COASTAL PROTECTION STUDY
CITY OF LONG BEACH, NY

Oceanside Shore Protection Plan

Prepared for:

City of Long Beach, New York

Prepared by:

Coastal Planning & Engineering, Inc.

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EXECUTIVE SUMMARY

In 1989, a Reconnaissance Study of Long Beach Island, New York was completed by the New York District, U.S. Army Corps of Engineers. The study concluded there was justification for proceeding to a Feasibility Study, which was completed in 1998 and recommended a shore protection project consisting primarily of beach fill and groin rehabilitation. A change in study area and site conditions led to a Limited Reevaluation Report (LRR) produced by the Corps in 2006.

The City of Long Beach had concerns with Corps plan and did not support moving forward with the proposed project. However, the City recognizes the risk for storm damage and flood potential, and contracted Coastal Planning & Engineering, Inc. (CPE) to provide guidance in implementing a Federal storm protection program. The results show that the shoreline of the City of Long Beach has been generally accretional since completion of the groin field in the late 1940's and relatively stable in recent years. However, the beach elevation is not high enough to prevent flooding and coastal protection measures one warranted. To address this issue, the City could implement the Corps LRR or a Locally Preferred Plan (LPP).

The LPP identified herein satisfies the City's objectives and criteria for a shoreline protection project for the Atlantic coast of the City of Long Beach. However, implementation of a LPP that differs significantly from the Corps current plan would likely require an engineering and economic reanalysis that may take many years to complete and is not guaranteed to be authorized by the Corps. In that timeframe, funding which has already been identified for the existing LRR plan may be lost. Therefore, accepting some form of the current plan would allow the process to move forward and secure funding for construction.

The current conditions are such that the beach is wide, but low in elevation, which demonstrates the need for a storm protection project. While the groins have been effective in stabilizing the shoreline, the low elevation of the beach allows for overtopping during moderate storm events. Dry beach fill placed as a berm cap would avoid sand placement in the water and increase the elevation of the existing beach to help address overtopping. Additional protection in the form of a sand barrier or floodwall is needed under the boardwalk to prevent flooding from major storms. If the storm protection project is implemented, the beach template would then be authorized for nourishment as needed, such as after a major storm event.

Based on the results of this study, it is recommended that the City of Long Beach support the Corps in completing the LRR process in order to secure funding and move the project forward. In addition, the City should continue to seek federal support for bayside flood protection, but separate from the oceanside project to avoid delays. Beach surveys are needed to better assess the current conditions and potential for dry beach fill. Additional geotechnical investigations should be conducted in the proposed borrow area to target sand areas that best match the existing beach. A wave analysis should also be conducted to evaluate the potential effects on wave breaking and the concerns of the surfing community. These studies may be done by the Corps or by the City as "in kind services" with federal reimbursement (credit) at the time of construction.

I. INTRODUCTION

The purpose of this report is to provide planning guidance to the City of Long Beach for implementing a federal storm protection program through the U.S. Army Corps of Engineers. The analysis contained herein includes a review of Corps studies and an independent assessment of local coastal processes. The recommended project may be structured as a locally preferred plan or minor modification to the Corps proposed plan that addresses the City's concerns for oceanside flooding and storm protection.

In 1989, a Reconnaissance Study of Long Beach Island, New York was completed by the New York District, U.S. Army Corps of Engineers (Corps). Further analysis of the project was performed by the Corps in 2006. This resulted in a Limited Reevaluation Report (LRR) that described the proposed project. The LRR recommended revising the project within the City of Long Beach to shift the dune structure under the Long Beach boardwalk and shift the beach berm landward a corresponding amount. However, the City maintained concerns regarding the volume and quality of beach fill proposed with the project. This report addresses those concerns and identifies alternatives to the proposed plan that could meet the requirements of a federal project.

II. BACKGROUND AND HISTORY

The barrier island of Long Beach is located on the Atlantic Coast of Long Island, New York, between Jones Inlet and East Rockaway Inlet (Figure 1). There are five communities on the barrier island: Point Lookout, Lido Beach, City of Long Beach, East Atlantic Beach and Atlantic Beach. All unincorporated areas on the island are under the jurisdiction of the Town of Hempstead, Nassau County, New York. For the purposes of this report, the barrier island is often referred to as "Long Beach Island" and the City of Long Beach as the "City."

The nine mile long barrier island varies in width from 1,500 to 4,000 feet, and is bounded on the east by Jones Inlet, on the south by the Atlantic Ocean, on the west by East Rockaway Inlet, and on the north by Reynolds Channel. Development on the island is primarily residential with extensive recreational areas and facilities. Beach clubs, apartment houses, condominium complexes and hotels dominate the Atlantic shore, while the north shore is primarily occupied by private homes and public facilities. The terrain is low-lying and flat, with elevations generally less than 10 feet above National Geodetic Vertical Datum (NGVD). The Atlantic shoreline consists of a continuous strip of generally low-lying beach with a series of groins constructed along the entire ocean front. The barrier island provides protection against wave attack to the mainland of Long Island along Hempstead Bay.

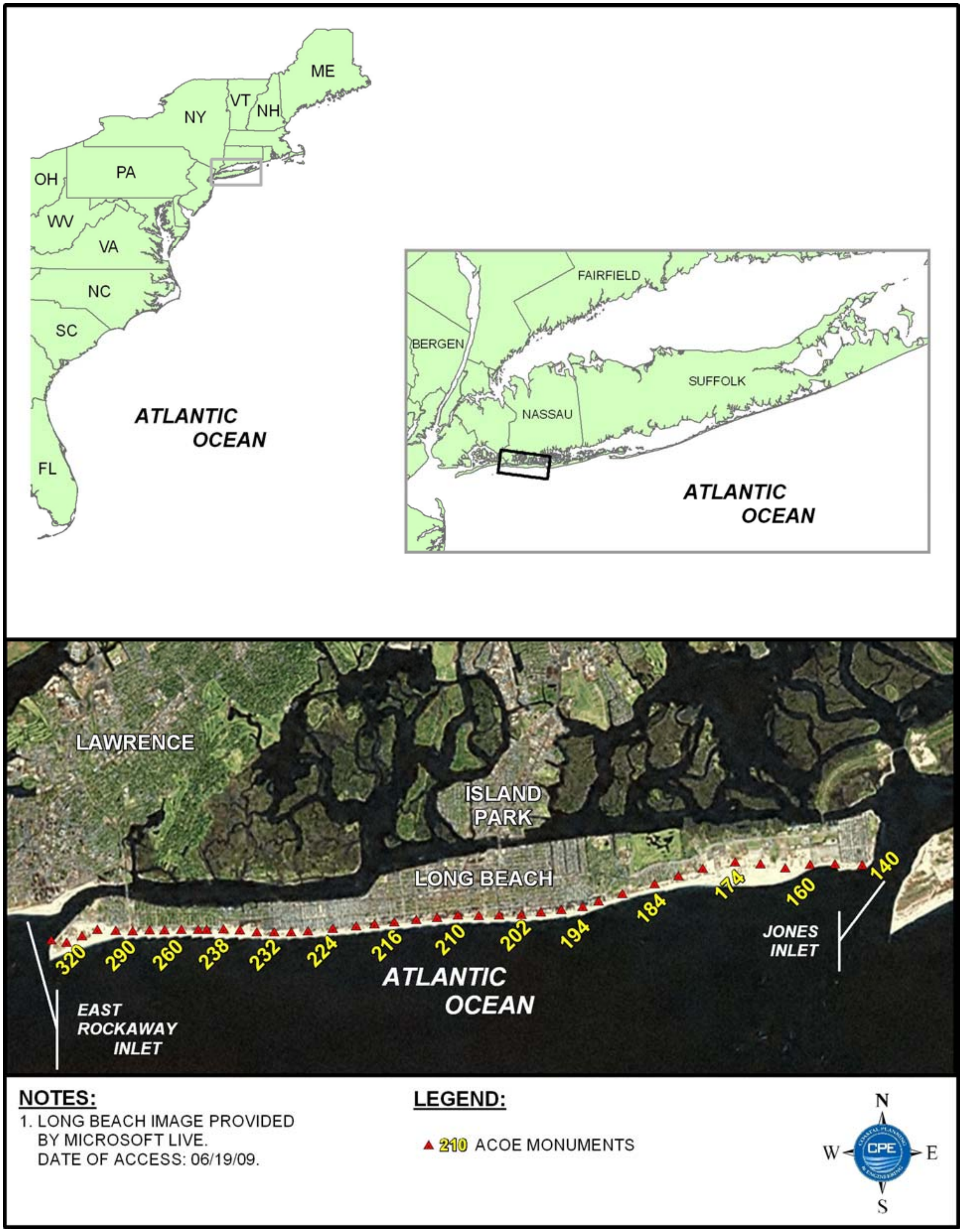

Figure 1. Location Map

The Federal project area is located on the south shore of Long Beach Island between Jones Inlet and East Rockaway Inlet, and consists of approximately 9 miles of oceanfront. The area has experienced major flooding during storms, causing damage to structures located along the barrier island. Damaging storms have occurred in 1938, 1950, 1953, 1960, 1962, 1984, 1985, 1991 and 1992. In response to these storm events and the potential for future damages, the U.S. Army Corps of Engineers, New York District, has conducted several planning studies at the request of local municipalities to determine the feasibility of coastal protection measures. These studies are summarized in the following sections.

Island Migration and Development

Long Beach Island is a relatively young geological feature, which owes its origins to coastal processes during the gradual worldwide rise in sea level since the last ice age. The barrier islands are landforms built up over the past several thousand years by sand transported westward along the south shore of Long Island by wave-generated longshore currents. This chain of sandy barrier islands extends from the western end of Long Island eastward to Southampton and is presently broken in continuity by six tidal inlets. Long Beach Island lies between two of these inlets, East Rockaway Inlet to the west and Jones Inlet to the east (USACE, 2006).

The City of Long Beach is by far the largest, oldest, and most established community on Long Beach Island. Founded in 1880 when the first Long Beach Hotel was built, it continued to grow at a steady pace. The City of Long Beach currently has a population of about 35,000 with about 15,000 households spread across two square miles of land surrounded by water. Along the beach on the oceanfront, there is a 2.25 mile long boardwalk. Adjacent to the boardwalk area is a 3.5 mile stretch of sandy beach open to the public year round (http://www.longbeachny.org, 2009).

Reynolds Channel Dredging and Disposal

Reynolds Channel is located between Long Beach Island and the mainland of Long Island, between East Rockaway and Point Lookout, in the Town of Hempstead. The channel is 8.9 miles long and varies in depth from 10 to 70 feet below Mean Low Water (MLW) (USACE, 1995). A 1995 USACE Reconnaissance Report ("Shallow Draft Navigation Reconnaissance Study – Reynolds Channel and New York State Boat Channel, New York") recommended proceeding to a Feasibility Study to address shoaling problems in Reynolds Channel. However, the local sponsors did not have the funding required and the study was never performed.

The State of New York periodically dredges the channel in problem spots where shoaling occurs and impacts navigation. The dredged material is placed in subaqueous "deep holes" nearby in the bay or in Reynolds Channel (USACE, 1995). The channel is roughly 200 feet wide in the western bay, where the deeper depths are found, and varies from 100-150 feet wide in the eastern section (USACE, 1989).

Groin Construction

Between 1930 and 1961, the seaside communities of Lido Beach, Point Lookout, Atlantic Beach and Long Beach, and the State of New York built a total of 50 rubblemound/timber groins to promote shoreline accretion and 2 jetties to stabilize the adjacent inlets. There are currently 23 groins in the City of Long Beach, which were constructed in the 1930's (USACE, 2006). At the east end of the island, there are two additional groins adjacent to the Jones Inlet jetty fronting the community of Point Lookout.

The groin field is fairly uniform, with spacing between groins varying from 600 to 800 feet. The groins begin approximately 4,600 feet east of the East Rockaway Inlet Jetty and extend eastward approximately 31,000 feet to roughly the eastern boundary of the City of Long Beach. The groins are between 500 and 600 feet long with crest widths ranging from 5 to 12 feet and landward elevations ranging from 7 to 10 feet above Mean Sea Level (MSL). Most of the groins are constructed of timber and stone, which have deteriorated over time. Some are considered to be in poor condition. Many of these groins have been turned to the east at the seaward ends and in need of moderate to significant repair (USACE, 1998).

III. OVERVIEW OF CORPS OF ENGINEERS STUDIES

The U.S. Army Corps of Engineers, New York District, has conducted several planning studies for Long Beach Island. These studies were initiated at the request of local municipalities to determine the feasibility of coastal protection measures for the south shore of Long Beach Island and are summarized below.

1965 Beach Erosion Control Study

In 1965, the New York District of U.S. Army Corps of Engineers prepared a draft survey report addressing storm damage protection for Long Beach, NY. The study was conducted in part as a response to the March 1962, "Five High" nor'easter. This storm extended over five consecutive high tides and caused severe erosion, wave attack, and inundation with the ocean meeting the bay in at least one location. The storm caused approximately $20 million in damages based on October 1992 price levels (1996 Feasibility Study).

The report entitled "Beach Erosion Control and Interim Hurricane Study for the Atlantic Coast of Long Island, NY, Jones Inlet to East Rockaway Inlet" was prepared to determine the best method to ensure continued stability of the beach, and to develop an adequate plan of protection against storm surge and tidal inundation of the barrier island. The plan was developed to provide protection during a hurricane surge level of 12.3 feet above sea level, which was representative of a 100 year storm.

The recommended plan resulting from the 1965 study included hurricane barriers, closure levees, an oceanfront dune with protective beach berm, groin reconstruction, construction of a terminal groin at Jones Inlet and periodic beach nourishment. The plan was deemed to be economically justified, but did not receive sufficient support at the time to move forward. The primary objection was that the proposed dune along the oceanfront was not compatible with the type of development on the barrier island of Long Beach. In a letter dated July 21, 1971, the Corps of Engineers, New York District, notified the New York Department of Environmental Conservation (DEC) that the study was to be terminated and the local interests concurred.

1989 Reconnaissance Study

In response to Hurricane Gloria in 1985, a resolution was authorized in 1986 allocating Federal funds to conduct a reconnaissance study of the Long Beach Island project area. The reconnaissance report, entitled "Atlantic Coast of Long Island, Jones Inlet to East Rockaway Inlet, Long Beach Island, New York", dated March 1989, was approved by the Office of the Chief Engineers (OCE) in July 1989.

The reconnaissance report indicated that a 110-foot wide beach at an elevation of +10 feet NGVD, backed by a dune system to elevation +15 ft NGVD with suitable advance and continuing nourishment would be an implementable design. The plan included rehabilitation of 30 groins and the reconstruction of the terminal groin at the eastern end of the island. This analysis estimated a first cost of $53.2 million (October 1988 price levels), with a resulting benefit to cost ratio of 1.74. These findings indicated that there was Federal interest in protecting the barrier island of Long Beach from storm damage, and the reconnaissance report recommended that the necessary planning and engineering studies proceed to develop a cost shared feasibility study.

1998 Feasibility Study

State and local government officials concurred with the recommendations of the Reconnaissance study and proceeded to sign a Feasibility Cost Sharing Agreement in September 1990. With the receipt of non-Federal and matching Federal funds, the Feasibility Study was initiated in May 1991. The resulting Feasibility Report was completed in March 1998. The recommended plan was also identified as the National Economic Development (NED) plan, which defines the maximum Federal contribution.

The recommended plan in the Feasibility Report provided protection against a 100-year storm event for 7 of the 9 miles of public shoreline between Jones Inlet and East Rockaway Inlet, including the communities of Point Lookout, Lido Beach, the City of Long Beach, and East Atlantic Beach. The plan included the construction of a 110 foot wide protective berm at an elevation of +10 feet NGVD backed by a 25 foot wide dune system at an elevation of +15 feet NGVD. Approximately 8.64 million cubic yards of fill would be required initially for the 41,000 ft project length, with periodic re-nourishment of about 2.1 million cubic yards on a 5 year cycle for a period of 50 years. The project also included the rehabilitation of 16 existing groins in the City of Long Beach and the construction of 6 new groins at the eastern end of the island.

Subsequent to completion of this study, local residents and officials expressed concern that the proposed new groin field adjacent to Jones Inlet would induce greater erosion west (downdrift) of the last groin. This was thought to potentially increase vulnerability of Lido Beach and West Lido Beach to storm damages, especially since the area experiences seasonal changes in beach width and elevation. Concern was also expressed that the recommended plan would leave about 7,000 feet of shoreline between the new groin field and the City of Long Beach without groins, and therefore more vulnerable. In March, 2000, as part of Preconstruction Engineering and Design (PED), a study was conducted to reassess the effects of the proposed groin field on adjacent shorelines, which recommended an extension and modification of the groin field to address these concerns.

In addition, the community of East Atlantic Beach withdrew from participation in the project, citing concerns about public access requirements tied to Federal funding. There was also concern expressed about the creation of vegetated dunes immediately seaward of the boardwalk in the City of Long Beach. City of Long Beach officials and citizens expressed concern that this would restrict beach access, reduce the available area for beach recreation, impact aesthetics, and result in a fill footprint that extended too far offshore, partially burying the existing groins and negatively impacting surfing and other recreational activities. To address these changes and concerns, a re-analysis was proposed by the Corps and the State, using more recent and comprehensive data and improved numerical modeling tools to update the existing conditions and reformulate the project.

