TOWN OF HUNTINGTON
LONG ISLAND, NEW YORK
BEACH EROSION STUDY REPORT

AUGUST 30, 2006
OCC PROJECT # 205073

Prepared for:
Town of Huntington
Town Hall
100 Main Street
Huntington, NY 11743

Prepared by:

OCEAN AND COASTAL CONSULTANTS, INC.

Ocean and Coastal Consultants Engineering, P.C.
35 Corporate Drive
Trumbull, CT 06611
Tel: (203) 268-5007 Fax: (203) 268-8821
www.ocean-coastal.com

in association with
EEA, Inc.
Stony Brook, Long Island, New York
Tel: (631) 751-4600 Fax: (631) 751-0597

EXECUTIVE SUMMARY

The Town of Huntington contracted with Ocean and Coastal Consultants Engineering, P.C. (OCC) and EEA, Inc. (EEA) to complete an erosion control study for a portion of the Town's Long Island Sound shoreline. The location of the study area spans from the Northport Key Span Power Station to the Smithtown – Huntington town line, a distance of approximately 2.75 miles.

In order to complete the erosion control study, OCC with the assistance of EEA, developed a scope of work that included: Historic Data Research (to identify available information to assist in determining historic erosion rates and the impact of erosion control efforts on the erosion rate); Site Investigation (to document existing site conditions); GIS Development and Analysis (to analyze the historic erosion / accretion rates and project future trends); Development of Best Erosion Control Strategies and Summary Report; and, Presentation of Findings to the Town.

Historic Data Research

The North Shore of Long Island has historically had significant coastal erosion related issues, partially as a result of a high population density, intensive use of the coastline and the complex coastal environment. In addition, residential and commercial development, public access, recreation, storm protection and natural resources all compete for use of the limited shorefront.

Huntington's shoreline is dominated by bluffs and features created from sediments supplied by bluff erosion such as barrier beaches and spits. Historically, eroding bluffs have provided a substantial volume of sediment to help maintain the beaches and the other sedimentary features. In this type of setting, reducing erosion at one location is often accompanied by increased or continued erosion at the other. Preservation of the overall character of the North Shore coastline is a delicate balance between maintaining sediment supply and mitigating erosion damage.

Site Investigation

On July 22 and August 23, 24 and 25, 2005, OCC and EEA conducted a site investigation of the Town of Huntington beaches within the study area. Work included documenting the condition of the beach area using a GPS survey to identify existing shoreline features and shoreline protection structures. In addition to documenting the existing site conditions, the field personnel evaluated existing land use patterns and potential concerns for developing an erosion control strategy.

The study area contains both eroding bluffs and barrier beaches (spits). High bluffs are most common on the western portion of the study area and are mainly protected by erosion control structures. Moderate sized bluffs on the central-eastern portion of the study are largely unprotected. In the central portion of the study area, adjacent to Crab Meadow Marsh, there are no bluffs. Beaches, especially in the eastern half of the study area are narrow, providing limited storm protection and public access. Public access to and use of the shoreline is concentrated at Crab Meadow Beach.

There are multiple forms of shoreline and bluff protection present in the study area. The most common are timber bulkheads and/or riprap revetments. Groins are also prevalent in the western and eastern portions of the study area, and many of the groins have been in place since the 1940s. A substantial portion in the middle of the study area (from Crab Meadow Beach to the west end of Makamah Beach) has no shoreline or bluff protection structures.

A well developed maritime dune, maritime shrub and early developing maritime woodlands occupy the upland areas behind the western end of Makamah Beach. Relatively narrow maritime dunes are found along the remainder of the project area, particularly along Soundview Terrace (Waterview East) and east of the Makamah Road (Geissler's Beach).

The area historically known as Broken Ground, which is currently occupied by the Indian Hills Golf Course, has a history of substantial slope failures most likely related to a saturated and weak underlying clay layer. The visible evidence of a deep seated failure plane is a scarp about 2000 feet long that extends inland about 500 feet at its maximum. There is on-going differential soil movement along the scarp, with up to 4 feet of vertical displacement since 2002.

GIS Development and Analysis

An historic analysis of shoreline and bluff change was undertaken to define long and short-term trends using the data collected in the field and historic data.

With regard to beach erosion, the areas of concern are Makamah Beach and the eastern portion of the study area. Comparison of two 30+ year data sets (long-term and recent) clearly shows that the middle of the study area has a consistent erosional signature. Bluff stabilization on the eastern end of the study area, near the Smithtown line, has resulted in a change from erosion rates more than 1 foot per year to less than 1 foot per year. However the beach width in this area has become narrower. Adequate beach width is important for protection of residences, bluffs, dunes, and shore protection structures such as bulkheads and is also critical for public beach access. Across the study area, a comparison of beach widths between 1947 and 2004 shows a dramatic trend of decreasing beach width, from an average of 130 feet (not including Crab Meadow Beach) in 1947 to 55 feet at present.

Over the long-term, the highest bluff erosion rates are concentrated in the eastern portion of the study area including the bluffs at Broken Ground (Indian Hills) and the west end of Geissler's Beach.

A comparison of the historic erosion trends and the present situation was extrapolated out 25 years to help differentiate where the system would be naturally and where it is currently restrained. As expected, Makamah Beach, the bluffs at Broken Ground and along Fresh Pond Beach are highly susceptible to damage based on the historic erosion patterns. Also, based on this scenario, about 30 percent of the study area will have no remaining beach fronting shoreline protection structures by 2030.

The trends of shrinking beach widths and long-term shoreline retreat coupled with recent bluff stabilization are indicators of a sand deficit in the study area. This condition is currently offset by increasingly more robust shoreline protection and localized efforts to stabilize bluffs. Once the beach width is reduced to a critical size, however, the constant interaction between shoreline structures (bulkheads) and the waves may render the present shore protection structures inadequate.

Development of Best Erosion Control Strategies

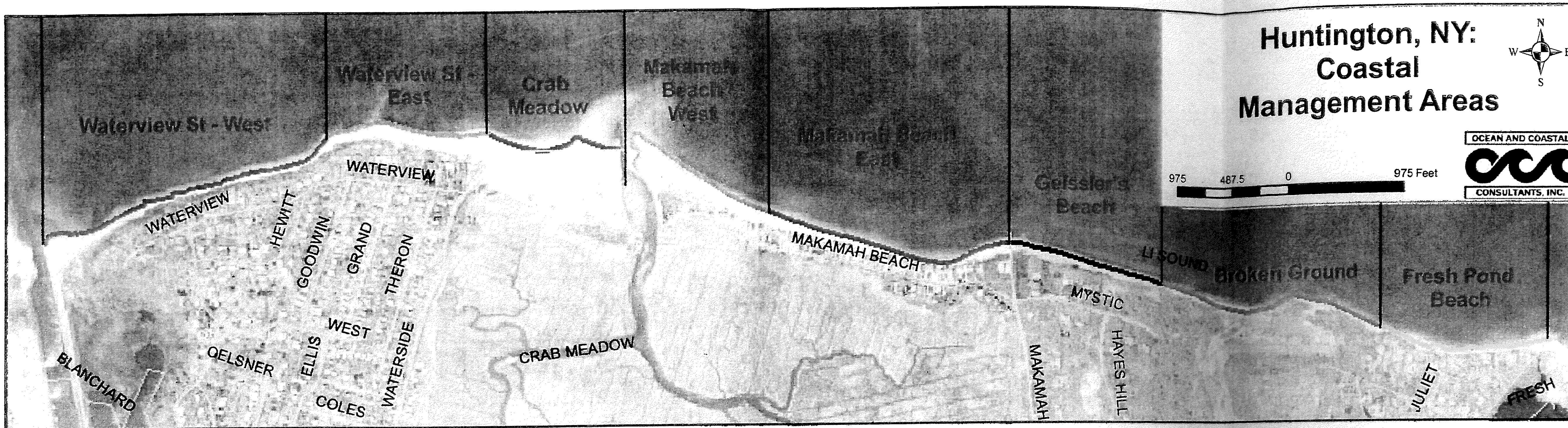
There are multiple levels of regulation (Federal, state and local) for erosion protection projects to be undertaken within the study limits. Agencies with jurisdiction include the US Army Corps of Engineers, the Federal Emergency Management Agency, the New York State Department of Environmental Conservation, New York State Department of State and the Town of Huntington (primarily under the Coastal Erosion Management Regulations). Erosion management strategies presented below were developed in light of and commensurate with the best practices and policies typically deemed acceptable by NYSDEC and USACE. However, for a specific project, coordination will be required between the various agencies in order to confirm that the proposed erosion control strategies are consistent with all of the applicable regulations.

