevation of structures, reduce the vulnerability of private and public properties to flooding, but do not reduce the flooding itself. Flooding, beginning at the first floor, is responsible for a large part of the damages to structures. By elevating structures above flood waters some damages can be avoided. An estimated 65 structures in Zone 2 are subject to flooding in the Nantasket Beach back shore. Of these, an estimated 13 structures receive one foot or more of flooding above the first floor level. Corps experience indicates that elevating those structures receiving one foot or more of flooding above the first floor level is likely to be economically feasible.

The implementation of an alternative plan to raise 13 structures would not affect flooding conditions nor prevent erosion in the study area. Only for those structures that are raised above the flood waters would conditions improve, thereby avoiding less than 25 percent of the annualized flooding damages. That means that a vast majority of damages would not be addressed by this measure. Due to the high level of residual flood damages, this plan was rejected.

Beachfill Nourishment System

Beachfill would be placed seaward of the existing sea wall to protect the toe of the sea wall and to cause storm waves to break further offshore to reduce overtopping of the sea wall. Periodic nourishment is an integral part of a beach fill plan. Its purpose would be to replace sand lost to littoral and offshore movement. Two beach fill plans offering 10-year and 25-year levels of protection have been considered in the analysis.

<u>Design and Costs</u> The modeling and analysis for the beach fill plans are presented in Appendix B. For 10-year protection of Zone 2, the direct placement of 246,000 cubic yards of sand seaward of the existing sea wall in Zone 2 is required. The project would be built to a 50 foot wide level berm with an elevation of 9.25 feet NAVD88 and then slope at a maximum rate of lV:l5H until it intersects the existing beach. For 25-year protection of Zone 2, the direct placement of 378,000 cubic yards of sand seaward of the existing sea wall in Zone 2 is required. The project would create a level berm 75 feet wide at elevation 9.25 feet NAVD88 and then

slope at a maximum rate of lV:l5H until it intersects the existing beach. In both cases, this initial material placement would equilibrate to a stable width over time. The 2,200 foot length of Zone 2 is small with respect to the size of DCR's Nantasket Beach Reservation and Nantasket Beach as a whole. Due to that small size, it is estimated that a beach fill project to protect Zone 2 only would suffer high end losses over time in proportion to the volume of material initially placed. Should DCR move to implement a similar level of beach fill protection in the adjacent Zones 1 and 3, then the anticipated end losses for a Federal storm damage reduction project in Zone 2 would be small. The beach fill costs in the project cost estimate Appendix G1 assume a land-based source of sand.

Beachfill A materials availability survey of offshore and land-based sources was conducted for the beach fill required for a beachfill nourishment system and is reported in Appendix D.

Two potential offshore sources of beachfill were examined: (1) maintenance dredged material from nearby harbors and (2) underwater materials in Massachusetts Bay. While the option of using materials to be dredged from nearby harbors seems attractive, an examination of the test data for the samples collected from these harbors reveals that less than 60,000 cubic yards of material consists of sand. This material is finer than the required specification. For these reasons, material dredged from nearby harbors as part of the Corps maintenance program would be unsuitable for the sand fill options.

Sediments of western Massachusetts Bay have been the subject of several studies since the early 1970's, which looked at the offshore geology and the potential for suitable borrow and disposal sites. No permittable borrow sites have been identified to date.

With respect to land-based sources, there are several well-established sand and gravel sources in the Plymouth/Kingston area operating within 30 miles of the study area that are capable of producing the required quantities of clean material having a gradation that meets the New England District sand fill specification. In addition, the DCR has expressed an interest in investigating the possibility of using a DCR-owned stockpile of sand located in Revere that was originally intended for the construction of Route I-95. The quantity of material would have to be determined, and the material tested for gradation. Depending on the testing results, the material may require processing to remove large particles, and washing to remove fines. The material would have to be hauled about 30 miles and possibly through downtown Boston.