1993 Jones Inlet Study

A separate but related study of Jones Inlet was conducted by the Corps concurrent with the 1998 Feasibility Study. This study was conducted under the authority of Section 933 of the Water Resources Development Act (WRDA) of 1986, which allows the Corps to participate in beneficial re-use of dredged material for shore protection purposes. The report titled "Section 933 Evaluation Report, Jones Inlet, New York" (March 1993) connected placement of dredged material from Jones Inlet with the storm damage reduction potential for the eastern end of the island at Point Lookout. This evaluation report determined that although it is not the least cost disposal method, it is justified to place material dredged from Jones Inlet onto the adjacent beaches based on the benefits derived from storm damage protection. The report was approved by the Headquarters of the Army Corps of Engineers (HQUSACE) in August 1993.

Based upon the findings of the Section 933 Evaluation Report, the incremental cost of placing the dredged material from Jones Inlet onto the adjacent beaches in the Town of Hempstead (instead of offshore) was cost-shared 50% Federal and 50% non-Federal. In March 1994, Jones Inlet was dredged and approximately 459,000 cy of material was placed onto Civic Beach, Middle Beach and Point Lookout Town Park, which are located on the eastern end of the Long Beach Island. Though the Corps report recommended dredging Jones Inlet every four to five years, it was not until 2008 that the channel was dredged again, primarily due to funding issues.

While maintaining navigational channels such as Jones Inlet is traditionally the responsibility of the federal government, New York State took the action of funding the 2008 project to ensure the project was expedited. The State funded the project by contributing $7.6M in FY07 to the Corps via a Contributed Funds Memorandum of Agreement. The funds were used to dredge approximately 650,000 cubic yards of shoals in the federal channel and deposition basin, with placement of the dredged sand on the same beaches as the 1994 dredging. Dredging began on January 13, 2008 and was completed on March 3, 2008. Table 1 summarizes historical records of Jones Inlet dredging obtained from the Construction-Operations section of the N.Y. District, USACE.

Table 1. 1982 to 2008 Jones Inlet Dredging

Summary of Jones Inlet Dredging, 1982 - 2008		
Year	**Total Vol (CY)**	**Disposal**
1982	216,000	Pt. Lookout
1985	266,000	Pt. Lookout
1987	503,000	Offshore
1995	459,000	Pt. Lookout
2008	650,000	Pt. Lookout

1999 Terminal Groin Rehabilitation Study

In February 1999, a report entitled "Terminal Groin Rehabilitation and Extension at Jones Inlet, Long Beach Island" was completed by the Corps. The study recommended the rehabilitation and extension of the terminal groin at Point Lookout to reduce the loss of sand from the beach and reduce shoaling in Jones Inlet. The recommendations were adopted as part of the 2006 Limited Re-Evaluation Report described below.

2006 Limited Re-Evaluation Report (LRR)

In February 2006, a Limited Re-Evaluation Report "Long Beach Island, New York, Storm Damage Reduction Project, Limited Re-Evaluation Report, February 2006" was completed by the Corps of Engineers. The study was developed to present and analyze the changes in site conditions that had occurred since completion of the Feasibility Study in 1995. The report addressed many of the concerns expressed by local residents and officials outlined above, and modified the plan recommended in the 1998 Feasibility Report.

As a result of the withdrawal of East Atlantic Beach, the dune length was shortened by about 7,000 feet and the beach fill by about 5,500 feet. To address concerns about the impacts of dunes fronting the boardwalk, the 11,200 foot section of dune proposed at the Long Beach boardwalk section was shifted 85 feet landward to an alignment underneath the boardwalk in the form of a sand barrier of similar geometry as the dune structure. The entire beach fill was also shifted landward with the dune structure to maintain the design berm width, which partially addressed concerns about the fill profile extending too far offshore and burying the groins. The revised alignment would maintain the design level of protection, preserve full ocean views from the boardwalk, and reduce the seaward extent of the beach fill footprint. The rehabilitation of approximately 700 feet of revetment along the western shore of Jones Inlet was eliminated from the recommended plan at this time because it had already been completed by local interests.

The overall project footprint was reduced in the LRR and several structural features (vehicle access ramps, dune walkovers) were eliminated. As a result, the proposed modification significantly reduced the area and the amount of fill placement. The amount of fill material required for the project was reduced by 2,042,000 cubic yards (cy), and the amount of fill material needed for 5 year renourishment activities was decreased by 385,000 cy per year (Table

2). Specifically, 170 fewer acres of beach area would be filled: approximately 104 in the upper beach zone, 35 in the intertidal zone, and 31 in the sub-tidal zone.

Table 2. Summary of Changes in 2006 LRR

Study	Total Fill (CY)	5-Yr Maintenance Renourishment (CY)	Length of Fill (ft)	Groins Rehab.	New Groins	Dune Vegetation (ac)
1998 Feasibility	8,642,000	2,111,000	41,000	16	6 @ 1200'	24
2006 LRR	6,600,000	1,746,200	34,000	17	4 @ 800' + 3 @ 1200'	12

Surfability Study

A study of surfing activity and potential impacts to surfing areas was also conducted as part of the 2006 LRR, and was included as "*Appendix F: Surfability of Long Beach and the Atlantic Coast of New York*". The study provided a basic description of what conditions are needed to produce good surfing waves and where these conditions occur within the study area. Potential impacts of the LRR proposed project on surfing opportunities were reviewed along with a discussion on the need for coordination with the surfing community to develop plans they can support.

Of primary concern was the possible effect on surfing that is enhanced by the existing groins and the favorable bottom conditions in proximity to and within the groin compartments. These spots are popular in nearly all types of wave conditions, from relatively small daily waves up to storm-generated swell. Popular surfing spots at Lafayette, Laurelton, and Lincoln Boulevards were identified in the study and are known to fall into this category.

As a result of partial burial of the groins that would occur under the 2006 Recommended Plan, there was concern for potential negative impacts to surfability in the City of Long Beach. The burial of the structures by beach fill would also result in burial of the surf break, which would take some time to adjust back to the pre-project conditions. Some of these factors also impact other beach recreational activities since the adjustment of the constructed beach profile can result in temporary profile shapes that differ from the pre-project conditions. These effects are usually short-lived and related to storm events, ending when the beach profile reaches equilibrium. The equilibrium process usually takes about six to twelve months, but could be accelerated by wave action depending upon the frequency and strength of storms that occur following sand placement. However, the equilibrium shoreline will most certainly be seaward of the pre-project condition due to the addition of sand.

The LRR included design features to address some of these concerns. For example, the berm fill profile was designed to have the same slope as the natural beach profile in order to facilitate the equilibration process and reduce the potential for scarping. Moving the dune structure under the boardwalk also allowed for a landward shift of the berm fill and reduced burial of the existing groins. Although this would likely reduce the negative impacts on surfing in these areas, adding sand to the system would still have some affect unless the groins were also extended. Other concerns voiced by the surfing community included potential loss of habitat when existing structures are altered or covered, and negative impacts on local businesses (surf shops, restaurants) if the surfability of the area is diminished.

The study included many suggestions regarding how the surfing community can be kept better informed on both the need for shore protection and the rationale for the formulation and analysis of alternatives. The study recognizes that this formulation can be enhanced by including input from the surfing community. Suggestions included: closer coordination using an objective liaison who understands the surfing community, additional numerical and physical modeling to predict impacts on wave breaking, and an interactive approach to demonstrate how planned project components or enhancements would not adversely affect surfing conditions or could create new or improved surfing areas. Enhancements discussed in the study included:

1) Installation of artificial reefs that would create local areas of improved surf as well as areas of habitat.

2) Extension of some of the groins to translate and preserve areas where surf is enhanced by the presence of the structures.

3) Strategic placement of beach fill material that is most similar to the native sand in specified selected groin compartments to preserve the shore-break of the existing beach.

A monitoring program was also suggested that would provide data for verifying conditions when surfing waves occur at sites of interest, and later to verify that project components have not adversely affected surf conditions. The local surfing community has recommended that web cameras be used for monitoring on a real time basis. There are at least two web cameras currently operating on Long Beach Island for surf reporting, which could be utilized as part of the monitoring program. The local surfing community has also recommended that wave gauges be used as part of the project monitoring. This information could be used to monitor surfing conditions to determine if the project had any beneficial or adverse changes to surfability.

IV. CITY OF LONG BEACH INTERESTS

The Recommended Plan in the 2006 Limited Re-Evaluation Report was authorized for construction, but was not fully supported by the City of Long Beach. While supporting key elements of the Corps Recommended Plan, the City formally withdrew their support for the beach fill component for specific reasons, which were summarized in a letter dated April 24, 2006 from the Planning Advisory Board (PAB) to the City Manager. The primary concerns were related to the beach fill component of the project, extending beach fill into the swimming zone, and the quality of the borrow area sand.

The City suggested that careful scheduling of the project components may eliminate the need for the beach fill portion. The NY State Department of Environmental Conservation (NYSDEC) was concerned that the westward beaches, which may not be nourished for at least 2 years after the project starts, will be starved without any supplemental beach fill. The City’s goal was to avoid the beach fill component if it could be proved that there is adequate sand on westward beaches.

The PAB strongly supported other elements of the LPP, and recommended that the beach fill be negotiated with additional information. The City Council would need to review sediment core samples from the borrow area. The inclusion of a professional consultant to assist the City in the negotiations was also recommended.

The City contracted Coastal Planning & Engineering, Inc. (CPE) to assist in negotiations regarding the federal program and to provide guidance on implementing an acceptable federal plan, which is the objective of this report. There is evidence that the City's beach is moderately stable due to the trapping of sand by the groin field over the long term and some indication that the Corps proposed template can be structured as a dry beach fill. The dry beach fill concept would avoid placing sand in the water in order to address some of the City's concerns.

It has also become apparent through meetings with the City staff that the residents favor the dimensions and sand characteristics of the existing beach. There are additional concerns that the proposed dune construction would inhibit oceanfront views and become a maintenance issue for the boardwalk. However, there is also a high risk of oceanside flooding during major storm events and a concern for increasing sea level rise. The City recognizes the need for a project and supports implementing some form of the proposed federal plan to address their concerns and achieve the needed level of storm protection.

V. REVIEW OF EXISTING DATA

An examination of existing data was performed to assess the coastal processes within and around the City of Long Beach. The data was collected from historic shoreline maps, beach profile surveys, GIS based shoreline location data, aerial and satellite photography, previous Corps studies, and anecdotal evidence/observations. The Corps studies have been reviewed in detail and are summarized in this section.

Corps Historic Shorelines Map

A historic shoreline map produced by the Corps was obtained from the City records and reviewed in the context of island development. The map was reviewed as a large format plan sheet drawing that covers the period from 1835 through 1990. Most of the early shoreline variation occurs around the inlets between 1835 and 1933. The installation of jetty structures at East Rockaway Inlet in 1933 and Jones Inlet in 1945 appears to have stabilized the earlier shoreline variability.

Since 1945, the historic shoreline map shows accretion at East Rockaway Inlet. The accretional zone extends for approximately 12,000 feet eastward along Atlantic Beach to approximately Vernon Ave. Minor variations are seen in the central portion of the study area within the City of Long Beach, but these changes are within the range of seasonal variation and are not considered significant.

Closer to Jones Inlet, accretion since 1945 was also observed along approximately 1 mile of shoreline roughly fronting the community of Lido Beach. Between this point and Jones Inlet, a highly erosional area was observed along the shoreline of the communities of Hempstead Beach and Point Lookout, with retreat ranging up to 500 feet.

Aerial Photography

Aerial photographs of the study area were used for comparison of recent beach width changes. The first set includes the beach from Jones Inlet west to roughly Putnam Blvd in East Atlantic Beach taken on April 15, 2003. The maps were obtained from City records as large-format plan sheets (1”=600’) prepared by the Corps of Engineers. Previous aerial photographs were not utilized for determining shoreline position because of the uncertainty of the time of the photograph and the corresponding tide level. In addition, the shoreline can vary by 100 feet or more on a seasonal basis in response to differing wave conditions between summer and winter.

An indication of short term shoreline stability can be inferred from an examination of the recent aerial photographs. The 2003 aerials were compared with a later set taken in 2007, which show beach widths ranging from 250 to 350 feet (boardwalk to shoreline) in the City of Long Beach. These beach widths are comparable to the observed conditions in the 2003 aerial photographs indicating overall stability. The 2007 aerials are shown on the shoreline change maps in Appendix A.

LIDAR Analysis

LIDAR (Light Detection and Ranging) is an optical remote surveying technology that measures properties of scattered light to determine distance to an object or surface though laser pulses. Since LIDAR is conducted by airplane, the survey results in a wide swath of high density topographic data. These types of surveys are commonly performed in coastal areas by the U.S. Army Corps of Engineers (Corps). The most recent Corps LIDAR survey for the Long Beach area was flown from October 1, 2005 to November 26, 2005 and covers the southern half of the island along the oceanfront shoreline.

The LIDAR data was used as a method of obtaining ground elevations in the City of Long Beach and was filtered to remove buildings and other structures that can interfere with the actual land elevation. The resulting data is provided in Appendix B and shows the elevations of the southern portion of the island. Generally, elevations are slightly higher along the oceanside beachfront, and decrease moving north across the island. Elevations of the beach berm are on average between +7.0 to +8.5 ft NGVD. The bayside has generally low land elevations of approximately +5.0 to +6.0 ft NGVD, but can range from +4.5 to +7.5 ft NGVD. The street elevations are typically lower than the adjacent land.

The data suggests that many of the oceanfront buildings, along with the boardwalk itself, are located where the natural dune system would exist had the structures not been built. This is evidenced by a stretch of vegetated dune located at the east and west end of the boardwalk that has not been built on. The eastern dunes have an average crest elevation of about +18.0 ft NGVD with a range from about +14.0 to +22.0 ft NGVD. The western dunes have an average crest elevation of about +17.0 ft NGVD with a range from about +15.0 to +19.0 ft NGVD. Two patches of undeveloped land were observed in the central portion of the City beachfront, located landward of the boardwalk with similar elevations to the adjacent dunes. Other areas of the boardwalk are backed by urban development, and although some sand appears to have built up beneath the boardwalk, the elevation is insufficient for storm protection. This low elevation in the boardwalk area provides a direct flooding pathway through the oceanfront street ends into the City of Long Beach.

FEMA Flood Maps

The 100-year and 500-year storm events are used by FEMA to determine base flood elevations and the level of protection at island locations. The approved FEMA Flood Insurance Rate Maps (FIRMs) for Nassau County that were available at the time of this study are dated April 2, 1997. Since then, FEMA has updated the FIRMs, which were only recently made available online in September 2009. However, the City of Long Beach has obtained hardcopies of the 2009 FIRMs for future reference.

The flood maps were reviewed to determine the risk areas within the City of Long Beach. FEMA's risk assessment in developing the maps was based on several factors, including velocity of water, terrain, size of watershed, volume of water, ground cover, topography, and tides. The base flood elevations computed in 1997 show that the majority of the City of Long Beach was already at risk for storm surge flooding during a 100-year storm event, while the entire island was at risk from the 500-year storm. The 2009 FIRM updates now depict the entire City within the 100-year flood zone, with the exception of a limited number of small zones of higher ground.

The expanded flood zone area from 1997 to 2009 is an indication of FEMA's recognition that the entire City of Long Beach is now at high risk from flooding of a 100-year storm event. Along the City's oceanfront, the 2009 maps indicate that the 100-year flood elevation varies between +15.0 ft and +18.0 ft (NAVD). The implication relative to this study is that the combined effect of storm surge and wave action has the potential to create water levels that exceed +15.0 ft-NAVD, which is equal to +16.1 ft-NGVD. Therefore, in addition to raising the elevation of the beach berm to address moderate storm conditions, a higher level of protection is need at the back of the beach to combat major storms. Considering that the existing boardwalk is at elevation +17 ft NGVD, implementing a flood protection measure to at least this elevation would greatly reduce the risk of oceanside flooding due to 100-year storm events.

Sea Level Rise

Sea level rise is the phenomenon by which the average water level of the world's oceans is rising over time due to a combination of man-induced and natural causes. While there is widespread agreement that global sea level is rising, the magnitudes of the predictions vary and are site specific. NOAA (National Oceanic and Atmospheric Administration) maintains two tide gages near the project area, approximately 15 miles away: Sandy Hook, NJ and The Battery, NY. The sea level rise at Sandy Hook is 0.013 ft/yr and at The Battery is 0.009 ft/yr. Tanski (2007) generally adopts the sea level trends from The Battery tide gage and approximates the sea level rise value of 1 ft/century, or 0.01 ft/yr, for Long Island coastal waters.

Rising sea level has major implications on planning for long term storm protection. For the purpose of this study, the sea level rise value for Long Beach follows Tanski's (2007) estimate of 0.01 ft/yr, which is the approximate average of the predictions of nearby tide gauges. However, a recent study on the review of sea level rise estimates by the end of the 21st century (Fletcher, 2009) has pointed out that recent IPCC projections do not include the potential effect of ice calving (melting glacial ice-sheets), which is also true for historic rates. Pointing to a previous study by Pfeffer *et. al.* (2008), Fletcher (2009) suggests that global sea level may rise between 0.8 m (2.6 ft) and 2.0 m (6.6 ft), favoring the lower end of this range by 2100. Although it is also noted that there are site specific factors that govern the local rate of rise, storm protection planning should consider the potential for acceleration of sea level rise due to global factors such as melting glacial ice sheets.

VI. U.S. ARMY CORPS EROSION ANALYSIS

The Corps' shoreline change estimates developed in the 2006 LRR are based on calculations and assumptions originally presented in the 1989 Reconnaissance Report. In that study, beach profile surveys performed in 1963 and 1988 were utilized for analysis. The results of the Corps analysis are described in this section.