Erosion and flood damage shoreline stabilization alternatives range from doing nothing to constructing various structures (including beachfills) for modifying the behavior or supply of coastal sediments. One of the primary goals of this study was to develop management recommendations for erosion control along the entire study area as a whole. However, during the course of the work it became apparent that there is a need for distinct "management areas" within the study area. The management areas were primarily defined based on physical conditions and upland uses. As the physical condition of the beach system and upland use changes, different management approaches are required. Each management area was evaluated based on nine (9) characteristic features which were identified during the course of the study. The extents of the management areas and specific management recommendations are presented in the following figure.

Significant findings of the erosion control report include:

- The eastern end of Makamah Beach has a critical beach erosion problem and additional storm damage to the adjacent residential properties can be expected unless significant shore protection management strategies are implemented.
- The beach nourishment program at Crab Meadow Beach is a success in providing both public beach access and shore protection.
- The Broken Ground area, including the bluff at Indian Hills Golf Course is expected to continue to have soil movement issues. The observed scarp is likely the result of a deep seated failure along a clay layer. While there are both structural and non-structural measures that can be implemented to reduce or mitigate the likelihood or rate of soil movement, an engineering solution to provide long term stability may not be feasible.

- Public use of the beach is currently limited by narrow beach widths in many areas. This trend is expected to become worse unless additional beach material can be added to the system.
- Given the sand deficit along the eastern portion of the study area, some level of beach nourishment will be required for long term stability of the area.
- An important component of the management program will be replacing sediment lost to the system by bluff and shore protection structures. We recommend a program of sediment mitigation to offset these losses.



Management Area	Geologic Feature	Shore Stabilization Structures	Beach Erosion	Beach Width	Bluff Erosion	Existing Building Setback from Shoreline	Dunes	Storm Damage Risk	Public Beach Access	Management Recommendations
Waterview St. Beach (West)	Bluffed Shoreline	Prevalent	Stable - Typically less than 1 foot per year	Portions are narrow	Stable - Typically less than 1 foot per year	100-200 feet	No	Moderate	Fair	1) Maintain existing shore protection structures; 2) New or substantially repaired shore protection structures to require beach material mitigation; 3) Consider stormwater controls and / or vegetative stabilization to reduce bluff erosion; 4) Provide for public access across existing groins; 5) preserve existing bluff vegetation
Waterview St. Beach (East)	Bluffed Shoreline	Moderate/Set back	Stable - Typically less than 1 foot per year	Wide	Stable - Typically less than 1 foot per year	More than 200 feet	Yes	Low	Good	1) Soft shore protection measures preferred; 2) New or substantially repaired shore protection structures to require beach material mitigation; 3) Protect and enhance existing dune system (i.e. snow fence and elevated walkovers)
Crab Meadow Beach	Barrier Beach	Minimal	Stable - Typically less than 1 foot per year	Wide	Not Applicable	Not Applicable	No	Low	Good	1) Maintain public access to beach; 2) Continue beach nourishment program as needed
Makamah Beach (West)	Barrier Beach	Minimal	Stable - Typically less than 1 foot per year)	Wide	Not Applicable	100-200 feet	Yes	Low	Good	1) Manage as an environmentally sensitive area; 2) Soft shore protection measures only (dunes, beach nourishment, vegetative stabilization); 3) Protect and enhance existing dune system (i.e. snow fence and elevated walkovers)
Makamah Beach (East)	Barrier Beach	Prevalent	High Erosion - Typically greater than 1 foot per year	Narrow	Not Applicable	Less than 100 feet	No	High	Poor	1) Maintain or improve existing shore protection structures to provide immediate protection for homes; 2) New or substantially repaired shore protection structures to require beach material mitigation; 3) Investigate innovative shore protection measures (i.e. offshore breakwater / shoal); 4) Consider beach nourishment at Makamah Road public access (to improve beach access and to provide down drift material)
Geissler's Beach	Bluffed Shoreline	Minimal	Long term erosion greater than 1 foot per year - recently stable	Portions are narrow	Portions greater than 1 foot per year	More than 200 feet	Yes (some)	Moderate	Fair	1) Soft shore protection measures preferred; 2) New or substantially repaired shore protection structures to require beach material mitigation; 3) Protect and enhance existing dune system (i.e. snow fence and walkovers); 4) Consider stormwater controls and/or vegetative stabilization to reduce bluff erosion; 5) Limit irrigation at top of bluff to reduce slope hazards
Broken Ground	Bluffed Shoreline	Prevalent	High Erosion - Typically greater than 1 foot per year	Narrow	Portions greater than 1 foot per year, recently stable	More than 200 feet (100-200 feet)	No	High; slope failures likely	Poor	1) Manage for continued slope failures; 2) Manage stormwater and utilities to prevent excess water from reaching the clay layer; 3) Maintain existing shore protection structures and enhance toe protection where lacking; 4) New or substantially repaired shore protection structures to require beach material mitigation
Fresh Pond Beach	Bluffed Shoreline	Prevalent	Moderate Erosion - Typically greater than 1 foot per year	Narrow	Stable - Typically less than 1 foot per year	Less than 100 feet	No	Moderate	Poor	1) Maintain existing shore protection structures; 2) New or substantially repaired shore protection structures to require beach material mitigation; 3) Consider stormwater controls and/or vegetative stabilization to reduce bluff erosion; 4) Groins may not be appropriate for this zone (limited longshore transport evident)

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1.0 INTRODUCTION

The Town of Huntington and its incorporated villages are located on the North Shore of Long Island, in Suffolk County, New York. The town has about 20 miles of Long Island Sound coastline. The North Shore of Long Island has historically had significant erosion related issues, partially as a result of a high population density, intensive use of the coastline and the complex coastal environment. In addition, residential and commercial development, public access, recreation, storm protection and natural resources all compete for use of the limited shorefront.

In recent years, one aspect of the coastline that has received more attention is the amount of sand (or sediment supply) that forms most of the Long Island shoreline. Historically, wide beaches and high bluffs provided shore protection, habitat and recreational opportunities. However, natural and man-made changes have altered much of the original coastline, in some cases resulting in loss of sediment from the system and fewer shore protection, habitat and recreational benefits.

This report details the coastal change and existing conditions on a portion of The Town of Huntington's Long Island Sound coastline. The specific location of the study area spans from the Northport Key Span Power Station – formerly Long Island Light Company (LILCO) to the Smithtown – Huntington town line (Figure 1.0-1). This represents about 2.75 miles of Long Island Sound shoreline. The purpose of documenting the existing conditions and coastal change is to assist with developing a management plan for the study area that can be implemented to address the concerns of the residents and businesses of the Town of Huntington. This report also provides shoreline erosion control management recommendations for the study area.