In conclusion, the required quantities of suitable material can be readily supplied by land-based sources located within an approximately 30-mile radius of the study area. At least two sources have the capability to barge their land based source to the project site. Significant environmental compliance and permitting issues exist at potential offshore borrow and would have to be resolved, which would increase the costs and delay completion of a beach fill project. Costs of offshore materials are generally competitive with land-based sources. Due to economies of scale, unit costs tend to decrease as quantities increase. Offshore dredged materials would probably not be cost effective for smaller quantities required for renourishing the project given the high mobilization and demobilization costs, unless the material is stockpiled for later use. Environmental concerns dictate the placement of sand between September 1 and May 31. The cost of dredging in the winter months can be significantly higher (up to 50 percent) due to the slower rate of production caused by working in rougher seas.

Conditions with Beachfill Nourishment Repair of cracks in the existing seawall is a prerequisite to the implementation of the beachfill nourishment plans. Implementation of a beachfill nourishment plan, including nourishment to periodically restore the dimensions of the beachfill and its design level of protection, would cause waves to break further offshore and reduce wave run up. The reduction in run up would thus provide protection to the sea wall or dune from ocean overtopping and consequent flooding and damage to back shore properties. In addition, the reduction in overtopping would prevent the buildup of hydrostatic pressure on the back of the sea wall and thereby increase stability against overturning. The beachfill in front of the sea wall would prevent the scouring of sand at its toe and possible undermining of the sea wall footing and reduce the long-term risk that continued erosion would cut off northern Hull from the mainland. The dry beach area created by the beachfill would provide recreational opportunities for beachgoers.

Periodic nourishment refers to the practice of periodically replacing sand fill to replenish sand volume that is lost to erosion. The DCR would be responsible for the entire costs and implementation of periodic sand fill nourishment if a sand fill nourishment project is implemented.

REAL ESTATE

All of the considered alternatives for reducing erosion and flooding of the Nantasket Beach backshore would be constructed on DCR property. Space for construction staging and access will be necessary for the implementation of these alternatives. There are no outside acquisitions needed for construction. It is conceivable that some local traffic patterns or traffic signal timing could be altered to minimize delays and disruption of through traffic as trucks delivering materials enter and leave the construction area; however no lands or easements should be necessary to implement that type of temporary change. The Real Estate Planning Report for the study is Appendix H.

Photo 7 Waves overtop the sea wall in front of the DCR bath house.

Photo 8 These sand bags are a necessary off season measure to prevent water coming over the sea wall from entering the DCR bath house.

5: EVALUATION OF ALTERNATIVE PLANS

ECONOMIC EVALUATION

Methodology

The economic analysis of the alternative plans to reduce coastal storm damages at the Nantasket Beach study area is addressed in Appendix F. Economic benefits are based on damages prevented by the project for different storm events. A stage damage function was developed to correlate damages with still-water flood elevations of each coastal storm event. The damages prevented by each level of protection provide the benefit for each alternative. The benefits and costs were then annualized using a CRF (Capital Recovery Factor) of 0.00457 based on the FY 2013 interest rate of 3.75% for a 50 year project life. For each plan, annual benefits are divided by annual costs to determine the benefit-cost ratio (BCR). Those projects with benefit-cost ratios equal to or greater than one are economically feasible. The Federal government may participate in plans that have benefit-cost ratios of at least one. The National Economic Development (NED) plan is an economically feasible plan that maximizes net benefits or the net value of national goods and services resulting from implementation of the plan. The NED plan is the plan with the largest net annualized benefits after deducting annualized costs. The detailed cost estimates are included as Appendix G.

Benefits

Benefits are the differences in damages and losses without and with each plan. Inundation damages were developed for each property using a typical stage damage function for residential, commercial and institutional structures. The stage or elevation at which flood damage begins is at the ground elevation for each property. Estimates of potential damages were made in one foot increments of stage, to a level six feet above the first floor. Dollar value estimates were made for physical damages to site, structure, contents and utilities. Project benefits are measured by the reduction in storm related damages, prevention of long term erosion, reduction in flood insurance overhead costs and incidental recreation. Incidental recreation benefits associated with beachfill alternatives are restricted to 50 percent of the benefits required for economic justification. The economic analysis employs the limited incidental recreational benefits, where applicable, required for economic justification in the evaluation of each improvement plan. See Tables 1-4.