The surveys utilized in the Corps studies were performed at reference locations set up along the coastline. Each profile station is called out by a reference number beginning with station 140 adjacent to Jones Inlet at approximately Hewlett Avenue, and ending with station 340 adjacent to East Rockaway Inlet at approximately the western terminus of Ocean Blvd (refer to Figure 1). The spacing of the profiles is uneven in some areas, but averages about 2,400 feet per ten stations (e.g., station 210 to 220). Denser spacing appears to have been used in the City of Long Beach.

In the 1989 Reconnaissance Study, the shoreline was divided into 10 reaches by the Corps based on four criteria: municipal boundaries, coastal protection features, critical erosion zones, and economic development zones. The reaches are numbered from west to east, while the profiles discussed above are numbered from east to west. Table 3 provides the location of the reaches and profile stations, along with the recession rates estimated in the Reconnaissance Study. It is to be noted that the shoreline change rates in Table 3 can be viewed as volumetric changes with a conversion of one cubic yard (cy) per linear foot of beach equal to one foot of shoreline recession. This conversion is based on an estimated depth of closure of approximately -20 ft NGVD and berm height of +7 ft NGVD.

To compute the shoreline change rates for the City of Long Beach, the Reconnaissance Report combined Reaches 3 through 7 (represented by beach profiles 200 through 270). In the report, the average long term recession rate for the City of Long Beach and Eastern Atlantic Beach is concluded to be a loss of 4 feet per year (Table 3). The report also notes that the rates are higher in the eastern study area and gradually diminish westward. In order to gain further insight into the changes specifically within the City of Long Beach, the data from that report was reviewed in this report at each profile as shown in Table 4.

Table 3. 1963 to 1988 Shoreline Recession by Reach (USACE, 1989)

Profile Stations	Reach Number	Approximate Location	Long Term Change Rate (Ft/Yr)
140 - 192	8 to 10	Point Lookout and Lido Beach	-5
192 - 230	5 to 7	Long Beach	-4
230 - 280	3 to 4	Eastern Atlantic Beach	-4
280 - 310	2	Central Western Atlantic Beach	-2
310 -340	1	Western Atlantic Beach	0

Data Source: 1989 Reconnaissance Report (USACE).

Table 4. 1963 to 1988 Changes by Profile within City of Long Beach (USACE, 1989)

Station	Street Location (approx.)	Net Profile Change (CY/FT)	Shoreline Length Represented by Profile	Total Volume Change (CY)	Annual Volume Change Rate (CY/YR)	Annual Shoreline Change Rate (FT/YR)
200	Franklin Blvd	13.0	5,300	68,900	2,756	0.5
210	National Blvd	106.8	4,900	523,320	20,933	4.3
220	Grand Blvd	-60.7	5,000	-303,500	-12,140	-2.4
230	Nevada Ave	-125.9	3,000	-377,700	-15,108	-5.0
OVERALL			**18,200**		**-3,559**	**-0.2**

Data Source: Table A2 of the 1989 Reconnaissance Report (USACE).

The Corps Reconnaissance and Feasibility reports estimated an overall erosion rate for entire barrier island as a loss of 195,000 cubic yards per year. The net erosion calculated within the City of Long Beach between 1963 and 1988 was 3,559 cubic yards per year (Table 4). Considering that the Long Beach shoreline is over 18,000 feet, this equates to an average annual recession of about 0.2 feet per year. Profile 230 (Nevada Ave.) was the most erosional area and had an average annual recession of about 5 feet per year, but only represents about 16% of the Long Beach shoreline. Profile 220 at Grand Blvd. had an average annual loss of about 2.4 feet per year. The remaining two profiles (200 and 210) indicate accretion in the western half of Long Beach between 1963 and 1988.

Based on the analysis of individual profiles, it is unclear how the value of -4 feet/year was developed for the City of Long Beach by the Corps. Data from the adjacent community in Eastern Atlantic Beach may have been used in the analysis, although the report states that "station 240 was discarded due to possible error of datum." Therefore, it is possible that the use of data from profile 230 to represent profile 240 caused the erosion estimates to be higher for combined area of Long Beach and Eastern Atlantic Beach. In any case, the calculations were based on data that is over 20 years old, which no longer accurately represents the beach. Updated surveys would provide more information on the current conditions of the existing beach.

Lido Beach, Hempstead, and Pt. Lookout

Long term erosion in the eastern half of Long Beach Island is restricted to a 4,000-foot segment of shoreline adjacent to Jones Inlet, from approximately profile 140 to profile 170. The overall trend presented in the Reconnaissance Study estimated shoreline recession at about 5 feet per year adjacent to Jones Inlet and gradually dropping off to zero at a point a few thousand feet east of East Rockaway Inlet. A follow-up study entitled "*Technical Reanalysis of the Shoreline Stabilization Measures for the Eastern Portion of the Long Beach Island, New York Project*" was conducted by the Corps during Preconstruction Engineering and Design (PED) in 2000, and showed that most of the erosion was actually occurring in a 4,000 foot segment adjacent to Jones Inlet. A new groin field was proposed for this area, with deferred construction of three additional groins to the west if needed to address potential downdrift impacts causing erosion at Lido Beach.

A supplemental survey was also conducted by the Corps as part of the 2006 LRR to compare more recent beach profiles in this erosional area. It was observed that material placed on the section of shoreline adjacent to Jones Inlet lasted between 2 and 5 years before the shoreline receded to its pre-nourished state. It was also determined by the Corps that the short fill life of 2 years was based on an unusual period of high storm activity, and that much of the eroded material was actually deposited offshore, but still within the littoral cell. Based on these observations and analyses, the study concludes that the shoreline is receding at a rate of about 19.4 feet per year in the 4,000 foot section adjacent to Jones Inlet. The next 20,000 feet of shoreline to the west was shown to be eroding about 4 feet per year on average with a decreasing trend from east to west, tapering to near zero at the City of Long Beach boundary.

Overall, the results of the study and observations by local officials and Corps staff indicate that the placement of dredged material from Jones Inlet on this section of shoreline (profiles 150 to 170) lasts about 4 years. It was also determined by the Corps that most of this material migrates westward, attenuating, but not completely balancing, the estimated 4 feet per year recession of the adjacent shoreline for a distance up to 20,000 feet. Therefore, the placement of dredged material on the erosional hotspot in Point Lookout also acts as a feeder beach for the shoreline to the west.

City of Long Beach

The formulation of the recommended plan in the Reconnaissance and Feasibility Studies is based on an average erosion rate of 195,000 cubic yards per year for all of Long Beach Island. This may be appropriate for a project formulated for the whole of Long Beach Island, but potentially overestimates the erosion occurring within the City of Long Beach.

The Corps Feasibility Study indicated that between 1963 and 1988, the entire shoreline of the City of Long Beach fluctuated between a loss of 123 feet and a gain of 128 feet, with a net annual accretion of +1.2 cy/ft. In addition, the 2006 LRR re-assessed historic shoreline positions and erosion rates based on more recent survey data and improved numerical models. The updated analysis cites stabilization efforts, namely construction of jetties, groin fields, and seawalls, as well as periodic beach fill, having reduced the observed rates of accretion and erosion. However, the predicted erosion rates were increased for reasons defined as follows (USACE 2006, pg 11):

"Measured erosion rates from the 1963-1988 period were increased to account for several trends. First, it was assumed that the East Rockaway jetty will reach capacity early in the 50 year projection, and that impoundment in western Atlantic Beach will cease. Second, deterioration of groins will result in increased sediment movement. Third, sea level rise over a 50 year period will cause an increase in erosion rates for the entire shoreline. Additionally, the 1963-1988 time period contained relatively few severe storm events, indicating that greater losses of material are likely to occur in the future……Overall predicted losses for the Long Beach shoreline are estimated at 195,000 CY per year."

These statements seem to concur with anecdotal reports from City residents that the significant long term erosion has been limited to the area adjacent to Jones Inlet since the groins and jetties were installed. The reasons cited for an expected increase in erosion over the project life provide some justification for the projected erosion rate of 195,000 cubic yards per year. Although this value may be appropriate for plan formulation for the entire island, it potentially overestimates the erosion within the City of Long Beach. In addition, the volumetric calculations were based on relatively old surveys from 1963 and 1988. In order to assess the conditions of the existing beach, updated beach surveys are needed to determine the current volumetric needs of the project within the City of Long Beach.

VII. INDEPENDENT COASTAL PROCESSES ASSESSMENT

As part of this study, CPE performed an independent analysis of the available data over longer timescales and with more recent data than studied by the Corps. The results indicate that the shoreline of the City of Long Beach has been generally accretional since completion of the groin field in the late 1940's and relatively stable in recent years. The results of this independent analysis are described in this section.

Shoreline Change Analysis

The Mean High Water (MHW) location measured at each profile line is used to determine shoreline location at the time of each survey. Shoreline position shape files showing the MHW line for 1947, 1974, and 1999 were obtained from the NOAA National Ocean Service, Coastal Services Center. The 1974 data covers only the western half of the island, but the 1947 and 1999 data span the entire length. Maps of the shorelines overlain on the 2007 aerial image are provided in Appendix A for reference.

An examination of the shoreline data reveals that Long Beach Island has been predominately accretional over the long term. The installation of groins along the island has been highly effective in trapping sand from the longshore drift. Overall, the island has gained 4.9 feet per year between 1947 and 1999 as shown in Table 5.

The shoreline changes used to calculate the averages for each community shown in Table 5 are displayed in Figure 2. Within the City of Long Beach, the shoreline has advanced seaward between 20 feet and 320 feet during this timeframe. The average gain in beach width has been 2.9 feet per year, indicating a long term accretion of the beach.

The downdrift areas in Atlantic Beach also exhibit a long term trend of accretion. The only area that exhibited erosion during this timeframe is Point Lookout, which has lost 8.3 feet per year on average. This represents an erosional hotspot at Point Lookout related to the inlet. The rest of the island appears to be advancing over the long term and the large amount of accretion at the near Hempstead Beach is likely related to mechanical and natural bypassing across Jones Inlet.

Table 5. 1947 to 1999 Shoreline Changes

COMMUNITY	SHORELINE LENGTH (FT)	AVERAGE SHORELINE CHANGE (FT)	ANNUAL SHORELINE CHANGE (FT/YR)
Pt. Lookout	3,041	-433.6	-8.3
Hempstead	6,370	786.0	15.1
Lido Beach	6,111	218.5	4.2
Long Beach	18,411	152.5	2.9
Eastern Atlantic Bch	8,388	236.2	4.5
Central/Western Atl. Bch	3,043	289.2	5.6
Western Atlantic Bch	2,774	572.5	11.0
OVERALL	**48,138**	**253.7**	**4.9**

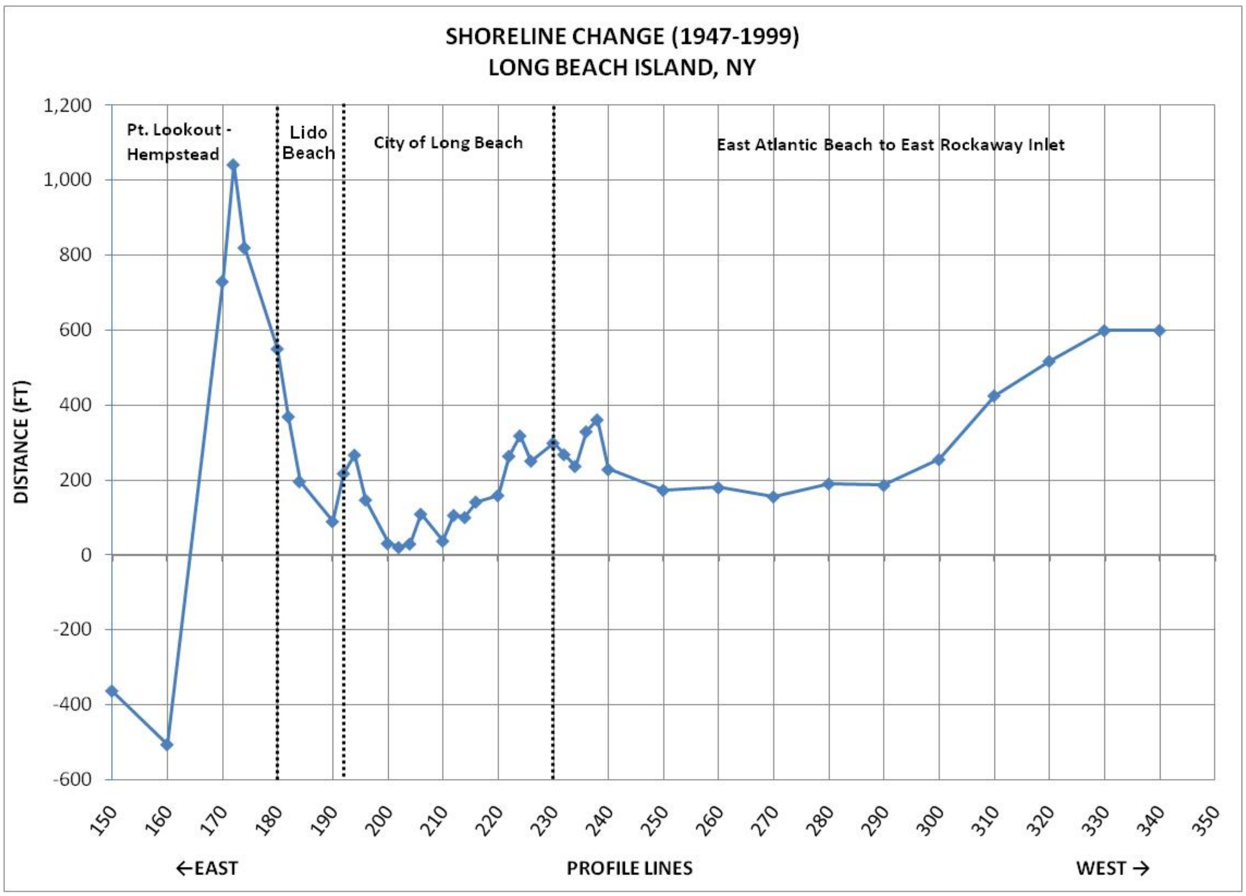

Figure 2. 1947 to 1999 Shoreline Changes

Volumetric Change Analysis

Volumetric changes discussed in this report represent the difference in the quantity of sediment measured through comparison of the 1947 and 1997 shorelines. The conversion of shoreline change to volume change is based on an estimated depth of closure of -20 ft NGVD and berm height of +7 ft NGVD, which represents the active profile of the beach. The depth of closure is defined as the seaward limit of the active changes in profile shape, but is recognized to vary with storm conditions, wave events, and geographic location. The berm height is representative of the average elevation of the dry beach.

Overall, the island has gained 234,657 cubic yards per year between 1947 and 1999 as shown in Table 6. The two profiles immediately west of Jones Inlet are likely sediment starved due to the effect of inlet stabilization with jetties. The sediment supply begins to deposit heavily at Hempstead Beach (profiles 170-180) and gradually decreases as it filters into Lido Beach, which is likely due to a combination of mechanical and natural bypassing. Volume changes in the City of Long Beach have been positive as well, gaining 53,714 cubic yards per year during this timeframe. Since these volume estimates are based on the shoreline changes, the trends are similar but informative for sediment transport analysis. The volume changes by profile line are shown in Figure 3.