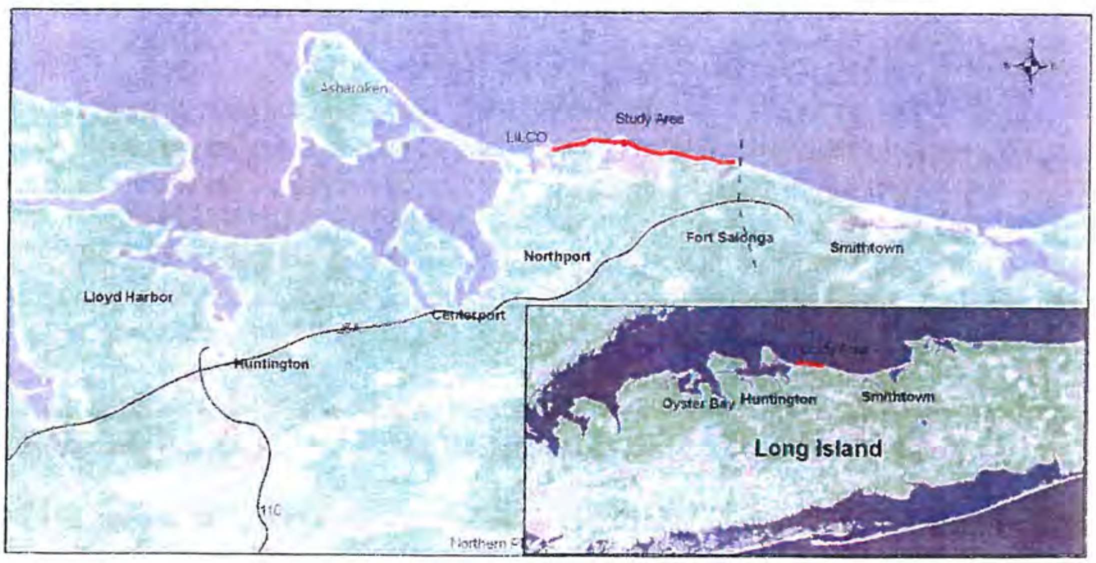


Figure 1.0-1: Overview map of study area.

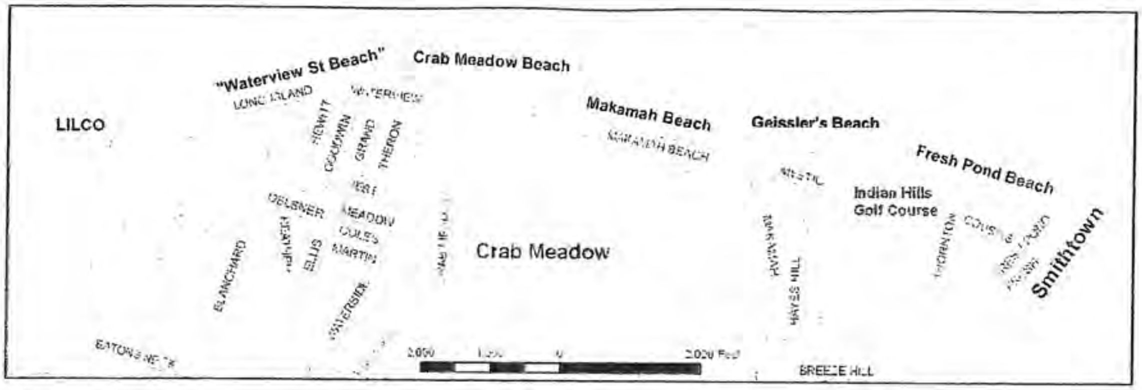


Figure 1.0-2: Study area beaches, roads, and features.

1.1 PURPOSE

The Town of Huntington identified five (5) aspects the study should address:

1.) The study should identify and discuss the historic and current erosion and / or accretion of the beach face, bluff, and / or immediate affected upland in the study area, as well as the littoral drift and other natural processes that affect it.
2.) The types and effects of existing erosion control structures or methods present in the study area should be discussed and a projection made of future conditions if no further erosion control structures, devices, or materials are put in place.
3.) Walking access along the beach at MHW is desirable and should be addressed in the study.
4.) There are outcroppings of clay at several locations within the study area and the slumping of upland clay deposits toward or onto the beach should be addressed in regard to stability and erosion of the beach face and bluff.
5.) Recommendations should be made for the best erosion control management strategy for the study area as a whole, and not for individual properties except as how they may affect the littoral drift or erosion / accretion over a larger area of the beach. Recommendations should be made in light of, and commensurate with, best practices and policies as permitted by the New York State Department of Environmental Conservation and the U.S. Army Corps of Engineers (USACE).

In order to address these requirements, Ocean and Coastal Consultants Engineering, P.C. (OCC), with the assistance of EEA, Inc. (EEA), developed a scope of work that included:

1.) Historic Data Research – to identify available information to assist in determining historic erosion rates and the impact of erosion control efforts on the erosion rate.
2.) Site Investigation – to document existing site conditions.
3.) GIS Development and Analysis – to analyze the historic erosion / accretion rates and project future trends.
4.) Development of Best Erosion Control Strategies and Summary Report.
5.) Presentation of Findings to the Town.

Working with the Town of Huntington Department of Maritime Services, OCC and EEA implemented the scope of work in order to address the study needs. The point of contract with the Town of Huntington Department of Maritime Services is Mr. Richard Koopman.

1.2 BACKGROUND

Many of the coastal processes that affect the study area are influenced by remnant glacial features and their associated surface geology. The northern shoreline of Long Island is characterized by glacial features that were created by the ice sheet's terminus (end moraines). The moraine in the study area stretches from Brooklyn to Orient Heights and is known as the Harbor Hill moraine. Along this moraine there are two general provinces, described as the "necks" and "bluffs" sections. The study area is in the necks section, which is characterized by multiple headlands projecting northward into the sound. The bluffs section starts east of Port Jefferson and is characterized by a straight, roughly east to west shoreline (USACE, 1995).

Like the other areas in the "necks" section, Huntington's shoreline is dominated by bluffs and features created from sediments supplied by bluff erosion such as tombolos, and barrier spits. Historically, eroding bluffs have provided a substantial volume of sediment to help maintain the beaches and the other sedimentary features.

Sediment can move, erode and accrete along the shoreline due to a number of factors. Sediment movement under the influence of waves and currents is referred to as littoral drift. This can be either movement along the shore, or onshore / offshore movement. Other factors, such as wind, can also contribute to sediment movement. Wind is the primary factor in dune formation.

Another factor that contributes to the erosion of the Long Island Sound shoreline is sea level rise. While there are many theories and predictions regarding future sea level rise, there is little doubt that sea level is currently rising. It is widely accepted that since the last glacial maximum (approximately 18,000 years ago) the sea level has risen about 300 feet (Curray, 1964). During the most rapid phase the sea level rose at about 10 mm per year (about ½ inch); this was followed by a relative stand-still in sea level rise that started about 7,000 years ago. Presently in Port Jefferson the sea level is rising at about 2.4 mm or about 0.1 inches per year (NOAA-NOS, 2005). As sea level rises, the shoreline moves landward and the beach and other shoreline features re-adjust to the new position. In most cases the location of the high water line moves landward, and in a natural system, would erode the interior dune or bluff to maintain equilibrium with changing conditions. Shrinking beach widths are an example of the conditions caused when the sea level rises and the shoreline can not move with it.

Bluffs, beaches, dunes and offshore bars are all potential sources for sediment. Inlets, headlands, bars and bays provide natural obstructions to longshore sediment movement. Man-made structures and actions can modify or impact this dynamic system. A "solution" which fixes a problem at one location can impact wave conditions, currents, sediment supply, and transport patterns affecting a broad region (Pope, 1997).