Analysis

The economic analysis indicates that the 10-year and the 25-year level of protection stone revetment alternatives for Zone 2 are economically feasible. See Tables 1 and 2. However the revetment offering a 10-year level of protection is the plan that maximizes net benefits. The sand fill nourishment plans offering 10-year or 25-year level of protection to Zone 2 show economic justification, however their first costs are far in excess of the ceiling for Federal expenditures per project under Section 103. See Tables 3 and 4. The Zone 3 backshore is partially protected by DCR's Northern Revetment. Few properties are located in the Zone 3 backshore; hence there is an absence of economic benefits in that area. Consequently, no project can be recommended in Zone 3.

Nantasket Beach, Hull, MA

SUMMARY OF ECONOMIC ANALYSIS FOR STUDY ALTERNATIVES

Table 1 10-yr Stone Revetment Plan

COSTS AND BENEFITS

Construction Cost	$5,133,686
Interest During Construction	$24,114
E&D	$308,021
S&A	$410,695
Project Cost	$5,876,516
Annual Cost	$261,941
Annual O&M	$1,100
Total Annual Cost of Alternative	**$263,041**
Annual Benefit	**$1,075,300**
Annual Net Benefit	$812,259
BCR	**4.09**

Table 2 25-yr Stone Revetment Plan

COSTS AND BENEFITS

Construction Cost	$5,800,224
Interest During Construction	$27,245
E&D	$348,013
S&A	$464,018
Project Cost	$6,639,500
Annual Cost	$295,951
Annual O&M	$800
Total Annual Cost of Alternative	**$296,751**
Annual Benefit	**$1,075,300**
Annual Net Benefit	$778,549
BCR	**3.62**

Table 3 10-yr Beach Nourishment Plan
COSTS AND BENEFITS

Construction Cost	$15,457,528
Interest During Construction	$268,463
E&D	$927,452
S&A	$1,236,602
Renourishment	$36,350517
Project Cost	$54,240,562
Annual Cost	**$2,417,731**
Annual Benefits	$1,408,100
Annual Recreational Benefit	$1,197,400
Total Annual Benefits	**$2,605,500**
Annual Net Benefit	$187,769
BCR without Recreational Benefits	**0.58**
BCR with Recreational Benefits	**1.08**

Table 4 25-yr Beach Nourishment Plan
COSTS AND BENEFITS

Construction Cost	$25,868,782
Interest During Construction	$449,284
E&D	$1,552,127
S&A	$2,069,503
Renourishment	$19,885,274
Project Cost	$49,824,969
Annual Cost	**$2,220,909**
Annual Benefits	$1,408,100
Annual Recreational Benefit	$1,197,400
Total Annual Benefits	**$2,605,500**
Annual Net Benefit	$384,591
BCR without Recreational Benefits	**0.63**
BCR with Recreational Benefits	**1.17**

ENVIRONMENTAL, HISTORICAL AND CULTURAL CONSIDERATIONS

Evaluation of the project site and for possible construction of the three plans that are economically feasible (elevation of structures, a stone revetment, and the sand fill nourishment options) indicate that there are no unacceptable impacts on environmental, historical, archaeological, and cultural resources. There are no threatened or endangered species in the project area.

Any negative environmental impacts would generally be minor and short term in nature. The trucking of stone, sand fill and other construction materials to the site would create noise along the trucking route. Construction of the plan would cause minor noise and dust impacts. Placement of sand fill would generate minor turbidity in near shore waters. Operating equipment on the beach could also cause local turbidity depending upon the tide.

COMPARATIVE EVALUATION OF PLANS

Elevate structures - A plan to elevate some 13 of the most flood-prone structures in the study area is economically feasible, but would benefit only those structures that are elevated. The remaining structures for which elevation is not economically feasible would continue to incur damages from flooding due to coastal storms. Some 75 percent of residual damages would remain. This high level of residual damages was the basis for dismissing raising structures as an effective storm damage reduction measure.