Table 6. 1947 to 1999 Volume Changes

COMMUNITY	SHORELINE LENGTH (FT)	TOTAL VOLUME CHANGE (CY)	ANNUAL VOLUME CHANGE (CY/YR)
Pt. Lookout	3,041	-1,314,395	-25,277
Hempstead	6,370	4,955,240	95,293
Lido Beach	6,111	1,297,848	24,959
Long Beach	18,411	2,793,121	53,714
Eastern Atlantic Bch	8,388	2,003,217	38,523
Central/Western Atl. Bch	3,043	881,372	16,949
Western Atlantic Bch	2,774	1,585,772	30,496
OVERALL	**48,138**	**12,202,176**	**234,657**

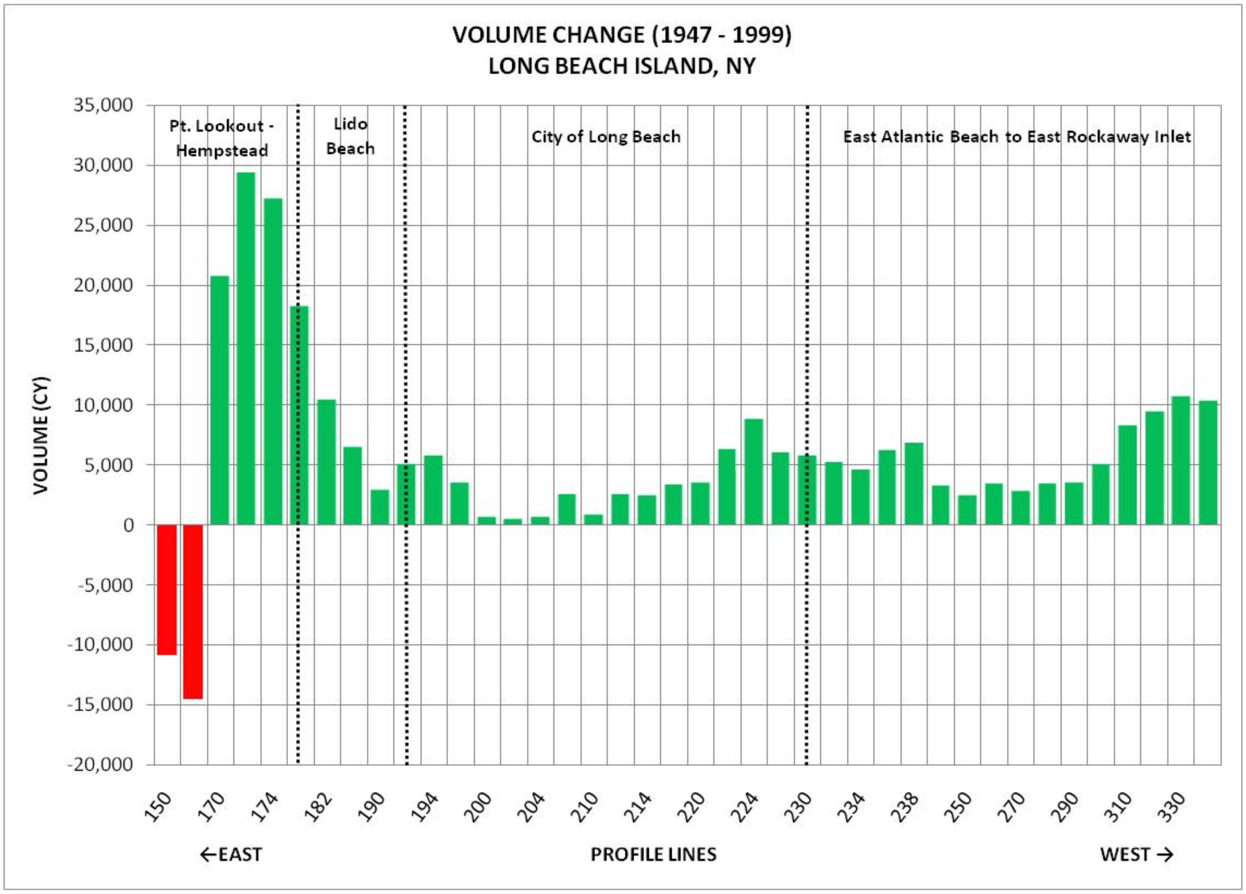

Figure 3. Volume change (1947-1999) at each profile line for Long Beach Island, NY

Historic Beach Nourishment

To determine if the long term stability of Long Beach is due to mechanical nourishment or natural processes alone, fill volumes placed on the island must be taken into account. Within the study area, Point Lookout, Hempstead Beach and Lido Beach have received beach nourishment on numerous occasions since the 1950's. A summary of these events is given in Table 7 (reproduced from Table 2-1 in Appendix B of the 2006 LRR). The total volume placed on Long Beach Island since 1956 is estimated to be 3,431,900 cubic yards, or about 66,000 cubic yards per year on average. This nourishment must be factored into the volumetric analysis to obtain a better estimate of the overall sediment budget and transport rates. There was an additional 731,000 cubic yards placed in offshore areas, which is assumed to be outside the active profile of the beach.

Table 7. 1956 to 2008 Sand Placement Events

Year	Hempstead / Point Lookout	Hempstead (Offshore)*	Lido Beach
1956			100,000
1962			40,000
1973	454,000		
1979		227,000	
1980	157,000		
1982	216,000		
1985	266,000		
1987		504,000	
1990	387,000		
1994	703,000		
1996	458,900		
2008	650,000		
Total 1956-2008	**3,291,900**	**731,000**	**140,000**

* Dredged sand was disposed offshore and not placed on the beach.

Littoral Transport Analysis

A 52-year littoral transport curve was developed for Long Beach Island based on volumetric changes from 1947 to 1999. The measured changes were annualized and plotted in a cumulative sense whereby the volume changes at each profile line are added or subtracted from the running total heading alongshore from east to west in the direction of littoral drift. The resulting cumulative volume changes and littoral transport curves are shown in Figure 4 and were used to track sediment migration along the island.

Figure 4 is an estimate of the net annual littoral transport along Long Beach Island. It is a cumulative plot of the measured volumetric changes adjusted for dredged sand placed on the beach as described above. The adjusted volume changes were annualized and summed alongshore to develop the littoral transport curve. The areas of the transport curve that show increasing slopes are erosional, whereas decreasing slopes are accretional, and flat slopes are stable areas. The starting point of the curve is based on longshore transport rates obtained from a report by New York Sea Grant titled “Long Island’s Dynamic South Shore” (Tanski, 2007).

The littoral transport curve suggests a decreasing sediment transport rate (accretion) to the west along the island’s beaches. The transport rate starts at about 620,000 cubic yards per year at Jones Inlet and decreases to about 450,000 cubic yards per year at the western terminus of the island at East Rockaway Inlet. The reduction in transport indicates a volumetric gain of approximately 170,000 cubic yards per year (adjusted for sand placed from dredging events). These rates match well with the values previously reported by Tanksi (2007), shown in Figure 5.

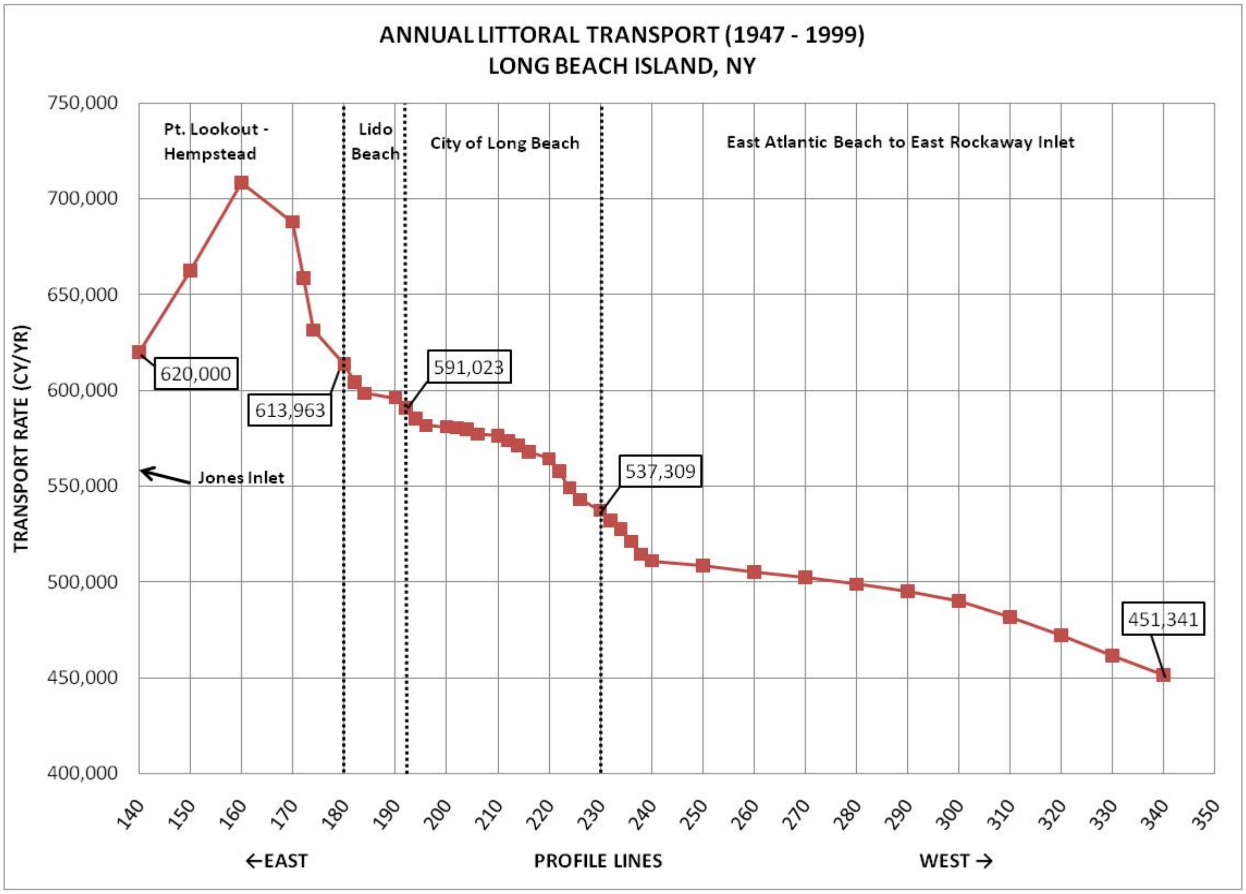

Figure 4. Long Beach Island Littoral Transport Curve (1947-1999)

Figure 5. South Shore of Long Island Sediment Transport Rates (Tanski, 2007)

Although there is some uncertainty in the factors that could influence the numbers at the beginning and ending points of littoral transport curve due to variability in the rates of sand movement at different times and places, the shape of the curve is most informative. Since the down slopes of the curve identify areas of accretion, the shape of the curve can be used identify rates of erosion or accretion in particular areas. Based on this concept, the curve shows the following:

- There is an erosional area immediately downdrift of Jones Inlet in Point Lookout, which is balanced by an accretional area through Hempstead Beach. The combined change results in a net gain of 6,000 cy/yr.
- Lido Beach appears to be relativly stable to accretional, gaining 22,900 cy/yr.
- The City of Long Beach exhibits long term accretion, gaining 53,700 cy/yr.
- Atlantic Beach is also long term accretional, gaining 86,000 cy/yr.

VIII. GEOTECHNICAL ASSESSMENT

In the 1965 *Long Beach Island Erosion Control and Hurricane Protection Report* (USACE, NYD), the Corps examined sediment boring logs of subsurface explorations in Reynolds Channel and Jones Inlet to determine the characteristics and potential volume of materials in the borrow areas. In addition, the 1989 Reconnaissance Report examined several historic borrow site investigation documents. In Appendix C of the 1989 report - "Borrow Area Investigations", the primary source of data on borrow material is cited as the ICONS report (*Geomorphology, Shallow Subbottom Structures, and Sediments of the Atlantic Inner Continental shelf off Long Island, New York, March, 1976, USACE, CERC Technical Paper No. 76-2*). For that report, 735 mile lines of high resolution sub-bottom profiling and 70 vibracores were collected and analyzed by Alpine Geophysical Associates.

Sand Search Investigation

Eight cores and boring logs from these two studies (two in Reynolds Channel and six offshore of the study area) were identified and analyzed further to assess potential borrow areas. The material from Reynolds Channel was determined to have a median grain size of 0.23 mm, but the high organic content and the impacts to sensitive back-bay habitat restricted its potential use. The Jones Inlet borrow site had a median grain size of 0.24 mm, and a potential volume of 4.5 million cubic yards. Analysis of the six samples taken at other offshore sites indicated a mean grain size of 0.32 mm, with a potential available volume of 250 million cubic yards. However, this average grain size represented a large area extending up to 10 miles offshore. In turn, further field investigations were conducted focusing in on the area within about one mile offshore from the study area. The characteristics of the identified sources are summarized in Table 8 below.

Table 8. Potential Sand Source Grain Size Characteristics (Corps, 1989)

Borrow Area Location	Potential Volume (CY)	Phi (16)	Phi (84)	Mean Size (mm)
Reynolds Channel	N/A	1.55	2.75	0.23
Jones Inlet	4.5 million	1.50	2.70	0.24
Offshore	250 million	1.05	2.25	0.32

Borrow Area Development

In 1991, the Corps contracted a geotechnical investigation of potential borrow areas for beach nourishment of the study area (*Final Report, Long Beach-Borrow Areas; Atlantic Coast of Long Island, Jones Inlet to East Rockaway Inlet, Long Beach Island, NY. January 1992*). Frederic R. Harris, Inc., subcontracted to Alpine Ocean Seismic Survey, Inc. for hydrographic and seismographic surveys, and additional vibracores. The study was completed in January 1992, and covered a rectangular area in the near offshore waters of Long Beach Island between the 25 foot and 60 foot (Mean Low Water, MLW) contours. Fifteen vibracores and 34,000 feet of seismic and bathymetric data were collected. A map of the core locations and summary table of sand characteristics, along with the vibracore photographs from Alpine's report, are provided in Appendix C.

In general, the bathymetry shows a gently sloping seafloor from 24 to 37 feet (below Mean Lower Low Water, MLLW) across the potential borrow areas. The sediments at the borrow site were characterized through a series of composite grain-size analyses and were determined to be predominantly fine sand with typically only trace amounts of silt. The vibracores all encountered a whitish gray sand layer for which the mean grain size ranged between 0.13 mm and 0.60 mm. The overall average median size was reported to be about 0.31 mm. This sand layer was found to range in thickness from about 4 feet to about 10 feet, covering most of the survey area. The identified offshore borrow area potentially contains approximately 36 million cubic yards of beach compatible fill material.

Beach Characteristics

As part of the investigations for the Reconnaissance Study, sediment grab samples were collected from the beach by the Corps in 1988. The samples were collected along ten profile lines at +8, 0, -8, -18 and -30 feet NGVD. Sand samples were described as tan to dark tan in color, with sizes ranging from very fine sand to coarse sand, with some shell fragments. Grain size distribution curves were then calculated based on composite beach samples for each profile line. Three overall composites were made by combining the individual profile composites to produce representative beach sand data for Lido Beach, Long Beach, and Atlantic Beach. The median grain sizes for the three typical beach models are 0.21 to 0.22 mm, which are classified as fine sand based on the Wentworth Classification. A summary of the data is shown in Table 9.

Table 9. Beach Sample Grain Size Characteristics (Corps, 1989)

Location	Phi (16)	Phi (84)	Mean Size (mm)
Atlantic Beach	1.38	2.75	0.22
Long Beach	1.31	3.03	0.22
Lido Beach	1.41	2.95	0.21

2009 Beach Samples

Beach samples were taken by CPE in January 2009 at three representative sites along the City of Long Beach. The samples were taken at a mid-berm location at Long Beach Blvd, Neptune Blvd, and Lindell Rd. A grain size analysis was performed on each sample as shown in Table 10.

Table 10. January 2009 Beach Sand Samples (CPE)

Location (mid-berm)	Phi (16)	Phi (84)	Mean Size (mm)
Neptune Blvd	1.54	2.35	0.27
Long Beach Blvd	1.58	2.42	0.26
Lindell Rd	1.56	2.38	0.26

Within the City of Long Beach, the beach berm samples taken in 2009 are coarser than the profile samples taken by the Corps in 1988. The mean grain size of the beach berm samples is on average 0.04 to 0.05 mm larger than the mean grain size of the profile average (from +8 to -30 MLW) computed by the Corps. This is an expected result since berm samples are generally coarser than the entire cross-shore profile average due to sand grains generally becoming finer further down the beach profile (underwater) due to wave action.

The berm samples represent the dry beach where the public most often perceive the “feel” of the sand. It is noted that these berm samples exhibit a grain size (0.26 mm) that is closer to the mean grain size of the identified offshore borrow area (0.31 mm) than the averaged profile results reported in the Corps engineering documents (0.22 mm).

Compatibility Analysis

In the March 1998 Feasibility Study, analyses were performed by the Corps to compare offshore borrow material with the beach material to determine compatibility. The offshore sand source was identified as the most feasible based on grain size suitability, environmental considerations, and unit costs. The analysis showed that the median grain size of the sand in the proposed borrow area is very close to the existing beach sand. Although the fill sand would be somewhat darker initially, sun bleaching and natural processes will blend the fill with native beach sand over time. This blending is typical following beach placement of dredged material, and can occur within a matter of weeks to months. Exposure to sunlight and precipitation also aids in this process.

The proposed borrow area occurs in a sand flat roughly between ½ mile and 1½ miles offshore of Lido Beach and Long Beach in water depths of 30 feet to 60 feet (MLW). Approximately 35 million cubic yards of compatible material is estimated to be available in this area. The nature of the offshore sand is variable but could produce an acceptable borrow source if the most compatible sand was targeted. Supplemental offshore borrow site investigations should be considered by the City of Long Beach to refine the location and quantities of the best available fill material for compatibility with the existing beach.

IX. FEDERAL PLAN FORMATION

As part of the Plan Formulation process, preliminary alternatives were identified and developed by the Corps to a level sufficient for rough comparison of relative costs and benefits. These preliminary alternatives were ranked based on these and other criteria, and the most promising were carried forward into a final alternative analysis. The preliminary alternatives developed by the Corps in the 1998 Feasibility Study are described below:

1. <u>No Action</u> – Under the No Action alternative, the existing groins would continue to deteriorate, accelerating a loss of beach. This alternative is the same as the without project condition, and is used as the basis to measure the effectiveness and economic benefits of the other alternatives.

2. <u>Beach Restoration</u> – This preliminary alternative involved the placement of beach fill from an offshore borrow source to widen and raise the existing beach profile. A design template was developed based on the findings of the 1989 Reconnaissance Report, including a 110 foot wide berm at elevation of +10 feet NGVD fronting a 25 foot wide dune at crest elevation +15 feet NGVD with 1 on 5 side slopes. The foreshore slope utilized for the eastern third of the project length matched the existing predominant slope of 1V:25H and the foreshore slope for the remaining two thirds of the project length matched the existing predominant slope of 1V:35H. The total initial fill volume was 10,940,000 cubic yards. Advanced nourishment was included in initial placement with periodic nourishment, estimated at 2,500,000 cubic yards every 6 years, planned throughout the 50 year project life in order to maintain the design profile. Existing groins that protruded above the beach fill placement were to be restored for stability of beach fill and for safety to beach users.

3. Beach Restoration with Groin Extensions – This preliminary alternative provided the same beach restoration plan as described above with the following changes: (1) a terminal groin was added at the eastern end of the project adjacent to Jones Inlet for closure, (2) seven new groins were added to 2 miles of currently un-structured shoreline near the eastern end of the study area and 24 existing groins were extended to the toe of initial fill placement along the remaining 7 miles of project frontage, and (3) advanced fill in initial placement and re-nourishment was reduced due to the presence of the groins which would reduce the erosion rate and therefore the amount of required renourishment. The initial fill volume including advance fill was 10,640,000 cy, with 2,200,000 cy of nourishment every 6 years. The stone volume to extend 24 existing groins was estimated at 460,000 tons. The stone volume to construct 7 new groins was estimated at 245,000 tons and the stone volume for the terminal groin was 102,000 tons. The additional stone volume required for this preliminary alternative would be much more costly than the additional sand required for the periodic nourishment of the beach restoration alternative 2 described above.