For example, eroding bluffs may feed, through longshore drift, barrier spits and beaches. In this type of setting, reducing erosion at one location is often accompanied by increased or continued erosion at the other. Preservation of the overall character of the North Shore coastline is a delicate balance between maintaining sediment supply and mitigating erosion damage.

The study area contains both eroding bluffs and barrier spits, which requires that the cause and effect situation described above be considered in developing a management plan for the area. Regulations and continued implementation of erosion control and shoreline protection measures, which have an effect on areas up-drift and down-drift of the installation, should be balanced to maintain equilibrium between safety, shore protection, environment, and accessibility.

2.0 HISTORIC DATA RESEARCH

OCC and EEA conducted research to find information that could be used to establish the historic erosion and accretion trends for the study area. Emphasis was placed on locating aerial photographs as these are valuable in the evaluation of shoreline trends utilizing a GIS methodology. In addition, there are a number of previous reports that have been completed for the study area. These were also reviewed and their results incorporated into the study as appropriate.

The importance of historic data research is that it will be used to determine the areas most susceptible to erosion. An accurate assessment of erosion trends and magnitudes depends on good historic data and is critical to development of an appropriate management program.

2.1 AERIAL PHOTOGRAPHS AND GIS DATA

Aerial photography has been used since the 1920's to document land and water features (Lillesand and Keifer, 1994). Data used in this investigation includes early aerial photographs (1938 and later) as well as maps made prior to aerial photography (See Appendix B for listing of dates and types). These early maps are from the Coast and Geodetic Survey, which was a precursor to the National Ocean Service, and were used in making charts as well as defining the natural resources for development. Both types of data include information on shoreline and bluff positions through time. Additional GIS information, including elevation data, soil types, and surface geology, was used to further define the land features. Data supplied by the town, including parcel and road information, helped tie all of the information together using present boundaries and features.

2.2 PREVIOUS STUDIES

Several studies have documented the regional coastal trends and storm related losses along the North Shore of Long Island and in the Huntington area. The following references have highlighted factors relevant to the current study.

- **"Geology of Long Island, New York", United States Geological Survey (USGS) (Fuller, 1914):** This paper describes the locally occurring Cretaceous outcrops and surface relief/features associated with them. The area known historically as the "broken ground", between Makamah Road and the east end of Indian Hills Golf Course, is composed largely of chocolate colored Cretaceous clays. This area is described as the most prominent landside region on the North Shore.

- **"North Shore of Long Island, Suffolk County New York Beach Erosion Control and Interim Hurricane Study (Survey)" (USACE, 1969):** This report defined the long-term change rates, how the specific features and bluffs have evolved, and how the varying mechanisms (landslides, erosion and sediment transport) have shaped the shoreline. In the study area shoreline retreat was documented at between 0.2 to 1.9 feet per year.

- **"The Erosion of the North Shore of Long Island" (Davies, et al., 1973):** Coastal management issues along the North Shore were developed and highlighted. Some of the conclusions relevant to this study include:

    - bluff coasts and barrier beaches differ in their response to severe wave attack – bluffs erode during wave attack whereas barrier beaches are flooded,
    - rain run-off is a significant cause of bluff erosion,
    - the beaches are supplied from two major sources – erosion of bluffs and deposits below the beaches and nearshore, and
    - widespread bluff stabilization and broad protective beaches are incompatible,
    - successful long term development of the coast will require long-range planning based on an increasingly thorough understanding of the processes affecting the shoreline.

- **"Northport Power Station Littoral Drift Study Phase I" (LILCO, 1977):** This report estimated littoral transport to be about 6,000 cubic yards per year toward the west at the western end of the study area (between Crab Meadow Beach and LILCO); the source of sediment was not defined. Near the Indian Hills Golf Course, littoral transport was estimated at 3,000 cubic yards per year. The overall wave climate was described as erosive, in that fair weather long-period waves, which help beach recovery, are not common.

- **"North Shore of Long Island, New York Storm Damage Protection and Beach Erosion Control Reconnaissance Study" (USACE, 1995):** USACE rated the problems of both flooding and erosion in the current study area as "severe". Of the North Shore communities studied, the current project area and Bayville were the only ones to have both flooding and erosion hazards rated as severe. In particular, the area of Makamah Beach was highlighted as especially vulnerable to storm damage.

- **"Engineering Report on Bluff Erosion – Indian Hills Golf Course" (Nelson and Pope, 1991):** This report on bluff erosion at the Indian Hills Golf Course indicated that the most prevalent cause of slope failure in the Indian Hills Golf Course area was from toe erosion and a revetment as opposed to a bulkhead was recommended because of the potential for landslides behind the bulkhead.

- **"Long Island Sound – Coastal Management Program" (New York State Secretary of State, 1999):** Makamah Beach was highlighted in the Long Island Sound Coastal Management Program as a critical erosion area. In a broader sense, this report has application in the overall implementation strategies suggested by the Long Island Sound Coastal Management Program.

- **"Glacial Features of the Huntington and Northport Area, Long Island – Notes and Road Log, Long Island Geologists Field Trip, November 3, 2002" (Bennington, 2002):** This report documents the underlying glacial geology of the study area. Various glacial features occur above the Cretaceous sediments; in the Northport region there are extensive melt-water channel deposits that run east-west and north-south across the moraine. Rapid changes in bluff sediment and character are partially a result of these ancient channels.

- **Town of Huntington, Department of Maritime Services (personal communications, 2005):** Based on information from the Town, Crab Meadow Beach has been renourished periodically over the past several decades. In the past four years about 300 cubic yards (330 tons) of sediment has been placed on the beach each year. Christmas trees have also been used to armor the bluffs at Geissler's Beach since 2000.

3.0 SITE INVESTIGATION

On July 22 and August 23, 24 and 25, 2005, OCC and EEA conducted a site investigation of the Town of Huntington Beaches within the study area. Work included documenting the condition of the beach area using a GPS survey to identify existing shoreline features and shoreline protection structures. The GPS survey allowed all data collected to be geo-referenced and included in the GIS database (see Section 5.0 of this report). Geo-referenced digital photographs were also taken to document existing conditions (see Appendix A).

In addition to documenting the existing site conditions, the field personnel evaluated existing land use patterns and potential concerns for developing an erosion control strategy.

During the field work portion of the project the coastal or littoral zone was separated into discrete "reaches" that defined unique spatial, physical, and development conditions. Reaches ranged in length from 150 to 1000 feet depending on the level of change. During the field visit (August 21 through 23, 2005) the position of the high water line (HWL) was defined in the field as the seaward most berm crest (Kraus and Rosati, 1997) and mapped using a differential corrected global positioning system (DGPS) receiver. This data was used as a "baseline" for further analysis (See Section 6.0 Coastal Analysis). The HWL has many definitions (Boak and Turner, 2005) but is commonly defined as an approximation of Mean High Water (MHW) (Shallowitz, 1964). However, it is not a legal definition of the MHW.

Conditions defined for each reach in the field included:

1.) The presence and approximate height of adjacent bluffs,
2.) Vegetation on bluffs,
3.) Dominant bluff erosion mechanism,
4.) Presence and approximate height of dunes,
5.) Presence and type of shore protection structure,
6.) Presence and height of erosional scarps,
7.) Type of sediment present on beach, and
8.) Upland development type.

This information was added to the attributes of the HWL baseline in a Geographical Information System (GIS) such that conditions adjacent to the shoreline were defined along the entire study area.