Sand fill beach nourishment - The sand fill nourishment plans for a berm placed seaward of the existing sea wall, including periodic nourishment, would cause storm waves to break further offshore and reduce ocean water overtopping of the sea wall and consequent flooding of the back shore and damages to structures and properties. The sand fill plans would provide protection against an approximately 10-year and 25-year recurrence storm events, respectively. The combination of less ocean overtopping, which reduces the potential for increases in the hydrostatic pressure on the back of the sea wall, and sand fill in front of the wall would increase the stability of the sea wall against overturning. The sand fill would guard against scouring at the toe of the sea wall and possible undermining of the sea wall footing. In addition, the plan would protect the DCR facilities and other public infrastructure as well as commercial properties. The dry beach area created by the berm would allow an increase in the number visitors that the reservation can be accommodated. The economic feasibility of the sand fill plans can be demonstrated, however the first cost of each of the plans was far in excess of the limit for Federal expenditures under the continuing Authorities Program's Section 103. The length of a sand fill project to adequately protect the 2,200 foot-long Zone 2 would be greater than 2,200 feet. If a sand fill berm were constructed as a stand-alone project, the expected end losses would be considerable due to the dimensional differences between it and the existing beach. Frequent maintenance would be a direct consequence of those material end losses. Unless the DCR elected to place sand fill over the remainder of its reservation in a coordinated construction effort, the practicality of maintaining such a relatively short berm would be marginal.

Stone Revetment - The stone revetment plans to build a revetment placed seaward of the existing sea wall would cause storm waves to break of the sea wall and reduce ocean water overtopping and consequent flooding of the back shore and damages to structures and properties. Revetment plans would provide approximately 10-year and 25-year protection against recurring storm events. The revetment would protect the toe of the sea wall from scour and the possible undermining of its footing. In addition, the plan would protect the DCR facilities and other public infrastructure close to the sea wall.

IDENTIFICATION OF RECOMMENDED PLAN

Based on the maximization of NED benefits, the recommended plan to provide shore protection for Zone 2 at the DCR Nantasket Beach Reservation is a stone revetment approximately 2,200 feet long designed to afford a 10-year level of protection to the backshore. The plan meets economic, engineering and cultural criteria for implementation, so the Federal government may participate in its final design and construction. Its cost of implementation falls within the expenditure limits for Section 103 projects and the net annual benefit of the plan is $812,559 with a benefit to cost ratio of 4.09. The costs associated with the recommended plan are presented in Table 5.

Table 5 10-yr Stone Revetment Plan
2,200-foot long Stone Revetment in front of existing wall in Zone 2

COSTS AND COST APPORTIONMENT

PLANNING PHASE COSTS

Activity	Total Cost	Federal Share (50%)	Non-Federal Share (50%)
Feasibility Study	$869,194.48	$434,597.24	$434,597.24

RECOMMENDED PLAN (10-YR LOP) IMPLEMENTATION PHASE COSTS

Activity	Total Cost	Federal Share (65%)	Non-Federal Share (35%)
Construction Cost	$5,134,000	$3,337,100	$1,796,900
Engineering and Design (E&D)	$308,000	$200,200	$107,800
Construction Management (S&A)	$411,000	$267,150	$143,850
Total Project Cost	$5,853,000	$3,804,450	$2,048,550