4. Seawall (entire project area) – This preliminary alternative included the construction of a "Galveston" type seawall placed along the entire nine mile project length with a top elevation of +20 feet NGVD to prevent overtopping from a 100 year storm event (the actual level of protection was higher, but the additional benefits were not needed for justification). This structure included fronting toe scour stone protection, was pile supported and provided with underlying sheeting to reduce seepage. The volume of concrete for the seawall was estimated at 498,000 cy. This alternative would not include any beach restoration but would provide storm damage protection consistent with the other structural alternatives. It was noted that the seawall section design made of concrete is approximately 10% less costly than an equivalent stone revetment section per linear foot.

5. Seawall (City of LB) with Beach Restoration – The seawall design was slightly downsized from the seawall in Alternative 4, due to the inclusion of beach fill in the design. The required initial beach fill for this preliminary alternative was 10,740,000 cy with the same periodic re-nourishment as for the other beach restoration plans. Concrete required for the seawall portion of this alternative was estimated at 170,000 cy.

6. Bulkhead with Beach Restoration – This preliminary alternative included the same beach restoration plan as above (Alternative 2) except that the constructed dune segment fronting the Long Beach area (3.5 miles) was eliminated and replaced with a bulkhead. A concrete capped steel sheet pile bulkhead would be utilized to provide storm damage protection at Long Beach in lieu of the restored dune system. The same 10,740,000 cy would be required for initial beach fill, 2,500,000 cy would be required for nourishment every 6 years and 868,000 sq. ft. of steel pile bulkhead would be required for the 3.5 miles fronting Long Beach.

7. Breakwaters with Beach Restoration – This preliminary alternative included 39 offshore stone rubble mound structures each approximately 600 feet long with 500 foot gaps

between structures placed about 700 feet offshore covering the nine mile project length. The capstone for these structures was 16 ton with a total quantity of stone of 2,145,000 tons. The beach restoration was similar to the beach restoration plan above except that the dune height was reduced since the offshore breakwater would trip the 100 year storm design wave before it intercepts the improved beach; the improved beach would be subjected to a lower impinging wave environment. In addition, nourishment requirements were substantially reduced since the erosion rate would be significantly lowered by the presence of the offshore breakwaters. The initial fill placement was 8,840,000 cy with 500,000 cy of nourishment required every 6 years.

8. Perched Beach with Beach Restoration – This preliminary alternative was similar to the beach restoration alternative above except that a submerged stone rubble mound structure was used to support the offshore end of the fill thus eliminating approximately the outer 300 feet of beach profile at the ocean bottom. The volume of initial sand fill as well as renourishment volume was therefore reduced since no placement of sand would extend beyond the submerged structure. Initial sand fill including advanced nourishment was estimated to be 8,600,000 cy with periodic re-nourishment estimated to be 2,000,000 cy every 6 years. The stone for the submerged structure was 630,000 tons. The perched beach was not anticipated to reduce the erosion rate of the improved beach.

All of the preliminary alternatives were compared to a baseline level of storm damage protection (with the exception of the No Action Alternative) with the following underlying assumptions:

- Minimum 73 year return storm used as the design storm for all alternatives
- Design wave heights, wave periods, still water levels and wave setup elevations were the same for all alternatives
- Continuous protection of the entire project area was provided by each alternative
- Same borrow area was assumed for all alternatives (offshore sand source)

In addition, consideration was given to rehabilitating and/or upgrading the existing groin field at Lido Beach. This would be done either alone or in conjunction with beach placement of material dredged during regular maintenance of Jones Inlet. It was determined by the Corps that such a plan alone would not provide any benefits against storm surge and inundation, especially since the supply of material from inlet dredging would be inconsistent and undependable. Therefore, this option was not considered further as a stand-alone plan, but was discussed as a potential addition to other alternatives.

Corps Cost Analysis

The 1998 Feasibility Study also provided a cost analysis for comparison of alternatives. Since the level of protection and resulting economic benefits would be similar for all alternatives, the evaluation was based primarily on the relative costs of each alternative. Local preferences and social impacts also played a role. Preliminary costs were developed and are presented in Table 11 (reproduced from Table 3 of 1998 Feasibility Report).

Table 11. Cost Estimates from the 1998 Feasibility Study

Alternative	First Cost (Million $)	Total Annual Cost (Million $) -1994 Discount Rate
No Action	0.0	0.0
Beach Restoration Only	75.5	8.5
Beach Restoration w/Groins	132.4	13.3
Seawall Only	275.1	24.2
Seawall w/Beach Restoration	168.0	16.8
Bulkhead w/Beach Restoration	150.9	15.0
Breakwater w/Beach Restoration	256.1	23.0
Perched Beach w/Beach Restoration	116.5	11.9

It should be noted that the preliminary costs developed for the "seawall" options were based on structures designed not only to prevent overtopping, but also to withstand direct wave energy forces in the event the beach erodes away. This resulted in higher costs and lower net benefits for these alternatives when compared with the other preliminary alternatives. Additional alternatives could be developed with less costly structures, similar to the "bulkhead" option, with sufficient strength to withstand wave run-up forces, but designed primarily to prevent flooding under the boardwalk into the street ends.

Beach Nourishment Alternatives

Based on the preliminary evaluation in the 1998 Feasibility Report, beach restoration was selected by the Corps as the most feasible, cost effective alternative that is consistent with New York State Coastal Zone Management regulations. The other preliminary alternatives were no longer considered viable options for various reasons such as cost and potential permitting issues. Therefore, additional analyses were performed to determine the optimal beach restoration plan.

Alternative beach fill cross-sections and dunes were designed by the Corps for the final alternative analysis. Berm width and dune elevation were varied in order to optimize the project net benefits, resulting in nine beach fill alternatives:

1. No dune with 50 ft advance nourishment
2. No dune with 110 foot berm and advance nourishment
3. No dune with 160 foot berm and advance nourishment
4. +15 ft NGVD dune with 50 ft berm and advance nourishment
5. +15 ft NGVD dune with 110 ft berm and advance nourishment
6. +15 ft NGVD dune with 160 ft berm and advance nourishment
7. +17 ft NGVD dune with 50 ft berm and advance nourishment
8. +17 ft NGVD dune with 110 ft berm and advance nourishment
9. +17 ft NGVD dune with 160 ft berm and nourishment

Several additional features were also considered by the Corps to address closure of the ends of the fill and the severe erosion that occurs on the eastern end of the study shoreline. These features included a sand taper on the west end of the fill, an extension of the existing terminal groin on the west side of Jones Inlet, a westward extension of the groin field along the Point Lookout shoreline, and rehabilitation of existing groins. The number of groins to be rehabilitated was based on the 1988 surveyed groin condition and whether or not they would be buried by the design berm width. The number ranged from 9 to 23 groins, as follows:

- 160 ft berm width alternatives (9 groins rehabilitated)
- 110 ft berm width alternatives (15 groins rehabilitated)
- Existing berm width (23 groins rehabilitated)

1998 Corps Recommended Plan

Alternative 5 (+15 ft NGVD dune with 110 ft berm and advanced nourishment) was identified by the Corps as producing the highest net NED (National Economic Development) benefits, and was selected as the Recommended Plan. Alternatives 2 and 3, with no dune, were economically justified but provided lower net benefits from storm protection. Alternative 4, which did not include an increase in the existing berm width, was justified and also provided substantial net benefits, but not as much as Alternatives 5 through 9. Increasing the berm width to 160 ft (as in Alternatives 6 and 9) provided only a small increase in storm protection at significant additional cost. Increasing the dune height to +17 ft NGVD (as in Alternatives 7, 8, and 9) also increased costs significantly without a proportional increase in benefits.

The Recommended Plan as presented in the 1998 Feasibility Report included approximately 41,000 linear ft of beach and dune fill. The fill plan extended from the easternmost end of the barrier island at Point Lookout to Yates Avenue in East Atlantic Village, where the fill would taper into the existing shoreline in Atlantic Village. The 1998 plan also included groin construction and rehabilitation of existing groins to minimize the need for future beach renourishment. The Corps' Recommended Plan consisted of the following components:

a) Dune Fill: Crest elevation of +15 ft NGVD with a crest width of 25 ft and 1 on 5 side slopes on the landward and seaward sides. A 15 to 25 ft maintenance area is included landward of the dune.

b) Berm Fill: Extending 110 ft from the seaward toe of the dune at an elevation of +10 ft NGVD with a slope of 1 on 25 for the easternmost 5,500 ft of the project then transitioning to a 1 on 35 slope for the remaining shoreline.

c) Fill Quantity: A total initial sand fill quantity of 8,642,000 cy including tolerance, overfill, and advance nourishment

d) Dune Vegetation: 29 acres of dune grass and installation of 90,000 ft of sand fence for dune sand entrapment.

e) Access: 16 dune walkovers and 13 timber ramps for boardwalk access, and 12 vehicle access ramps over the dune.

f) New Groins: 6 new groins west of the existing groins at the eastern end of the island, spaced approximately 1,200 ft apart across 6,000 ft. of beach frontage.

g) Rehabilitated Groins, Revetment: Rehabilitation of 16 of the existing groins, including rehabilitation of 640 ft of the existing revetment on the western side of Jones Inlet.

h) Periodic Renourishment: Approximately 2,111,000 cy of sand fill every 5 years for the 50 year project life.

i) Borrow Area: Beach fill for the proposed project is available from an offshore borrow area containing approximately 36 million cy of suitable beach fill material. The borrow area is located approximately 1.0 mile offshore of Lido Beach and the City of Long Beach.

j) Monitoring: To properly assess the functioning of the project, monitoring of the placed beach fill, borrow area, shoreline and wave and littoral environment was included in the plan. Environmental monitoring was addressed through coordination with other interested agencies.

2006 LRR Plan Revisions

For various reasons, the 2006 Limited Reevaluation Report (LRR) incorporated several changes to the 1998 Recommended Plan. Following completion of the Feasibility Study, the community of East Atlantic Beach withdrew from participation in the storm damage reduction project. The Recommended Plan length was shortened accordingly (from 41,000 liner ft to 34,000 liner ft), with the dune line ending at the border of the City of Long Beach and East Atlantic Beach. The berm was revised to taper into the existing shoreline west of the end of the dune line (approximately 1,500 ft into East Atlantic Beach).

The dune alignment proposed in the 2006 LRR was the same as the Feasibility Report Recommended Plan for the 18,000 ft of the eastern end of the project area (i.e. from Point Lookout west to the Long Beach boardwalk) and the 4,000 ft of the western end of the project area (west of the Long Beach boardwalk to the East Atlantic Beach boundary). However, 11,200 ft of dune alignment along the Long Beach boardwalk was shifted landward from the 1998 Recommended Plan.

Three possible modifications of the 1998 Feasibility Report Plan were considered by the Corps regarding dune alignment along the boardwalk in the City of Long Beach: (1) An update of the 1998 Recommended Plan with boardwalk extensions, (2) A Seawall Plan, and (3) A Sand Barrier Plan.

The sand barrier plan was selected by the Corps as being the most cost effective and acceptable to the local sponsor. For this modified plan, an 11,200 ft long sand barrier under the Long Beach boardwalk would replace the sand dune fronting the boardwalk. This barrier would maintain the design level of protection, preserve full ocean views from the boardwalk and would reduce the beach fill footprint and seaward extent, alleviating some of the concerns of surfers and beach users. The sand barrier, like the original dune, would have a crest width of 25 ft at elevation +15 ft NGVD, but would add reinforcement of the seaward and landward slopes to reduce the chance of significant deformation from wind and storm wave action.

In accordance with the Corps' Environmental Operating Principles, the LRR Plan also added a Bird Nesting and Foraging Area in the eastern segment of the project. The rehabilitation of revetment along approximately 700 ft of the western shore of Jones Inlet, adjacent to the terminal groin at Point Lookout, was removed from the recommended plan because this revetment rehabilitation had already been accomplished by local interests.

After applying the above design changes, the Corps' LRR Recommended Plan consisted of the following components.

a) Berm: Two segments of berm fill were recommended, each with a berm width of 110 ft at elevation +10 ft NGVD. The first segment, in the easternmost 4,000 ft of the project (Point Lookout and Hempstead Beach, station 140 to 170 approximately) would have a shore slope of 1V on 20H. For the second segment of 25,000 ft (Lido Beach and Long Beach, station 182 to 230 approximately), a 1V on 35H shore slope was recommended. The different shore slopes were selected to match existing natural conditions, with a transitional zone between them. The western end of the berm fill in this segment would taper into the existing shoreline in East Atlantic Beach. The 5,000 ft reach between these two segments (station 172 to station 180 approximately, within the Town of Hempstead) would require no beach fill improvement at this time due to its designation as a bird nesting and foraging area. Design level of protection is maintained in the nesting and foraging area due to the existing dune and berm system. Thus, the total project length would be approximately 34,000 ft, with 29,000 ft requiring berm fill.

b) Dune: Three segments of dune fill/creation were recommended, two east of the Long Beach boardwalk and one west of the boardwalk, totaling about 13,000 ft. All segments would have a crest elevation of +15 ft NGVD and a crest width of 25 ft with 1 on 5 side slopes on the landward and seaward sides. The first segment would extend 4,000 ft, from Point Lookout to the eastern limit of the bird nesting and foraging area. The second segment would begin at approximately the western limit of the bird nesting and foraging area and continue to the eastern end of the Long Beach boardwalk (approximately 5000 ft), where it would transition to the sand barrier under the boardwalk. The third segment would continue from the western limit of the boardwalk (at the westerly end of the sand barrier), extending 4,000 ft to the western boundary of the City of Long Beach.

c) Sand Barrier: The sand barrier would be aligned beneath the City of Long Beach boardwalk, approximately 85 feet landward of the formerly proposed dune alignment. It would have a crest elevation of +15 ft NGVD and a crest width of 25 ft with 1V on 5H seaward side slopes and 1V on 3H landward side slopes. At existing boardwalk ramp locations the barrier would have 1V on 2.5H landward and seaward side slopes. In addition, the 11,200 ft long sand barrier would be reinforced with: (1) a buried 6" thick crushed stone filled coated wire mattress on the seaward slope, (2) a 4" high cement filled geoweb surface, halfway up the landside slope, and (3) a pervious geotextile underlying the marine mattress and geoweb and continuing over the exposed to sand surfaces of the remainder of the sand barrier. It should be noted that this would require removal of the wood decking for construction, and replacement of the boardwalk with composite material decking. Composite planking is recommended because it is not susceptible to rotting, which would be accelerated if a wooden deck was used for the boardwalk above the sand barrier. A life cycle cost analysis of different options for boardwalk decking showed that this was the lowest cost alternative for decking options (USACE, 2006). It should also be noted that despite the geo-mattress reinforcement, there is still a chance of the sand barrier being damaged or washed out during an extreme event. If this occurs, the decking would have to be removed again before repairs could be made.

d) Fill Quantity: A total sand fill quantity of 6,600,000 cy would be required for the initial beach and berm fill placement, including tolerance, overfill, and advanced nourishment width of 50 ft.

e) Dune Vegetation and Access: The dune construction included planting of 12 acres of dune grass and installation of 47,000 ft of sand fence for dune sand entrapment as well as construction of 12 timber dune walkovers, 12 gravel surface dune walkovers, 8 extensions of existing dune walkovers, 8 gravel surface vehicle accessways, 1 timber raised vehicle accessway, 2 swing gate vehicle access structures, reconstruction (relocation) of 1 lifeguard headquarters, construction of timber retaining walls around 4 comfort stations, 2 comfort 29 stations with concession stands, and 1 lifeguard headquarters.

f) Boardwalk Decking: the replacement of boardwalk timber deck along the entire length of 11,200 linear feet with composite material would be required as part of construction.

g) Periodic Renourishment: Approximately 1,746,000 cy of sand fill is estimated to be required from the offshore borrow area every 5 years for the 50 year project life. Note that Jones Inlet may also be used as a sand source depending on the maintenance dredging schedule, but it is not considered a dependable source.

h) Groin Rehabilitation

- Long Beach - There are 23 groins in this stretch of beach. Fifteen (15) of the groins inspected are recommended for rehabilitation based on a condition survey in 2003. The proposed rehabilitation consists of repositioning existing armor stone and adding additional armor stone along the seaward 100 - 150 ft of each of 8 groins fronting the dunes and along the seaward 200 - 330 ft of each of 7 groins fronting the sand barrier. The difference is due to length of the portion of the existing groins that will be buried by the design fill. Groins fronting the sand barrier will be exposed for most of their length due to the more landward position of the berm in that area. Groins east and west of the sand barrier will be partially buried, and so do not require rehab for their entire length. A minimum constructible crest width of approximately 13 ft was selected with side slopes of 1V on 2H. An armor stone weight of 5 tons per unit was selected in order to approximately match the existing armor stone.

- Lido Beach - There are four groins on this length of shoreline. Each of these groins is in poor condition and considered to be deteriorated to such a point that they have ceased functioning and were not considered for rehabilitation.