Similar to the HWL, a bluff/upland baseline was also collected using the DGPS receiver. This physiographic feature defined the area above which normal processes were not driven by littoral transport (transport by water) and included the toe of dunes or bluffs, and bulkhead or shore protection structures.

To document the specifics of the site, geo-referenced land based photos were taken at representative locations (Figure 3.0-1) using the GPS and picture direction (heading). They constitute an important data source for regulatory review, planning, and disaster and historic documentation. These photos, locations, and directions and notes are provided in Appendix A and in electronic format in Appendix D.

Figure 3.0-1: Map of photo locations.

During the site visit several residents along Waterview Street and Makamah Road expressed interest in the study and provided local insights. For example, during northeasters, such as the 1991 "No-Name" storm, the Waterview Street area has seen significant sediment build-up against the bluffs. These sediments would subsequently be reshaped into a broader gentler beach slope following storm passage. The Makamah Beach area, on the other hand, had a significantly higher level of damage during these storms such that property losses typically resulted. Other local insights included a description of large ice blocks occurring during spring melt periods and a resident noted that the town had modified the dune separating Crab Meadow Beach and the private beach to the west.

As part of the initial field investigation, OCC met with several interested parties at the Indian Hills Golf Course. Participants included: Mr. Paul Mandelick, Chairman of the Town Planning Board; Joseph Caputo, General Manager of the Indian Hills Country Club; Andrew Rapiejko, neighbor; and Paul Zachers, neighbor. OCC was shown the scarp along hole #6, along with photographs showing the progressive enlargement of the scarp. Mr. Caputo indicated that the fairway on hole #6 has not been watered in over a year to try and reduce the movement at the scarp. OCC was also shown the revetment and other site improvements that were completed along the bluff in 2002.

OCC also met with two residents of Makamah Beach, Mr. John Salacain and Mr. Jack Provenzano. Mr. Salacain and Mr. Provenzano indicated that they have seen a reduction of beach sediment in recent years. They indicated that the groin at Indian Hills Golf Course was reset during the 2002 site work and that this groin is preventing sediment from reaching Makamah Beach. The residents also indicated that there is a seasonal variation in the beach profile, with a lower beach elevation typically occurring in the winter. Riprap toe protection has been approved by the State Department of Environmental Conservation – the riprap will be used along the toe of the existing bulkheads to prevent on-going scour problems. The residents also described several storm damaged properties and showed photographs of large storm waves overtopping the existing seawalls.

4.0 SITE CONDITIONS

The study area (Figure 1.0-2) is roughly divided by Crab Meadow, which is a wetland preserve and one of the last undeveloped salt marshes on the north shore (USACE, 1995). To the west are Crab Meadow Beach, partially owned by the town, and "Waterview Beach", a private beach owned by several neighborhood associations. At the end of Waterview Street there is a public property known as the Kirschbaum Property. On the east side of Crab Meadow are several beaches, starting with Makamah Beach to the west of Makamah Road and Geissler's Beach to the east of Makamah Road. The "Broken Ground" area, including Indian Hills Golf Course, occupies a large portion of the shoreline east of Geissler's Beach and Fresh Pond beach stretches between the golf course and the Smithtown town line. While most of the nomenclature used for the various project segments is from published sources, OCC will use the Waterview Beach designation for the area between Northport Keyspan Power Station to the west and Crab Meadow Beach to the east. Likewise, OCC will use the Fresh Pond Beach designation for the area east of Broken Ground to the Smithtown town line.

4.1 EXISTING CONDITIONS AND USES

For the purposes of this report, the study area has been characterized by a number of variables. The following sections describe the physical attributes of the study area.

4.1.1 Shoreline Protection

There are multiple forms of shoreline and bluff protection present in the study area (Figure 4.1-1). The most common are timber bulkheads (vertical) (Photo 4.1-1) and/or riprap revetments (Photo 4.1-2) (22 percent and 21 percent, respectively). Groins (Photo 4.1-3) are also prevalent in the western and eastern portions of the study area; many of the groins have been in place since the 1940's. A substantial portion in the middle of the study area (from Crab Meadow Beach to the west end of Makamah Beach) has no shoreline or bluff protection structures (45 percent; Photo 4.1-4). The remaining shoreline (12 percent) has a variety of miscellaneous shore protection structures (Photos 4.1-5 and 4.1-6), including large diameter circular culverts placed upright along the eastern portion of Indian Hills Golf Course (4.1-1).

Figure 4.1-1: Types and locations of bluff and shoreline structures in the study area.

An aspect of erosion control structures noted in the field, but not classified is the condition of the structures. Some bulkheads and erosion control structures (groins) were new, while others, especially groins on Waterview Beach, were dilapidated.

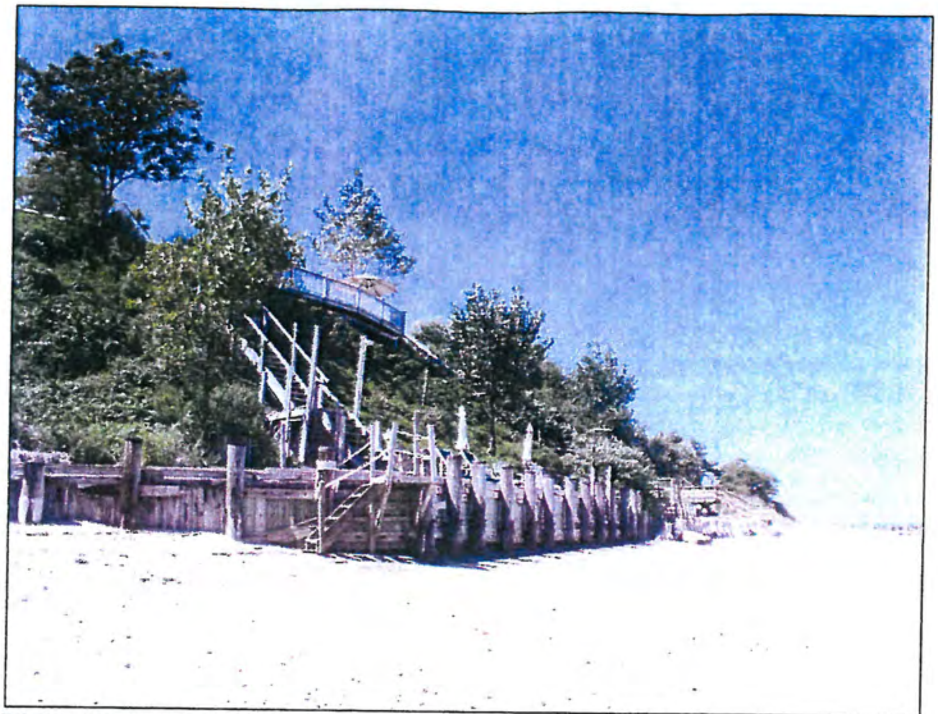


Photo 4.1-1: Typical timber bulkhead protected shoreline.

Photo 4.1-2: Riprap revetment.

Photo 4.1-3: Typical wooden groin on western section of study area.

Photo 4.1-4: Natural shoreline.

Photo 4.1-5: Miscellaneous (upturned culverts) shore protection east of Indian Hills Golf Course

Photo 4.1-6: Concrete seawalls on Makamah Beach.

4.1.2 Dunes and Bluffs

Dunes and bluffs are prevalent along the study area as well as along the North Shore of Long Island. Erosion of bluffs contributes sand to the system allowing dunes to form and provide substrate for dune grasses such as American and Panic beach grasses (*Ammophila breviligulata* and *Panicum amarum*), which helps to stabilize the sediment. The dunes, in-turn, protect bluffs from moderate wave conditions. Areas without dunes (where once existing) indicate a negative sediment balance (Coates et al., 2000) (Figure 4.1-2). About 55 percent of the study area does not have dunes; the remaining (45 percent) has mainly small (less than 2 feet high) dunes.