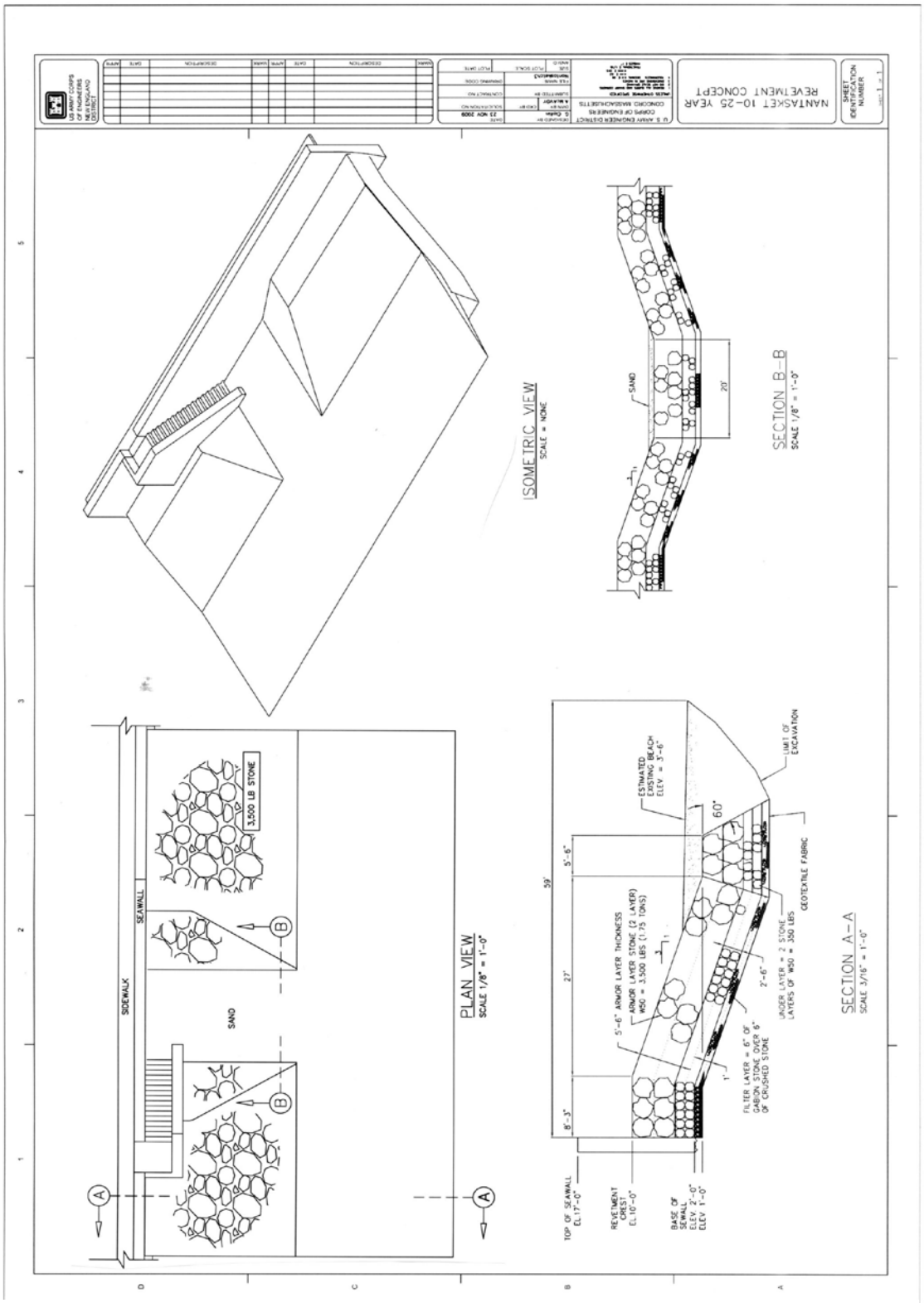

Figure 3 – Concept Stone Revetment for 10-year level of protection for Nantasket Beach

6: COSTS AND RESPONSIBILITIES

IMPLEMENTATION RESPONSIBILITIES

Cost Apportionment

The Section 103 authority, under which this present study has been conducted, provides for Federal participation of 65 percent of all project costs, including construction, contingencies, Engineering and Design (E&D) and Construction Management (CM) up to $5,000,000 in Federal costs, including the Federal share of reconnaissance and feasibility studies. The non-Federal sponsor, the Department of Conservation and Recreation, is responsible for all operation and maintenance costs.