- Point Lookout - There are three stone groins on this length of shoreline. Two of these are generally in good condition, except for a 100 ft length of each of the head sections which requires rehabilitation by repositioning and adding additional armor stone. The third groin, which is the terminal groin, is recommended for rehabilitation of the seaward 100 ft in accordance with the design proposed in the report.

i.) New Groins: Based on the results of circulation and sediment transport modeling performed by the Corps, a modification to the new groin field proposed in the 1998 Feasibility Study was included. The modification consisted of 7 new groins with the first groin constructed 800 ft west of existing Groin 55 in Point Lookout and the second through fourth groins constructed at intervals of 800 ft further west, with tapered lengths. The remaining 3 groins, extending the groin field to the west, would be authorized under the study authority, but constructed as a separate component at a later date if needed. This area, known as the "weldment," covers the eastern half of the nesting and foraging area and is part of a sand shoal that shifts position from year to year. The "trigger" for implementing the construction of the deferred groins (including design fill and renourishment) in the weldment area is a berm width of 250 ft or less (measured between the dune toe and the seawardmost +7 ft NGVD contour) persisting for one year. A one-year time period will ensure that the narrowed berm condition is representative of a long-term trend, and not seasonal or temporary. If and when the trigger conditions are met, the three additional groins would be built west of the first four groins, at 1,200 ft intervals with tapered lengths.

j.) Borrow Area: Beach fill for the proposed project would be available from an offshore borrow area containing approximately 36 million cy of suitable beach fill material. The borrow area is located approximately 1.0 mile offshore of the barrier island of Long Beach.

k.) Monitoring: To properly assess the functioning of the proposed project, monitoring of the placed beach fill, borrow area, shoreline and wave and littoral environment was included in the plan. Environmental monitoring was addressed through coordination with other regulatory agencies.

l.) Bird Nesting and Foraging Area: The 5,000 ft reach between the two berm segments (station 172 to station 180 approximately), within the Town of Hempstead, would be designated as a bird nesting and foraging area. Design level of protection would be maintained in the nesting and foraging area by the existing dune and berm system.

X. POTENTIAL STORM PROTECTION MEASURES

Based on concerns and desires expressed by the City of Long Beach regarding the Corps 2006 LRR Plan, several engineering measures for storm damage protection were assessed as part of this study. These measures were based on previous studies and available data, and were then combined into stand-alone alternatives for comparison using several criteria. The development of these alternatives was guided by several issues related to previous efforts by the Corps of Engineers and concerns specific to the City of Long Beach. The criteria considered in developing alternatives to the LRR Plan are outlined as follows:

- Magnitude of the project life cycle costs vs. need
- Construction impacts to boardwalk
- Aesthetic impacts, ocean view from the boardwalk and beachfront residences
- Consideration of sea level rise and flood potential
- Integration with City Master Planning efforts
- Consideration of the needs of neighboring coastal communities
- Impacts to surfing
- Public coordination
- Development of a plan that meets the requirements for Federal cost sharing
- Potential use of Section 206 (WRDA 92) authority to construct the project in advance of Federal funding with reimbursement

Additional considerations in the development and assessment of measures were associated shoreline recession, levels of protection, and damage categories. These are discussed briefly below as a prelude to the discussion of engineering measures.

Sea Level Rise and Shoreline Recession

The effects of possible changes in relative sea level were examined in accordance with Corps of Engineers publication EC 1105-2-186. The historic, or local low level rate of rise of 0.01 ft/yr was obtained from NOAA (The National Ocean and Atmospheric Administration) for the Long Beach Area, which correlates to 0.5 ft of increased water elevation over the 50 year project life. The Corps (Weggel, 1979) proposed a formula for computing the rate of shoreline recession from the rate of sea level rise that takes into account local topography and bathymetry. The equation below was developed:

$$x = ab/(h+d),$$

where: x = shoreline recession attributable to sea level rise;
h = elevation of shoreline above MSL;
d = depth contour of significant sediment motion (Depth of Closure);
b = horizontal distance from the SWL elevation to the depth contour, d;
a = specified relative sea level rise for specified time period.

If a shoreline is in equilibrium, then the quantity of material required to reestablish the equilibrium bottom profile in response to sea level rise comes from erosion of the shore. The 50 year shoreline recession based on the historic estimate of sea level rise of 0.01 ft/yr would be 19 feet, or a change of -0.38 feet per year. The shoreline recession based on a “high” estimate of sea level rise could be up to 50.3 feet, or approximately -1.0 foot per year. Additional sand volumes needed to compensate for both rates of rise were calculated.

The historic rate of sea level rise requires placement of 21.5 cy/ft of sand over the 50 year project life (0.43 cy/lf/yr). This volume has been included in the Corps’ calculated nourishment volumes as part of the project design, and served as the basis for the estimates developed in this study. The high rate of rise would require 55.9 cy/ft of shoreline over 50 years (1.12 cy/lf/yr). Should the more rapid rate of rise occur, additional compensatory volumes could be added to future nourishment cycles. Since sea level rise will occur regardless of the project design, all project alternatives would require the same additional nourishment volumes and the same increase in berm and dune elevation.

Levels of Protection (USACE)

The existing low elevation beach conditions provide a minimal level of protection against storm-induced recession, inundation, and wave attack, estimated at a 10 to 30 year event (1998 Feasibility Study). Table 12 provides storm surge and total water levels based on the Waterways Experiment Station of the Corps of Engineers data developed for Jones Inlet, which is considered to be representative of the entire project shoreline (USACE, 1985). The Ocean Stage data from the 1985 source was increased in Table 12 by 0.2 feet to approximately account for 20+ years of sea level rise since the data was published.

Table 12. Atlantic Coast Storm Surge and Total Water Levels

Return Period (yrs)	Ocean Stage[1] (ft. NGVD)	Total Water Elevation[2] (ft. NGVD)
10	8.6	10.3
20	9.4	11.2
50	11.0	12.8
100	12.3	14.0
200	13.8	15.4
500	15.5	17.0

Notes: 1. Ocean Stage levels include storm surge and wave setup.
2. Total water levels include wave run-up.

Shore Protection Measures

The following sections focus on individual shore protection measures for the Atlantic shoreline of the City of Long Beach that appear to be effective, efficient, feasible, and acceptable to the local community. These measures are then combined into a set of alternatives that were compared to the City's objectives. Based on this comparison, a Locally Preferred Plan (LPP) was developed as a conceptual plan for the City of Long Beach to pursue under the federal program. This process was performed on behalf of the City of Long Beach, recognizing the following:

- Neighboring communities may still wish to pursue the existing proposed plans recommended in the 2006 LRR for their shorefront.

- A locally preferred plan for the City of Long Beach would need to be incorporated into the comprehensive Corps' plan for the entire project as an update of 2006 LRR.

- The City may consider moving forward with the project as defined in the 2006 LRR in the interest of timing and funding.

The following measures include some elements of the Corps' Project for consideration and modifications or substitutes to the Corps' plan that may better meet the needs of the City.

<u>Measure 1 - Sand Barrier Under Boardwalk (as proposed by the Corps)</u>

Creation of a sand barrier underneath the Long Beach boardwalk could be an effective measure to reduce potential storm damages and was presented in the 2006 LRR. The 11,200 ft long barrier would have the crest aligned underneath the boardwalk at an elevation of +15 ft NGVD and a crest width of 25 ft, with 1V on 5H seaward side slopes and 1V on 3H landward side slopes (Figure 6). Landward and seaward side slopes of 1V on 2.5H would be used at existing boardwalk ramp locations. In addition, the barrier would be reinforced as designed by the Corps:

- A buried 6" thick crushed stone filled coated wire mattress on the seaward slope,
- A 4" high cement filled geoweb surface, halfway up the landside slope, and
- A pervious geotextile fabric underlying the marine mattress and geoweb.

<u>Measure 2 - Floodwall under Boardwalk (modified Corps's design)</u>

In the 1998 Feasibility Study, two seawall alternatives and one bulkhead alternative were developed in the preliminary screening. The "seawall" alternative design was based on a "Galveston" type seawall to a crest elevation of +20 ft NGVD, which is 3 feet above the existing boardwalk deck. The seawall was designed to be continuous over the entire nine mile project length, but had the highest cost of all preliminary alternatives and so was eliminated.

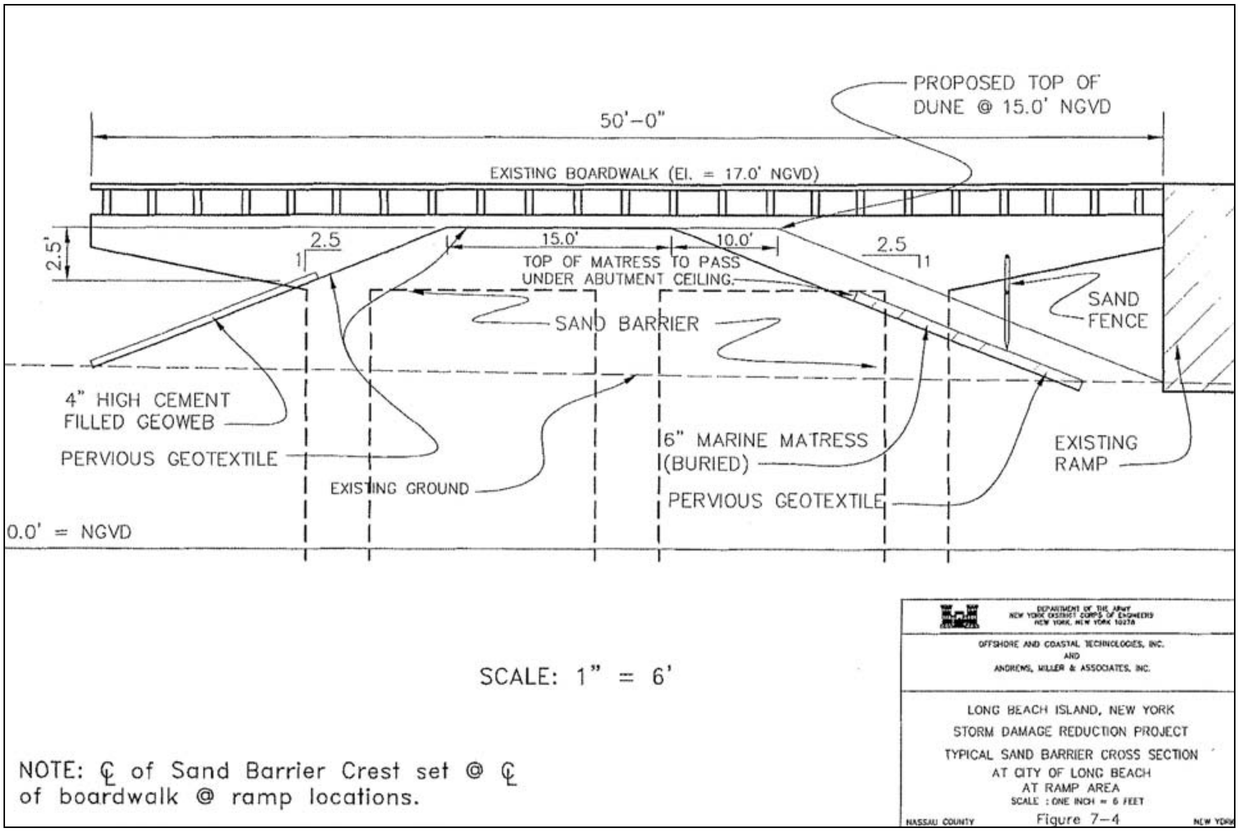

Figure 6. Corps Sand Barrier Design from LRR (USACE, 2006)

A second preliminary alternative developed in the 1998 Study, "Seawall with Beach Restoration" was developed based on restoration of the beach berm on the entire study area shoreline with a seawall fronting the Long Beach boardwalk and dune restoration elsewhere. This alternative was also more costly than others with the same protection benefits, and was also eliminated.

A third preliminary alternative titled "Bulkhead with Beach Restoration" was developed based on the "Seawall with Beach Restoration" alternative, but replacing the seawall design with a concrete capped steel sheet pile bulkhead (Figure 7). This alternative was economically justified, but was eliminated by the Corps because *"it does not comply with New York State shoreline policy concerning hardened structures running parallel and near to the shoreline."* (p. 57, Appendix B, 2006 LRR, USACE). This concern relates to the coastal erosion control line, which runs along the seaward edge of the boardwalk. A permit may be required from NY Department of State to place structures on this alignment, which marks the boundary of the Coastal Erosion Hazard Area (CEHA). However, if the floodwall were moved off the CEHA line to a location under the boardwalk, this alternative would be feasible and would be outside the State's Coastal Erosion Hazard Area. Some sand placement in front of the wall may be required by the State depending on its location in proximity to the beach.

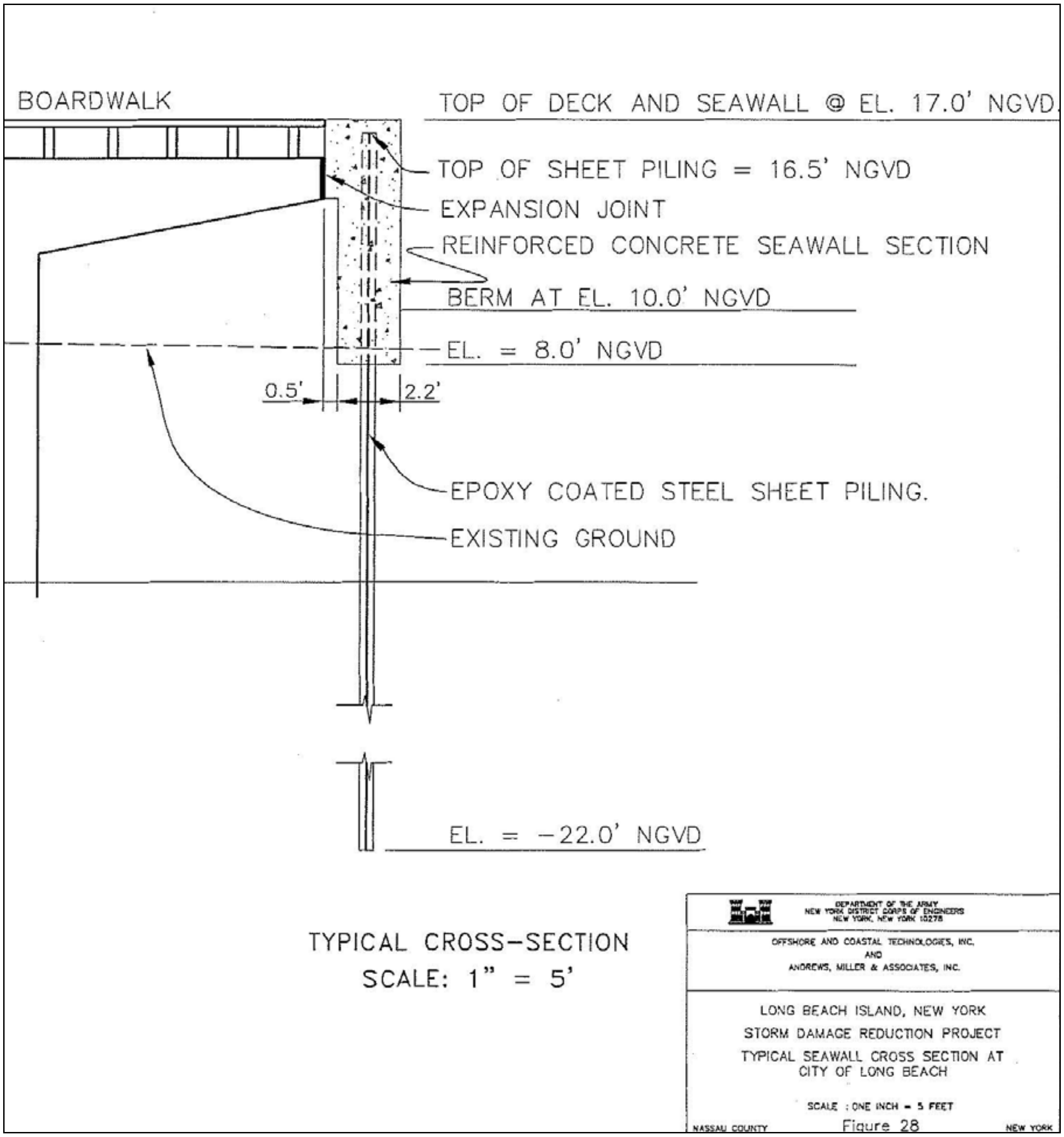

Figure 7. Corps Seawall Design from LRR (USACE, 2006)

With a minor modification to the Corps third alternative design shown in Figure 7, the floodwall could be moved beneath the entire length of the boardwalk (11,200 ft). With this adjustment, the alignment would be under the centerline of the boardwalk, rather than along the seaward face. The floodwall would be designed with a top elevation of +17 ft NGVD and constructed as part of the boardwalk support structure with its top elevation flush with the underside of the decking. Installation would be performed as part of the boardwalk replacement, and a maintenance program would be recommended to repair any damages incurred over the project life.

Approximately 900,000 square feet of sheet pile would be required to construct the 11,200 foot long floodwall beneath the boardwalk. The top of the steel sheet piling would be encased in a concrete floodwall cap section approximately 2 ft thick. The 40 ft long steel sheeting would extend down to approximately -22 ft NGVD (about 30 ft below the existing beach) for structural stability and prevention of seepage. The reinforced concrete cap would extend down from the top of the floodwall to approximately +6 ft NGVD, which is about 2 ft below the existing beach grade.

The basic design was developed by the Corps of Engineers and has proven to be effective at Ocean City, Maryland, and Virginia Beach, Virginia. That project, titled "*Beach Erosion Control and Hurricane Protection, Virginia Beach, Virginia*", utilized steel sheet pile driven to a depth of -30 ft with a concrete cap incorporated into the boardwalk and aligned along its seaward edge. It was designed to provide protection from a 146 year storm event. The local sponsors of the project rejected any alternatives that would have included a dune system fronting the boardwalk, primarily because it was incompatible with the type of development, land use, and aesthetics in the project area. During Hurricane Isabel in 2003, the wall performed as designed and prevented an estimated $80 million in damages, nearly paying for itself in one storm event.