Figure 4.1-2: Map of dunes location and relative size along the study area.

Bluffs in the study area were categorized based on relative heights (Figure 4.1-3). Bluff heights in the study area are typically lower than 40 feet (USACE, 1969). Four categories of bluff heights were defined based on heights estimated during field work: none, low (0 to 15 feet), moderate (15 to 30 feet), and high (30+ feet). High bluffs are most common on the western portion of the study area and are mainly protected by erosion control structures (Figure 4.1-1). Moderate sized bluffs on the central-eastern portion of the study are largely unprotected. Moderate and high bluffed shorelines make-up 51 percent the study area, areas with no bluffs, mainly in the center of the study area, comprise 39 percent, and the remaining 10 percent of the study area is characterized by low bluffs.

Figure 4.1-3: Map of relative bluff heights.

Bluff erosion occurs through several processes including overland flow (sheet-flow), slumping (caused by groundwater), toe erosion (from waves), and overwash from wave overtopping (behind revetments or bulkheads). In general the entire western portion of the study area had stable bluffs; a result of bluff stabilization and/or bulkheads and wide beaches. In the eastern portion, there are areas of active bluff erosion (Figure 4.1-4).

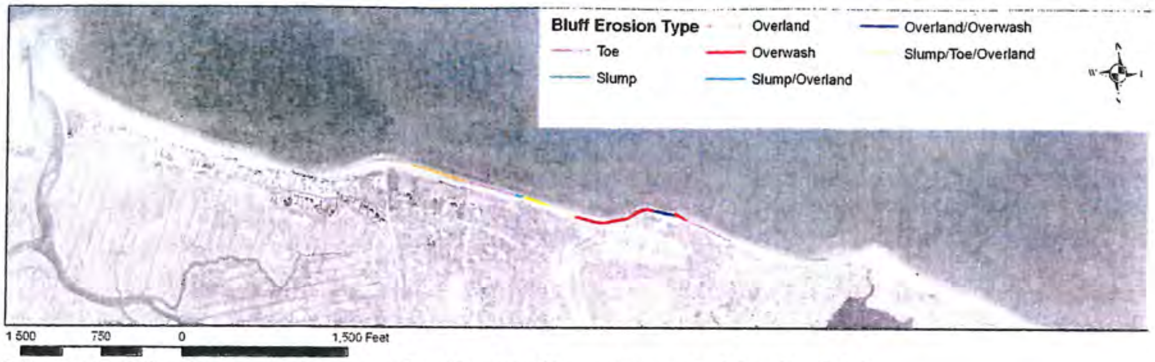


Figure 4.1-4: Areas and types of active bluff erosion noted in the field.

4.1.3 Development Type

Coastal development types defined for this study included public, commercial, residential, and undeveloped or open. Of the entire shoreline (14,500 feet) about 50 percent is residential, 35 percent is public, 12 percent is commercial (Indian Hills Golf Course), and 3 percent is undeveloped residential (Figure 4.1-5).

Figure 4.1-5: Shoreline upland development.

4.1.4 Coastal Vegetation

Following the New York Natural Heritage Program's classification system "*Ecological Communities of New York State*" (Reschke, 1990) the communities present within the study area can be grouped into four main categories, as follows. Table C.1 in Appendix C provides a list of the vegetation commonly found in the Huntington study area:

- <u>*Maritime beach*</u> – the sparsely vegetated, unstable sand, gravel and cobble beachfront directly impacted by waves.
- <u>*Maritime dunes*</u> – occupy the high beach area away from the influence of diurnal tides, and are characteristically covered by a meadow of beachgrass (*Ammophila*

breviligulata), beach pea (*Lathyrus japonicus*), dusty miller (*Artemisia stelleriana*) and seaside goldenrod (*Solidago sempervirens*).

- Maritime shrubland – the community that covers the bluff face exposed to high winds and salt spray, or located immediately upland of stabilized dunes. Characteristic vegetation varies depending upon the soil types occupying the bluff face. Typical shrub species that occur on the dry soils (e.g., Carver and Plymouth sands) include northern bayberry (*Myrica pensylvanica*), beach plum (Prunus maritima), winged sumac (*Rhus copallina*), planted or escaped beach rose (*Rosa rugosa*) and shadbush (*Amelanchier canadensis*). Tighter clays or wetter soils (e.g., Scio or Walpole) support black willow trees (*Salix nigra*), cottonwood (*Populus deltoides*) saplings, pussy willows (*Salix discolor*) and common reed (*Phragmites australis*).

- Successional maritime forest – a deciduous woodland community that has developed on the formerly eroded, but now relatively stable bluff faces. The plant species seem to vary depending on the relative stability of the substrate, the height of the bluff crest above sea level, and the composition of the woodland communities in the adjacent uplands. Shadbush, black cherry (*Prunus serotina*), eastern red cedar (*Juniperus virginiana*), and sassafras (*Sassafras albidum*) were typically found on the lower portions of the slope, while stands of invasive black locust (*Robinia pseudoacacia*) and Norway maple (*Acer platanoides*) were found to dominate nearly the entire bluff face adjacent to Waterview Street on the western portion of the study area.

With the exception of the Crab Meadow tidal flats, which are situated south of the study area, estuarine high marsh and intertidal plants were noticeably lacking along the Sound shorefront throughout the study area. One patch of remnant peat bog was evident just west of the public beach access at Makamah Road, but it did not support any tidal wetland vegetation.

A relatively wide maritime beach occurs immediately east of the Northport Power Plant, along with an established maritime dune, maritime shrub and maritime woodland community behind. The gradation between these four community types is evident in Photo 4.1-7, looking west along the shorefront towards the Northport Power Plant.

Photo 4.1-7: Vegetation communities at the west end Waterview Street.

Another wide maritime beach area is evident on the west end of Makamah Beach, that harbors a colonial shorebird-nesting colony for Federally threatened and State endangered piping plover (*Charadrius melodus*), and State endangered least tern (*Sterna antillarum*). A well developed maritime dune, maritime shrub and early developing maritime woodlands occupy the upland areas behind the western end of Makamah Beach.

Relatively narrow maritime dunes are found along the remainder of the project area, particularly along Soundview Terrace (Waterview East) and east of the Makamah Road (Geissler's Beach). This narrow dune area is likely due to a combination of factors, including a lack of beach width to provide an adequate supply of sand to nourish the dunes, plus an inadequate separation between the rear of the dunes and adjacent residential areas to allow for natural dune migration and height development.

The type and coverage of vegetation above coastal protection features varies depending upon the elevation above high tide and the level of human intervention. Low profile cobble revetments, as seen in Photo 4.1-8, just east of the Makamah Road end, have allowed a narrow dune to develop at the toe of the bluff.

Photo 4.1-8: Low-profile stone toe protection.

In contrast, many shorefront residents have taken more elaborate measures to landscape the bluff face and have constructed bulkheads and sea walls, as evident in Photo 4.1-9. In these cases, horticultural specimens and hybrid plant varieties have been installed, often in conjunction with small timber terraces or masonry retaining walls for additional slope stabilization.

Photo 4.1-9: Timber bulkhead and landscaped bluff.

The effectiveness of these landscape treatments at controlling long-term bluff erosion is dependant upon a number of factors, including but not limited to: the degree of toe protection, the slope of the bluff, bluff soil and drainage characteristics, proper plant selection, and maintenance activities on the bluff face and above the bluff crest. Chronic, severe bluff erosion has occurred at the Indian Hills Golf Course (Photo 4.1-10). The Country Club has implemented numerous vegetative and structural practices to alleviate these problems and some have proven more successful than others. The vegetative and bio-engineering techniques that can be implemented for shorefront stabilization are discussed in Section 7.4.2.