For the Nantasket Beach Project, Federal study costs are $434,597.24 thereby leaving up to $4,565,402.76 in Federal funds remaining available for design and construction of a Section 103 project. The apportionment of costs between the Federal government and non-Federal sponsor for the recommended plan are presented in Table 5. Federal and Non-Federal first construction costs respectively are $3,804,450 and $2,048,550 for a total of $5,853,000. Periodic maintenance costs over the 50-year period of analysis estimated to be $1,100 annually and are a non-Federal responsibility. The estimated Federal share of the project implementation cost shows the project is within the $5 million limit for Section 103 projects; however careful consideration should be given to both the project specifications and the acquisition strategy so the possibility of exceeding the limit is minimized.

Cost Methodology

An Abbreviated Risk Analysis (ARA) was conducted and a Total Project Cost Summary (TPCS) prepared for the recommended plan. The exercise resulted in a changed project contingency, however these costs are relative, and recognizing the recommended plan benefit to cost ratio was 4.09, it is reduced to 3.03 but the report recommendation does not change.

Updated project costs and cost apportionment are presented in Table 5a. The revised Federal and Non-Federal first costs respectively are $4,129,700 and $2,223,600 for a total of $6,353,300.

Seawall Repairs

If the benefits attributable to a project to construct a stone revetment seaward of the sea wall are to be realized, minor repairs to the sea wall must be made by the sponsor as prerequisite to the construction phase of the project.

Table 5a 10-yr Stone Revetment Plan
2,200-foot long Stone Revetment in front of existing wall in Zone 2
Project costs with TPCS contingency applied

COSTS AND COST APPORTIONMENT

PLANNING PHASE COSTS

Activity	Total Cost	Federal Share (50%)	Non-Federal Share (50%)
Feasibility Study	$869,194.48	$434,597.24	$434,597.24

RECOMMENDED PLAN (10-YR LOP) IMPLEMENTATION PHASE COSTS

Activity	Total Cost	Federal Share (65%)	Non-Federal share (35%)	
			Non-Federal cash	Lands (100% non-Fed)
Construction Cost	$5,537,600	$3,622,700	$1,914,900	------
Lands	$35,800	------	------	$35,800
Engineering and Design (E&D)	$338,400	$220,000	$118,400	------
Construction Management (S&A)	$441,500	$287,000	$154,500	------
Total Project Cost	$6,353,300	$4,129,700	$2,187,800	$35,800

MEPA Schedule and Permits

The local sponsor will be responsible for compliance with the Massachusetts Environmental Protection Act (MEPA) and for the distribution of the draft Environmental Impact Report (EIR) to all appropriate parties and to the MEPA office for a statement on the adequacy of the draft EIR. Based on the comments received on the draft EIR, a final EIR will then be prepared by the local sponsor and be distributed to interested parties. The Secretary of the Executive Office of Environmental Affairs (EOEA) will then make a determination as to whether or not the final EIR is in compliance with MEPA. Upon a finding of compliance with MEPA, the local sponsor will prepare a Section 61 Finding.

During the Engineering and Design phase of this project, and after completion of the final EIR, the local sponsor will obtain the Local Order of Conditions, and Chapter 91 License. The Corps of Engineers will obtain the Water Quality Certification and a Coastal Zone Consistency Determination.

Maintenance

Maintenance applies to the upkeep, repair and care of work constructed for the project. Maintenance includes inspection to detect any deterioration that would adversely affect the performance of the project and undertaking the repair or replacement as required. The requirements for maintaining the project would be addressed in a Corps-prepared operation and maintenance manual and future maintenance would be the responsibility of the local sponsor.

Project Partnership Agreement

After the completion of this Feasibility Study and final design during the E&D phase, a Project Partnership Agreement (PPA) defining the responsibilities of the parties for the construction of the project, will be executed by the Federal and non Federal parties. In the PPA, the sponsor will agree to pay its share of project implementation costs and provide the lands, easements and rights of way required to construct the project.