Measure 3 - Groin Rehabilitation without Beach Fill

Another shore protection measure developed and assessed in this study is the rehabilitation of groins within the City of Long Beach. This would effectively reconstruct the existing groins to their original design intent. Compared to their current degraded state, rehabilitation would tighten the structures and help stabilize the beach with naturally supplied littoral material. The proposed rehabilitation consists of repositioning existing armor stone and adding additional armor stone along the seaward 300-350 ft (estimated exposed length) of each groin. A minimum crest width of approximately 13 ft was with side slopes of 1V on 2H would be used to rehabilitate the structures. A primary armor stone unit weight of 5 tons would be used in order to approximately match the existing armor stone.

The 23 groins in the City of Long Beach can be classified by location. Fourteen groins are located in front of the boardwalk, and the other 9 are in front of the adjacent dune areas. Eight of fourteen the groins fronting the boardwalk were designated as candidates for rehabilitation in the 2003 Corps survey. The remaining 6 groins were determined to be non-functional, and would require a complete rebuild since less than 40% of the stones remained visible. Seven of the groins in front of the adjacent areas were identified as candidates for rehabilitation, and 2 were recommended for a complete rebuild.

In summary, there are 15 groins within the City of Long Beach identified by the Corps as candidates for rehabilitation. There are an additional 8 groins that were deemed to be in need of complete rebuild because they were either degraded to the point they were no longer functional, or because they have settled into the beach. For measures that involve rehabilitation and/or extension of the existing groins, additional studies may be required to determine what level of repair or reconstruction is warranted since additional time has passed since the last assessment.

Measure 4 - Beach Berm Fill with Groin Extensions

If beach fill is placed as part of the project, the existing structures may need to be extended in order to maintain similar beach shapes within the groin field. The concern expressed by locals is that beach construction could negativity affect the quality of surfing since the fill template would directly bury the existing surf breaks near the groins. This concern could be alleviated to some extent by extending the existing groins seaward to match the shift in equilibrium beach profile or by placing fill only on the dry beach landward of mean high water. Translating the entire beach system seaward, including the terminus of the groins, would preserve the beach profile shape and surfing areas, whereas a dry beach fill would avoid direct placement of sand into the surfing and swimming areas.

The length of the groin extension would be dependent on the quantity of beach fill, the current condition of the beach, and location/extent of each groin. The berm fill would have a width of 110 ft at elevation +10 ft NGVD, with a 1V on 35H slope to the existing beach. For example, with an average profile shift of about 160 feet at MHW, the expected necessary groin extensions would be in the range of 120 to 200 feet. If the fill was placed entirely on the dry beach, groin extensions may not be warranted due to the limited quantity of fill. The current condition of the beach needs to be surveyed to make this determination. Rehabilitation of the existing groin sections is a separate determination that may also be required irrespective of the quantity of beach fill.

Measure 5 - Fill As Needed

Beach berm fill was included in all previous Corps Recommended Plans to elevate and widen the beach to address storm induced erosion and flooding problems. The design was intended to ensure a minimum 110 foot wide berm at an elevation of +10 ft NGVD, with advance nourishment based on an estimated shoreline retreat rate of 4 to 5 feet per year. Renourishment projects were also scheduled to maintain these minimum dimensions for the 50-yr life of the project. The berm fill proposed by the Corps would also provide a buffer to protect the dune/sand barrier system and maintain the design elevation of +15 ft NGVD to protect against storm surge and flooding.

The analysis performed by CPE as part of this study suggests that the City of Long Beach shoreline has not exhibited a significant long term erosional trend. This conclusion is based on the performance of the existing beach over the last 50 years and shoreline stability provided by the groins. Considering the historic performance and current beach widths, the "fill as-needed" concept was developed to account for benefits of the existing beach. Although the existing berm is low in elevation, the total volume of sand on the beach is also related to the beach width and storm protection. The existing groin field and beach width also provide protection against storm recession damages, and would be combined with other measures to address storm surge flooding. However, fill may be needed to raise the current dry beach elevation and at some time during the project life to address unexpected storm losses or an increase in background erosion.

There are a number of factors that could cause erosion to increase in the future. An unusually severe storm event, reduction or elimination of mechanical bypassing (dredging) of Jones Inlet, and the potential for significant sea level rise are examples of the events that could cause an increase in erosion along the barrier island. Although initial beach fill is proposed "as needed" in this measure, authorization would be needed for beach renourishment for the 50 year project life. Once authorized, renourishment events would be triggered by specific conditions and occur during the planned maintenance cycles. For example, the "trigger" for implementing the renourishment could be described as recession beyond a prescribed beach berm dimension, such as defined by the Corps design template.

XI. ALTERNATIVES DEVELOPMENT AND COMPARISON

The measures identified in the previous section may be combined in a number of different ways to indentify alternatives for comparison. Each alternative must include measures that address inundation (flood) damages, because this is the largest damage type. Measures that address erosion and wave attack damages should also be included. Measures that address the same damage type have not been combined, as that would create redundancy. For example, the sand barrier would not be combined with the floodwall, because they both address storm surge inundation. By this rationale, there are six feasible alternatives to consider:

Alternative 1: 1A – Sand Barrier with Groin Rehabilitation
1B – Sand Barrier with Berm Fill as Needed and Groin Rehab
1C – Sand Barrier with Berm Fill and Groin Extensions

Alternative 2: 2A – Floodwall with Groin Rehabilitation
2B – Floodwall with Berm Fill as Needed and Groin Rehab
2C – Floodwall with Berm Fill and Groin Extensions

Sand Barrier vs. Floodwall

A sand barrier or floodwall under the boardwalk would provide flood protection during times of storm surge inundation. Both would likely be socially acceptable, although construction of the sand barrier could create more inconvenience and disruption in addition to boardwalk maintenance issues. The sand barrier would also be more likely to suffer damage in an extreme event and would require removal and replacement of the boardwalk decking to repair. Both would provide storm surge/inundation protection during major storm events. However, the floodwall would have 2 ft of additional elevation, resulting in protection from a higher storm surge.

The floodwall would be more expensive than the sand barrier as a first construction cost, but the maintenance cost is likely to be lower. The additional initial cost may also be justified by the added protection, especially if implemented along with boardwalk reconstruction and/or bayside floodwall improvements. A more detailed, updated Cost Benefit Analysis may be required to further evaluate the long term maintenance costs.

The floodwall initially considered by the Corps was along the front of the boardwalk and would likely require a permit from State for construction in a Coastal Erosion Hazard Area (CEHA). However, the CEHA line runs along the seaward edge of the boardwalk and moving the floodwall landward to a location underneath the boardwalk would provide a setback from this line. In either case, there appears to be sufficient justification to meet the criteria for permit issuance. For these reasons, the Floodwall is recommended over the Sand Barrier as the flood protection measure for major storms.

Berm Fill vs. Groin Rehabilitation

The floodwall measure may be combined with measures designed to address erosion damages, providing varying levels of protection from storm induced erosion. The highest level of protection is provided by Alternative 2C, since it includes a wider beach berm than currently exists. The second highest level of protection is provided by Alternative 2B, since it maintains (approximately) the current beach berm for the life of the project. The lowest level of protection is provided by Alternative 2A, which would further stabilize existing the beach over time though groin rehabilitation. However, if the project area is subject to shoreline recession in the future, there would be no renourishment measure authorized to restore the beach under Alternative 2A.

Floodwall with Fill as Needed and Groin Rehabilitation

Alternative 2B is recommended to be pursued for the City of Long Beach portion of the federal project. This option would provide an increased level of protection for the life of the project by installing a floodwall as part of the boardwalk replacement, rehabilitating the groins to their intended design and the opportunity to place beach fill on the dry beach. This alternative would utilize the Corps design template (or a minor modification thereof) as the minimum beach berm needed to protect against erosion damages and maintain recreational values. Beach nourishment in Point Lookout and Lido Beach would act as a feeder beach updrift of the City's shoreline that would also help nourish the area through natural transport.

XII. LOCALLY PREFERRED PLAN

A conceptual plan for oceanside shore protection within the City of Long Beach that satisfies the concerns of the local community and meets the requirements for Federal cost sharing has been identified. Incorporation of the City's Locally Preferred Plan (LPP) into an update of the comprehensive LRR plan would not impact the shore protection measures currently proposed by the Corps in Lido Beach and project areas of the Town of Hempstead. However, close coordination with these neighboring communities is essential to the development of a comprehensive shore protection strategy and Corps authorized project for Long Beach Island.

The recommended Locally Preferred Plan (LPP) that best addresses the objectives of the City of Long Beach is Alternative 2B – Floodwall with Fill as Needed and Groin Rehabilitation. It should be noted that the use of the term "Locally Preferred Plan" in this document refers only to the project features recommended within the City of Long Beach. Unless otherwise specifically stated, all other aspects of the federal project would remain the same as described in the Corps 2006 LRR. The plan is described below and includes a floodwall as part of the boardwalk replacement, groin rehabilitation, and authorization of a beach fill design template.

Floodwall under Boardwalk

A floodwall under the boardwalk was selected for inclusion in the Locally Preferred Plan as the primary flood protection measure. The floodwall would be constructed beneath the boardwalk as part of the underlying support structure. The sheet pile and concrete wall would extend the full length of the boardwalk and tie into the existing dunes or seawalls at both ends. It would be designed to a crest elevation of +17 ft NGVD so that it would be flush with the underside of the decking. It is expected that this elevation would provide storm protection that exceeds the flood level of a 100-year return interval storm (Table 12).

The floodwall would be constructed as part of the boardwalk reconstruction following the Corps initial design from the 2006 LRR (Figure 7). The only difference from the Corps design would be an alignment under the centerline of the boardwalk as part of the support structure, rather than along the seaward face. Approximately 900,000 square feet of sheet pile would be required to construct the 11,200 ft long floodwall. The wall would consist of 1.0 ft wide epoxy coated steel sheet piling with a concrete floodwall cap section approximately 2 ft thick. The 40 foot vertical sections of steel sheeting would be driven down below the beach to an elevation of approximately -22 ft NGVD for structural stability and prevention of seepage. The reinforced concrete cap would extend down from the top of the floodwall to approximately +6 ft NGVD, which is about 2 feet below the existing beach grade.

The wall would not be readily visible from the beach as it would be underneath the boardwalk. Some type of water tight doors or ramps over top of the boardwalk may be needed at the street ends for emergency vehicle access, essential equipment and maintenance.

Groin Rehabilitation

Groin rehabilitation was selected for inclusion in the Locally Preferred Plan as the primary erosion control measure. There are 23 groins within the City of Long Beach that help stabilize the beach by holding sand in alongshore compartments between the structures. In a 2003 survey, the Corps identified 15 of the existing groins as candidates for rehabilitation. There are another 8 groins that were deemed to be in need of complete rebuild because they were either degraded to the point they were no longer functional, or because they have settled into the beach.

The proposed rehabilitation consists of repositioning existing armor stone and adding additional armor stone along the top and exposed portions of each groin. The total estimated length of groin rehabilitation is approximately 4,950 ft assuming 15 groins that average 330 ft each. The actual length of repair or rebuild may vary for each groin, but each structure should be rehabilitated along its entire length to restore the original intent of erosion control.

An updated survey and evaluation should be conducted to better determine the current condition of each structure, which could be done by the City and their consultant. To further analyze the potential effect on surfing, a wave breaking model should also be utilized.

Berm Fill As Needed

In addition to the flood wall and groin rehabilitation, beach fill on an as needed basis is included in the Locally Preferred Plan. Although sand nourishment may only be needed on the dry beach as part of the initial construction event, authorization would be included for beach nourishment design template on an “as needed” basis for the 50 year project life. The existing beach in the City of Long Beach is about 250 to 350 feet wide from the boardwalk to the shoreline, and has exhibited a long term trend of accretion. However, beach fill is needed to raise the elevation of the current berm and will be a critical part of the authorization for response to a major storm or change in the long term erosion rate.

Once authorized, sand nourishment events would be triggered by specific conditions and occur during the planned maintenance cycles. For example, the "trigger" for implementing the renourishment could be described as recession into the Corps design template. A time period should also be included to determine if the narrowed berm condition is representative of a long-term trend, and not seasonal or temporary. If and when the trigger conditions are met, a sand fill event would be included in the next maintenance project from the existing borrow areas, as authorized by the federal shore protection program for the island. The criteria would be based on beach conditions and analysis, and annual monitoring surveys would be critical to evaluating the conditions.

Sand for the nourishment events would be available from an offshore borrow area located approximately one mile offshore of the barrier island of Long Beach. There may be other nearby submerged hills and ridges that could provide an additional/alternate source of sand if needed. Supplemental offshore borrow site investigations should be considered by the City of Long Beach to refine the location and quantities of the best available fill material for compatibility with the existing beach.

Feeder Beach

In the past, both natural bypassing around Jones Inlet and placement of inlet dredge material in the eastern communities have acted as a feeder beach and benefited the City of Long Beach. The underlying assumption in determining the long term stability of Long Beach is that material dredged as part of normal maintenance of Jones Inlet will continue to be placed on the beach. The sand would then continue to be available as a feeder beach to the littoral cell to the west. In addition, implementation of any Corps sponsored project will likely include nourishment and maintenance of Lido Beach, immediately updrift from the study area. This would also act as a feeder beach for the City of Long Beach, allowing sand to migrate though the littoral system from east to west.

Cost/Benefit Analysis

In order to qualify for Federal cost sharing as a Locally Preferred Plan, the plan must be economically justified in accordance with National Economic Development (NED) criteria. The Federal cost share is defined by the maximum Federal contribution allowed under the NED plan. Therefore, if the Federal share of the LPP is greater than the Federal share under the NED plan, the Federal share is limited to the NED cost with local entity paying the difference. However, an update of the Cost Benefit Analysis may result in adjustments to the Federal share of the NED plan. If an updated NED analysis results in the LPP becoming the NED plan, then the Federal cost share would be the same for both.

Cost estimates were developed as part of this study for the Locally Preferred Plan using the same methodology defined in the Corps 2006 LRR (Table 13). The LPP option replaces the sand barrier with a floodwall, includes the groin rehabilitations and considers different quantities of beach fill in the City of Long Beach. All other elements remain the same as the Corps 2006 LRR plan (adjacent communities, boardwalk replacement, etc.). The variations were developed to evaluate the cost implications of implementing the LPP with different quantities of beach fill in the City of Long Beach.

Based on the existing dimensions of the beach, a berm cap could be constructed that replicates the Corps template on the dry beach. The berm template would be 110 ft wide at +10 ft NGVD for the length of the City, with a 1:35 slope to the existing berm at +7 ft NGVD. It is estimated that the berm cap option would require approximately 332,000 cubic yards of sand placed on the dry beach. Updated surveys would be needed to verify the feasibility of this option and determine the actual quantity of sand needed. The Corps 2006 LRR plan estimated 5,500,000 cubic yards of sand would be required within the City of Long Beach. The plan variations for which costs are compared in Table 13 are defined as follows:

- LRR: Corps plan with full beach fill, groins and sand barrier under boardwalk.
- LPP without fill: An assumed “no fill” plan with groins and floodwall under boardwalk.
- LPP with Berm Cap: Adds berm cap to elevate existing beach within City (332,000 cy).
- LPP with Full Fill Plan: Includes Corps proposed beach fill within City (5,500,000 cy).

Table 13. Cost-sharing Estimates for 50-Year Project Authorization.

Plan	Total Cost	Federal Share (65%)	Non-Federal Share (35%)	NY State DEC	Local Municipalities	Cost Benefit Ratio
2006 Corps LRR Plan	$98,535,285	$64,047,935	$34,487,350	$24,141,145	$10,346,205	2.7
LPP without Beach Fill	$88,793,360	$57,715,684	$31,077,676	$21,754,373	$9,323,303	2.9
LPP with Berm Cap	$90,633,360	$58,911,684	$31,721,676	$22,205,173	$9,516,503	2.9
LPP with Full Fill Plan	$119,622,030	$77,754,320	$41,867,711	$29,307,397	$12,560,313	2.3

Note: Locally Preferred Plan (LPP) options include changes within City of Long Beach only, but cost estimates shown represent the total cost of the island-wide Federal Project as defined in the Corps 2006 LRR.

The cost-sharing for the project is defined in the 2006 LRR as 65% federally funded and 35% non-federally funded. The estimates from the LRR are provided in Table 13 along with estimates developed with the same methodology for the City’s LPP options. The non-Federal portion is distributed 70/30 between the New York State Department of Environmental Conservation (NYSDEC) and local municipalities. In other words, 70% of the Non-Federal share would be paid by NYSDEC, with the remaining 30% split between Nassau County, the Town of Hempstead, and the City of Long Beach.

The same annual benefits were assumed for all cost benefit ratios shown in Table 13 since each has the same storm protection objective. A more detailed economic analysis will likely be required by the Corps depending on the plan proposed by the City. However, this preliminary assessment shows that the benefit cost ratios for both the LPP without Beach Fill and the LPP with Berm Cap are 2.9, which is higher than the 2.7 ratio of the 2006 LRR plan. Therefore, delaying or reducing the sand nourishment portion of the initial project outweighs the potential higher cost of the floodwall verses sand barrier. The LPP option that includes the floodwall and the full beach fill has a benefit cost ratio of 2.3, which is lower than the other plans, but still qualifies for federal funding by a large margin (> 1.0).