Photo 4.1-10: Severe bluff erosion at the Indian Hills area.

4.1.5 Public Access

Public access to and use of the shoreline is concentrated mainly at Crab Meadow Beach. The only other car accessible area is at the end of Makamah Road; the public beach is known as Geissler's Beach. This is a relatively un-crowded beach used mostly by local residents.

The entire shoreline below the mean high water line is open to the public. Residential and commercial areas with narrow beach widths have access problems during high tide when the water reaches the bluffs or structures.

Areas with narrow beach widths, which are considered potential problems for public access at higher tide levels, are depicted in Figure 4.1-6. Groins can also present access problems depending on the condition of the groin and difference in elevation on either side. The most critical public access area is just west of Makamah Road. The public beach at the west end of Makamah Beach (adjacent to Crab Meadow) is only accessible from the public access area at the end of Makamah Road. In order to reach the western public beach, the public must cross the narrow beach at the east end of Makamah Beach.

Figure 4.1-6: Areas that may impede the public access to the shoreline.

4.2 PHYSIOGRAPHIC CONDITIONS

In addition to the data collected in the field, a range of previously collected data was included to define the overall environmental setting. This data included soil, geologic, and elevation data from the National Resource Conservation Service (NRCS), the New York Geological Survey, and the United States Geologic Survey (USGS) Eros Data Center.

4.2.1 Surface Geology

The surface geologic map (NY Geological Survey) shows that the area is dominated by till and moraine deposits (tm) and with pockets of kame (k) or melt-water features such as eskers (see Photo 4.2-1). In addition, there are exposed outcrops of Cretaceous sediments in the area around Indian Hills Golf Course (see Photo 4.2-2). The surface geologic units, to a large degree, define the shallow hydrology; melt-water features have high permeability and Cretaceous clays have almost none (aquiclude). Till and moraine units have varying levels of permeability depending on location.

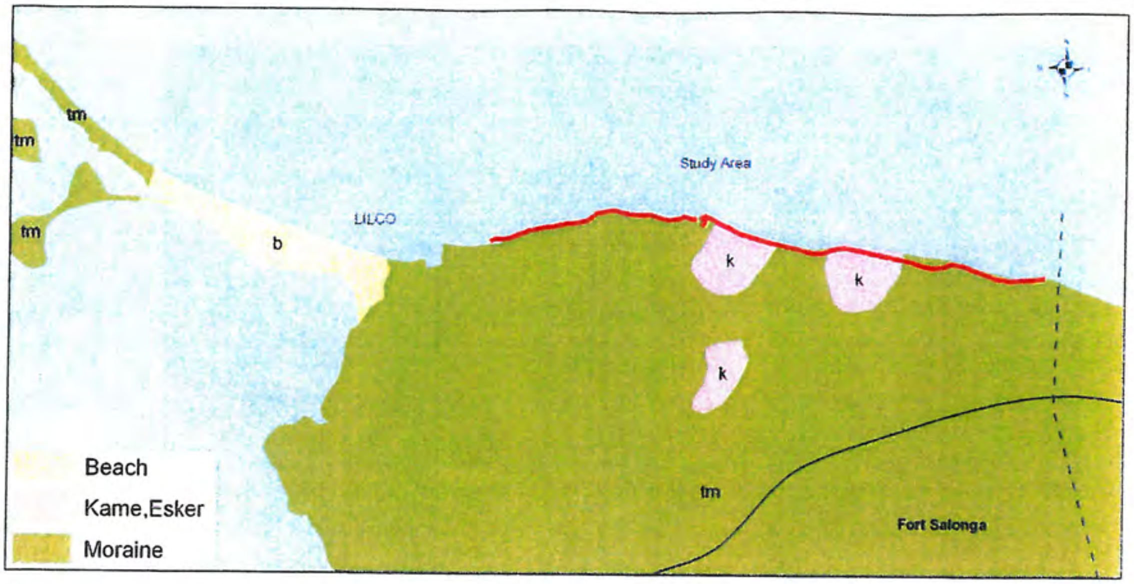


Figure 4.2-1: Surface geology in study area; terminal moraine (tm), kame (k), and beach (b) deposits dominate the surface features.

Photo 4.2-1: Bluffs in area of melt-water (k) deposits adjacent to Geissler's Beach.

Photo 4.2-2: Brownish orange colored Cretaceous clay outcrops offshore (north) of Indian Hills Golf Course.

4.2.2 Soil Types

There are multiple soil types that have been mapped (NRCS, 2005) in the study area (Figure 4.2-2). Based on field observations, the mapped soil type appears to correlate with the general condition and aspect of the bluffs as well as the geologic surface units. Implementation of vegetative solutions is dependent on the type of soil present. Additionally, soil type has a bearing on the stability of the bluffs (Table 4.2-1).

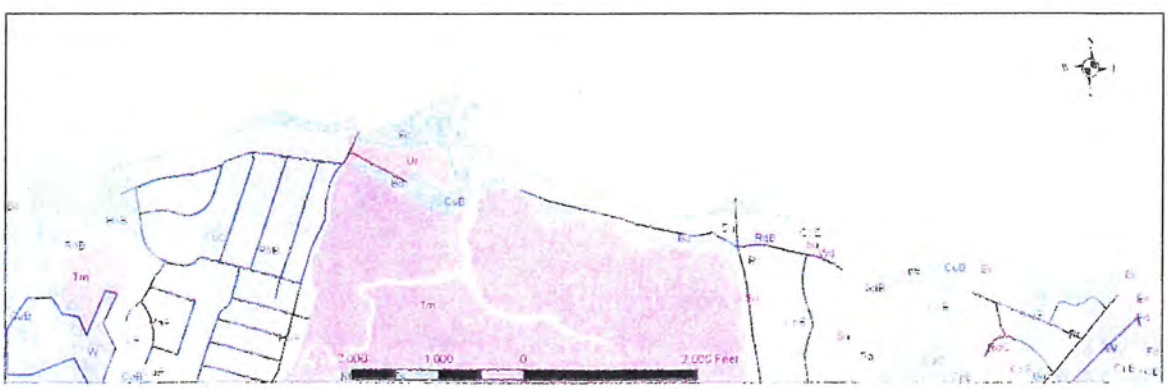


Figure 4.2-2: Map of soil types in the study area; see Table 4.2.1 for soil type descriptions.

Table 4.2-1: Overview of the coastal soils and their erosion potential.

Soil Type	Symbol	Description
Beach	Bc	Littoral and wind drift sediments
Carver Plymouth sands (15-35 percent slopes)	CpE	Moderate to severe erosion, low natural fertility
Dunes	Du	Should be stabilized and left undisturbed
Escarpments	Es	No soil profiles, actively eroding
Fill land	Fd	Fill sediments
Haven loam (2 - 6 percent slopes)	HaB	Slight to moderate erosion, run-off concerns
Riverhead sandy loam (3 – 8 percent slopes)	RdB	Slight to moderate erosion, run-off concerns
Scïo silt loam, sandy substratum (2 - 6 percent slopes)	SdB	Slight to moderate erosion,
Sudbury sandy loam	Su	Slight erosion hazard, maintains moisture
Urban land	Ur	Greater than 80 percent coverage by buildings/pavement

4.2.3 Elevation and Flood Data

Elevation data was sourced from the National Map (USGS); the 1/3 arc second (30 meter spacings) data, is the best available data. Although not accurate enough for detailed spot elevation analysis it does provide an overall estimate of areas with high slopes (Figure 4.2-3). The combination of high slopes, soil types, and underlying geology provides important baseline management data. The highest slopes (greater than 30 percent), quite predictably, correspond with the highest bluff areas and are dominant on the western third of the study area.