Construction

In an effort to control temporary increases in noise levels, the contractor will be required to restrict truck traffic through the town of Hull to reasonable hours. It is expected that much of the construction activity can be accomplished during low and mid-tides. Negative impacts to water quality will be minimized by not allowing equipment into the water to the maximum practical extent.

7: CONCLUSION AND RECOMMENDATIONS

CONCLUSION

The publicly owned Nantasket Beach Reservation is exposed to erosion and flood damage from coastal storms its protective works (sea wall, sand fill, revetments, etc.) and backshore recreational, commercial and residential properties. The Massachusetts Department of Conservation and Recreation has taken steps to prevent or reduce damages by providing toe protection for the vulnerable sea wall at the south end of their reservation and reconstructing a failed portion of their sea wall at the north end of their reservation. The threats of erosion, flood damages and risk of undermining the remaining portion of the sea wall are projected to continue if a project is not undertaken to address that segment of the beach. This study concludes that, of the plans considered for reducing coastal storm damages at Nantasket Beach, the construction of a stone revetment to provide a 10-year level of protection to the central portion of the DCR reservation and its backshore is economically justified and is a locally-preferred plan in which the sponsor would participate. The proposed revetment would be approximately 2,200 feet long and would be constructed directly in front of the existing sea wall once DCR has performed repairs to all cracks, etc that are identified prior to new construction.

The revetment will consist of a layer of geotextile fabric, a 6" thick filter layer of crushed stone, a 2'-6" under layer of stone, W50 = 350 lbs (2 stones thick), and a 5'-6" armor layer of stone, W50 = 3,450 lbs (2 stones thick).

The excavation limits can be determined by viewing Section A-A on the attached concept plan Figure 3. The footprint of the revetment concept conforms to the approved MEPA footprint according to DCR. The bottom of the excavation will be -8.0 ft NGVD.

One impact of the revetment in Zone 2 would be the reduction of dry beach area equal to the size of its footprint. There should be no impacts to surf clams, and the number of trucks required to bring materials over local roadways to the site will be significantly less than what was estimated for the beachfill alternative.

Building the revetment is the National Economic Development (NED) Plan and qualifies for Federal participation in its final design and construction. It would be environmentally and culturally acceptable. None of the improvement plans to provide additional protection fot Zone 1 where the sea wall is fronted by the TSF, Zone 3 with the Northern Revetment or the 1,400 portion of the shoreline north of the sea wall, were found to be economically feasible.

RECOMMENDATIONS

I recommend the construction of the 2,200-foot long stone revetment in front of the sea wall at an elevation of 10 feet (NGVD), with a lV:3H slope to a toe buried below the existing beach and maintained periodically to restore the geometric configuration and level of protection of the plan. It is the most technically and economically feasible and socially, environmentally and culturally acceptable project for reducing storm damages due to flooding and erosion at Nantasket Beach. The project is estimated to have a first cost of $6,353,300 with annual

maintenance during the life of the project is estimated to be $1,100. The Federal cost is limited to $5,000,000 under Section 103 guidelines. The Federal share of the costs of prior studies is $434,597.24 and the estimated Federal cost of construction is $4,129,700.

I have considered all significant aspects in the overall public interest including engineering and economic feasibility and environmental, cultural, and social effects in concluding that the approved plan described herein is the best implement able alternative meeting the objectives of this investigation.

I further recommend that this Feasibility Report be the basis for proceeding with Engineering and Design and construction of the approved plan under the authority of Section 103 of the 1962 River and Harbor Act, as amended.

This recommendation to proceed to the Engineering and Design Phase is contingent on a commitment on the part of the Department of Conservation and Recreation, to perform repairs, as deemed necessary, to the sea wall in Zone 2, prior to the construction of the approved project.

The recommendations contained herein reflect information available at this time and current Department of the Army policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of the national civil works construction program nor the perspective of higher review levels of the Executive Branch. Consequently, the approval may be modified before transmission for authorization and /or implementation.

_____ _____

Date

Charles P. Samaris
Colonel, Corps of Engineers
District Engineer