XIII. FUNDING AND TIMING CONSIDERATIONS

It is likely that significant changes to the Corps 2006 LRR plan would trigger a project reformulation, which has funding and timing implications. The objective of the reformulation would be to address all of the City's concerns with the current plan, but the Corps would be required to perform a detailed economic and engineering analysis to verify that the revised plan still meets the cost/benefit requirements for federal funding. This process can take on the order of 10 years to complete and has no guarantee of being authorized or funded. In that timeframe, funding that has already been identified for implementation of the existing LRR plan may be lost as well. To avoid this outcome, the City of Long Beach can support the Corps in completing the LRR process and accept some form of the current plan to allow the process to move forward and secure funding for the project.

Based on the analysis developed in this study, it is possible that many of the City's concerns with the current plan can be addressed. For example, the data used in developing the LRR is over 20 years old and the beach has been shown to be stable to accretional based on more recent observations. Therefore, it is possible that a dry beach fill would be sufficient to fill the Corps design template and would avoid sand placement in the swimming and surfing zones. Other modifications may be implemented by the Corps during the final design phase to address the additional protection needed under the boardwalk and other minor issues. Sand quality concerns can be addressed with additional geotechnical investigation to refine the borrow area, and a wave study can be developed to evaluate any remaining surfing concerns. Therefore, in order to avoid delays and secure funding to move the project forward, the City should support the LRR with the consideration for these additional studies.

XIV. NY STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION

In an effort to control shoreline development and alterations, Article 34 of the "Environmental Conservation Law - Coastal Erosion Hazard Areas Act" was adopted by The State of New York in 1981. The Coastal Erosion Hazard Areas (CEHA) Act empowers the NY Department of Environmental Conservation to identify and map coastal erosion hazard areas and to adopt regulations to control certain activities and development in those areas.

The Act required the State of New York to establish two setback lines along the state's shoreline, subdividing the CEHA into two zones. The Natural Protective Feature Area (NPFA) is defined by the morphologic features found along a shoreline that provide natural protection to upland features. For example, the setback line exists 25 feet back from the coastal dunes in some areas. The Structural Hazard Area (SHA) is determined based on the projected local coastal erosion for the next 40 years. Only where erosion rates are greater than 1 ft/yr is a structural hazard line defined.

The location of the SHA is determined by multiplying the coastal erosion rate by 40 (years) to determine additional setback from the NPFA. The premise of these regulations is a permitting system aimed specifically at all proposed construction in erosion hazard areas. The construction or placement of a structure, or any action or use of land which materially alters the condition of land, including grading, excavating, dumping, mining, dredging, filling or any disturbance of soil is a regulated activity requiring a coastal erosion management permit from the NYSDEC. To implement this policy, the DEC created the Coastal Erosion Control Permit Program to ensure that construction and other activities on specified coastal areas meet the standards for permit issuance.

A SHA has not been established on the Atlantic shore of Long Beach Island, or at least could not been identified. However, a CEHA map was issued by the NYDEC in 1988 (*Coastal Erosion Hazard Area Map, City of Long Beach, Nassau County, NY, August, 1988*) and was reviewed as part of this study. The CEHA map shows the location of the landward limit of the designated Natural Protective Feature Area. Within the City of Long Beach, the line runs directly along the seaward edge of existing development and the seaward edge of the boardwalk. It appears to define the entire beach area as within the CEHA, while the boardwalk and development are not.

Due to the location of this jurisdictional boundary, any structure constructed seaward of the boardwalk would require a permit from the DEC. This was the main reason that the Corps rejected the seawall option in the 2006 LRR and previous studies. However, constructing a floodwall landward of the CEHA as part of the boardwalk reconstruction should alleviate this concern since the structure would be outside of the State's jurisdiction. In addition, the floodwall would be designed as part of the central underlying supporting structure of the boardwalk itself. A nominal amount of fill placed as a berm cap may further resolve any remaining concerns of regulatory agencies.

XV. SECTION 206 WATER RESOURCES DEVELOPMENT ACT 92’

Through formal agreement with the Corps of Engineers, the City of Long Beach could construct the federal project under authorization of Section 206 of the Water Resources Development Act (WRDA) with federal reimbursement. Passed in 1992, Section 206 of WRDA, “Construction of Shoreline Protection Projects by Non-Federal Interests”, authorizes construction of shoreline protection projects on the U.S. coastlines by non-Federal interests subject to permits and approval of the Secretary of the Army.

Section 206 also allows non-Federal entities to utilize Corps study information or contract with the Corps to do studies and direct monitoring of construction and O&M where appropriate. In essence, it authorizes the Secretary of the Army to reimburse non-Federal interests the appropriate Federal share of a project approved for construction. In-kind services, whereby the local sponsor pays for necessary studies as credit toward their share of the project cost, is also an option for the City.

For construction, an agreement with the Corps would be required in the form of a Project Cooperation Agreement (PCA), or Project Partnership Agreement (PPA) as it has been recently referred to. The agreement must be in place prior to building the project or there is no guarantee that reimbursement funds are available. Requests to receive such credit should be submitted to the Assistant Secretary of the Army for Civil Works and would be subject to a favorable Chief's Report (Final approval by the Chief of Engineers, HQUSACE).

If funding is available from the participating non-Federal sponsors (N.Y. State, City of Long Beach, Town of Hempstead), it may be possible to update the design to include the City's preferred plan and begin construction of the project on an accelerated schedule. The costs incurred by the local sponsors at the time the work is complete will be based on information provided by the local sponsors on actual costs. No audit is required as part of the Feasibility Study (or associated Reevaluation Report), however, an audit of the local sponsors work will be required prior to execution of the Project Partnership Agreement (PPA).

XVI. BAYSIDE FLOODING CONSIDERATIONS

The ongoing studies for the U.S. Army Corps of Engineers Storm Damage Reduction Project for Long Beach Island have not included bayside flood potential. It is well documented that the City of Long Beach floods from both sides of the island so there may be sufficient justification for Corps to include a bayside flood protection element in an overall flood protection plan. In fact, the U.S. House of Representatives, Committee on Transportation and Infrastructure, passed a Resolution on April 5, 2006 that requests the Secretary of the Army to initiate a review the pertinent reports to determine the need for a bay shore storm protection project in Long Beach.

Although there is a standing directive from the federal government for the Corps to determine the need for a project dealing with bayside storm protection in Long Beach, tagging a new bayside study onto the ongoing ocean-side plan could result in a delay of the overall process. It may also be possible for the City to address the bayside flooding issues apart from the existing Corps plan and seek Federal reimbursement through Section 206 of WRDA. In either case, if Corps support is warranted, the process can be run in a separate but parallel track. It is suggested that the Corps representative be contacted to discuss the feasibility of such a plan and determine the best course of action to commence a reconnaissance study for the bay side.

XVII. MONITORING PROGRAM

Monitoring programs are common to all coastal protection projects. Beaches are dynamic and seasonal, and the data collected is used to determine the differences between seasonal variations and long term trends. The results are then used to quantify and assess project performance in order to provide a basis for planning and future maintenance. Monitoring data is also used to evaluate impacts of a project on coastal processes, environment, and recreational resources.

Physical Monitoring

A physical monitoring program should be developed and implemented by conducting annual surveys of the beach and nearshore bathymetry. Even if the project is not constructed in the near future, the data collected will be a valuable tool in assessing beach conditions and evaluating storm damage potential. If a project is implemented, pre-construction surveys will be needed to provide a baseline for comparison with monitoring surveys.

After the project is in place, post-construction monitoring conducted on an annual basis provides the information needed for performance monitoring and determination of nourishment needs and timing. In addition, beach monitoring surveys provide the data needed to quantify storm losses and provide justification for federal funding to address impacts to the project area.

Environmental Monitoring

It is unclear at this time what level of environmental monitoring would be required for the proposed project. The most common environmental monitoring for similar projects in the region (i.e. Fire Island) involve shorebird monitoring and surf clam surveys. Considering that Long Beach is a highly developed barrier island, the potential for bird nesting and associated activities of protected species is probably low. A surf clam survey may be required prior to dredging sand from the borrow area, but the potential for the existence of clams in the area is unknown.

Surfability Monitoring

A surfability monitoring program would be beneficial to ascertain the benefits and/or impacts of the proposed project on surfing areas. The data collected could include the collection of wave buoy data, photographs from stationary cameras along the beach, as well as periodic interviews with the local surfing community. This effort would also be tied to the physical monitoring program to provide a correlation between beach conditions and surfability.

XVIII. ADDITIONAL STUDIES

Before the project can proceed to the construction phase, additional studies are recommended to assess particular aspects of the project and address plan modifications for federal authorization. These studies can be done by the Corps of Engineers, or may be expedited by the City through their consultant. If an agreement with the Corps were approved, the City could potentially perform these evaluations as "in-kind services" and receive credit toward their share of the project cost at the time of construction. The following additional studies are recommended:

Engineering and Economic Analysis

An engineering and economic reanalysis may be needed to demonstrate that implementation of the City's Locally Preferred Plan would result in a positive net benefit to cost ratio. The normal Corps document for this type of analysis would be a General Re-evaluation Report (GRR) or an updated Limited Reevaluation Report (LRR). A GRR is used for reanalysis of a previously completed study, using current planning criteria and policies, which is required due to changed conditions and/or assumptions. The adoption of a Locally Preferred Plan by the City of Long Beach may be considered such a changed condition. However, a local plan that is similar to the LRR plan would not require such a reformulation. An alternate type of assessment such as a supplemental engineering report may also suffice to make this determination.

The construction authorities previously granted through existing Corps documents imply the authority to undertake reevaluation studies. The results may modify the previous plan as appropriate. A General Reevalution Report (GRR) is considered a Post Authorization Study, and as such, is generally funded as a part of engineering and design studies under the General Investigation appropriation. This authority may be used under the current Feasibility Cost Sharing Agreement (FCSA) between the USACOE and the local sponsors. If undertaken by the local sponsors, credit may be allowed under Section 206 provisions.

Topographic and Bathymetric Survey

In order to assess the current condition of the beach, an updated topographic and bathymetric survey is needed. The topographic portion is performed on the dry beach with land surveying techniques, while the bathymetric (offshore) portion requires a boat with hydrographic survey equipment. These surveys should be performed along the profile lines established by the Corps for comparison with previous surveys. Annual surveys would also provide a continual record of data to monitor the beach over time, which is critical to maintaining a healthy beach.

The surveys are needed to determine the existing beach dimensions and the volume of sand that would be needed to fill out the Corps design, or a modification thereof. Due to the width of the existing beach, a berm cap (sand placed on the dry beach) may suffice to elevate the beach to the Corps design level and would be determined though an updated survey. In addition, the survey could also be used to compare the current beach width and the design beach width to develop a standard by which the “as-needed” condition of the City’s Locally Preferred Plan would be determined. The dunes adjacent to the boardwalk would also be included in the survey to evaluate the level of protection of the existing dunes system.

Geotechnical Investigation

Although sand fill is proposed as part of the Locally Preferred Plan on an as-need basis, the City should conduct a supplemental geotechnical investigation in order to identity the best possible sand for future placement. These investigations usually involve sand sampling with vibracores and mechanical sieve analysis to determine grain size and other characteristics, as well as various remote sensing (hydrographic surveys, side-scan sonar, etc) techniques.

The information gathered on the available sand resources would be used to refine the proposed borrow area for the project. With this data, the borrow area for the City of Long Beach would be designed to optimize beach compatibility, grain size and color, distance offshore and dredging efficiency. Defining the City of Long Beach’s preferred sand source ahead of time would allow the “Fill as Needed” renourishment events to proceed with high certainty for sand quality and minimal delay. These studies should be performed in parallel with ongoing work so that the federal authorization includes the City’s preferred sand source.

Groin Field Inspection and Evaluation

As discussed previously, there is a mix of groins on the City's shoreline that would require rehabilitation or complete reconstruction to restore their effectiveness. The groins are more than half decade old and an updated investigation is needed to determine the current condition and effectiveness of each structure. The study would include site visits to inspect, survey and photo-document each structure. The data complied would then be used to determine the effectiveness of the structures and level of repair needed from moderate rehabilitation to complete rebuild.

A wave model study is also recommended in order to determine the optimum height, length and orientation of the groins. The wave model would be used to analyze wave transformation patterns and effectiveness of the overall groin field. The existing conditions would be compared the original design to gain insight into any potential modifications that may be warranted such as increasing/decreasing the length and height of the structures. A wave model of this nature could be combined with an extended surfability study described below.

Surfability (Breaking Wave) Modeling

A wave analysis should also be conducted to evaluate the effects of the groin rehabilitations on wave breaking and address the concerns of the surfing community. Wave modeling is recommended to assess potential impacts to surfing from:

1) Doing nothing and allowing the groins to continue to deteriorate
2) Groin rehabilitation/reconstruction as proposed
3) Beach fill with and without groin extensions
4) Potential enhancements such as artificial reefs, additional groins, etc.

A Boussinesq-type model (i.e. BOUSS-2D) would best suit this purpose because factors such as refraction, diffraction, reflection, and transmission would need to be evaluated to determine wave breaking, run-up, structure overtopping, and energy dissipation. A morphology-type model (i.e. DELFT-3D) could also be implemented to simulate three-dimensional changes to erosion and deposition patterns associated with the various project components. The models should be run for storm-length (5-10 day) and project-length (5-10 year) time scales, with wave cases developed through an interactive approach with the surfing community.

XIX. CONCLUSIONS AND RECOMMENDATIONS

In 1989, a Reconnaissance Study of Long Beach Island, New York was completed by the New York District, U.S. Army Corps of Engineers. The Feasibility Study was followed in 1998 and recommended a shore protection project consisting beach and dune fill with sand dredged from offshore, and rehabilitation of 16 groins. The 2006 Limited Reevaluation Report (LRR) recommended revising the project within the City of Long Beach to shift the dune structure under the Long Beach boardwalk due to local concerns.

Many of the City of Long Beach's concerns with Corps plan remained after the modifications and the City did not support moving forward with the proposed project. However, the City recognizes the risk for storm damage and flood potential, and contracted Coastal Planning & Engineering, Inc. (CPE) to provide guidance in implementing a Federal storm protection program.

The findings of this study indicate that the shoreline of the City of Long Beach has been generally accretional over the long term. The groin field appears to have been effective in trapping sand and stabilizing a wide beach that currently exists. However, the beach elevation is relatively low and puts the City at risk of storm surge and flood damages during times of elevated water levels. The lack of a barrier to storm waters along the oceanfront provides a direct path for flooding from the ocean into the City's streets and infrastructure. In addition, there are reasons to expect some increase in future erosion such as further degradation of the groins, sea level rise, reduced inlet bypassing and increased storm activity. Therefore, additional storm protection measures are needed.

The Locally Preferred Plan (LLP) identified herein satisfies the City's objectives and criteria for a shoreline protection project for the Atlantic coast of the City of Long Beach. However, implementation of a plan that significantly differs from the Corps LRR plan would likely require a reformulation by the Corps. This analysis may take many years to complete and is not guaranteed to be authorized by the Corps. In that timeframe, funding which has already been identified for implementation of the existing LRR plan may be lost. Therefore, accepting some form of the current plan would allow the process to move forward and secure funding for construction.

Based on the results of this study, it is recommended that the City of Long Beach support the Corps in completing the LRR process in order to secure funding and move the project forward. Dry beach fill placed in the Corps design template as a berm cap would raise the elevation of the existing beach and help to address overtopping. Additional protection in the form of a sand barrier or floodwall is needed under the boardwalk to prevent flooding from major storms. If implemented, the template would then be authorized for nourishment as needed or after a major storm event. In addition, the City should continue to seek federal support for bayside flood protection, but separate from the oceanside project to avoid delays.

In order to update the volume of sand needed for the project and better assess the current condition of the beach, beach surveys are needed. It has also been shown that the sand quality concerns can be addressed, and additional geotechnical investigations should be conducted in the proposed borrow area to target sand areas that best match the existing beach. A wave analysis should also be conducted to evaluate the effects of the groin rehabilitations on wave breaking and address the concerns of the surfing community. These studies may be done by the Corps of Engineers directly, or may be performed by the City through a consultant as "in kind services" with federal reimbursement (credit) at the time of construction.

In order to move forward with implementing a Storm Damage Reduction Project for Long Beach Island, it is recommended that the City take the following specific actions:

1. Support the Corps to re-active the process with local support and complete the LRR to secure funding and move the project forward.

2. Request that additional studies be performed by the City through a consultant as “in kind” services for credit toward their share of the project cost and develop an agreement with the Corps to do so.

3. Perform updated topographic and bathymetric surveys in order to assess the current condition of the beach and quantify the volume of sand needed to elevate the berm as a dry beach fill.

4. Perform a supplemental geotechnical investigation to refine the borrow area for the City of Long Beach and to provide additional assurance on sand quality.

5. Inspect the current condition of the existing groin field to evaluate the effectiveness and determine the level of rehabilitation needed for each structure.

6. Conduct a modeling analysis to evaluate the effects of proposed groin rehabilitations and various project components on wave breaking to address the concerns of the surfing community.

7. If required, prepare a supplemental engineering and economic analysis to demonstrate the viability of the project and confirm that it would result in a positive net benefit to cost ratio for federal funding.

8. Consider a formal agreement with the Corps of Engineers, to construct the federal project under authorization of Section 206 of the Water Resources Development Act (WRDA) with federal reimbursement.

9. Continue to seek federal support for bayside flood protection, but separate from oceanside project to avoid delays. Contact the Corps representative to discuss the feasibility of such a project and to commence a reconnaissance study based on the existing directive from the House of Representatives.

10. Implement a long-term annual monitoring plan to quantify and assess beach performance in order to provide a basis for project planning and future maintenance.

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