Figure 4.2-3: Map of relative slope.

The 1998 Federal Emergency Management Administration (FEMA, 1998) Flood Maps have defined the Zone VE (structural hazard (velocity) wave zone) Base Flood Elevation (BFE) as 16 feet NGVD along the entire study area (Figure 4.2-4). Adjacent to the VE Zone, the AE Zones typically have a BFE of 13 feet to the west and 12 feet to the east. It appears that the BFEs on some of lots on Makamah Beach Road have been revised through a Letter of Map Change (LOMC). However, the revisions appear inconsistent with surrounding properties and conditions. The FEMA data predates changes to the shoreline at the Indian Hills Golf Course.

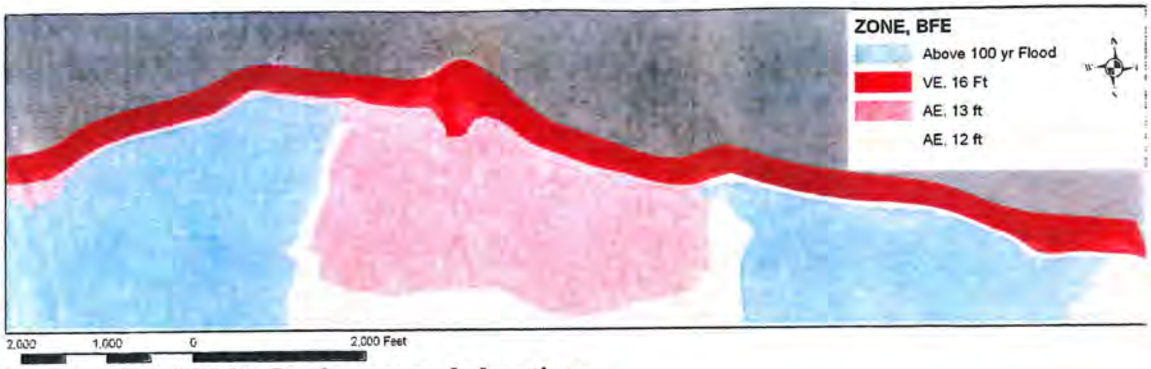


Figure 4.2-4: FEMA flood zones and elevations.

4.2.4 Broken Ground Geology

The geology in the area known historically as "Broken Ground", including the Indian Hills Golf Course and immediately adjacent areas, differs substantially from the surrounding geologic units. This area is underlain by Cretaceous sediment deposits, which may have been reworked by glacial ice sheet and incorporated into the moraine deposits (Bennington et al., 1999). The exposed portion of clay on the beach and bluff base appears to be the clay member of the Raritan Formation or a clay rich layer of the Magothy Formation, which acts as a confining unit over the lower Lloyd sand member. This clay unit effectively separates the surficial unconfined aquifer from the underlying Cretaceous aquifer and, thus, limits vertical groundwater movement. The lack of downward connectivity to underlying aquifers creates a situation that favors oversaturation and high pore pressures in the surface aquifer and slippage (landslides) along bedding planes.

This area has a history of substantial slope failures (Nelson & Pope, 1990; Fuller, 1914; USACE, 1969) most likely related to a saturated and weak underlying clay layer. The visible evidence of a deep seated failure plane is a scarp. The scarp is about 2000 feet long and is visible in historic aerial photographs dating back to at least the 1940s. The scarp is semi-circular in plan, with the ends extending to the shoreline to the east and west of the Indian Hills Golf Course. The scarp extends about 500 feet inland at its maximum.

In 2002, the bluff along Indian Hills Golf Course was re-graded and a stone revetment was constructed along the bluff toe. The purpose of the 2002 work was to help stabilize the bluff. A previous engineering report (Nelson & Pope, 1990) identified several causes of bluff instability and erosion: beach erosion due to groins; erosion of the toe of the bluff due to storm waves; an unstable slope of the bluff; and surface runoff. The 2002 work addressed each of these causes: removal of several groins to promote long shore sediment transport; installation of a stone revetment along the bluff to prevent toe erosion; re-grading the bluff to a stable slope; and surface water drainage improvements. The 1990 report also identified several possible options for stabilizing the failure plane associated with the clay layer. However, the report recommended additional analyses be completed prior to engineering a solution for the slope failures.

Since 2002 there has been additional differential soil movement along the scarp. Several areas along the scarp have developed near vertical faces and substantial depressions that channel water into the failure plane. Visual inspection, discussions with golf course staff and review of photographs indicates that vertical movement of up to 4 feet has occurred since 2002 (see Photo 4.2-3). While the work completed in 2002 has reduced erosion of the bluff toe it has not eliminated soil movement along the underlying failure plane.

Photo 4.2-3: Soil failure plane and vertical scarp at Indian Hills Golf Course.

Without a substantial engineering and construction effort, this observed soil movement is expected to continue, eventually resulting in a complete slope failure. Storm water runoff, irrigation and inadvertent discharge of water (through broken pipes) will likely contribute to the on-going soil movement. As the depression expands, additional surface water enters the failure zone and further reduces the strength of the clay layer.

4.3 OCEANOGRAPHIC – PHYSICAL CONDITIONS

An in-depth analysis of the wave climate and associated littoral drift is beyond the scope of this work; however, wave information has been developed for the area in the Northport Power Station Littoral Drift Study (LILCO, 1977). In general, mean wind speeds are about 13 miles per hour in the winter months with resulting wave heights of 2.3 feet and periods of 3.5 seconds. These are not storm-generated waves, but what a typical winter day may create and would not lead to any significant beach changes. Storm waves would likely be two to three times the presented wave heights and about two times the period.

Storm flood levels are sourced from the USACE New England Coastline Tidal Flood Survey (USACE, 1986) and show that the 100 year tidal flood elevation is between 11.5 feet NGVD-29 (western end) and 11.3 feet NGVD 1929 (eastern end) in the study area. This is consistent with the flood insurance rate maps (FIRMs) that show 100 year flood elevations between 12 and 13 feet (AE Zones).

Longshore transport of littoral sediment has been quantitatively estimated in previous reports (LILCO, 1977) between 3,000 and 6,000 cubic yards per year to the west. Based on field observations most of the area appeared to have westerly directed longshore transport; however, on the eastern end of the study area between Indian Hills Golf Course and the Smithtown line (Figure 1.0-2) there were areas that appeared to have localized eastward directed longshore transport. This is not uncommon given that during the summer months southwest winds dominate, but it was not noted in other areas. It may indicate that net transport rates are lower on the eastern portion of the study area than on the western portions.

Photo 4.3-1: Groin on eastern portion of study area (note possible accumulation of sediment on the west (left) side of the groin, possibly indicating seasonal eastward littoral drift).

Photo 4.3-2: Groin on western portion of study area with elevation difference from east to west.

On and off-shore directed sediment transport (cross-shore transport) is not defined in the previous works. Parallel bedforms (bars) are present offshore of the study area (see for example Figure 4.2-3) which are indicative of cross-shore transport. They are more pronounced to the east of the inlet at Crab Meadow, suggesting that cross-shore transport plays a larger role in littoral transport in the eastern portion than in the western portion of the study area. Anecdotal discussions with the residents of Makamah Beach indicate that the beach tends to fill in during the summer and retreat during the winter, which would indicate cross-shore transport and/or seasonal variation in wave energy. However, over the years, there has been a net loss of sand, with progressively less sand returning to the beach during the summer months.

5.0 COASTAL ANALYSIS

An historic analysis of shoreline and bluff change was undertaken at the site to define long and short-term trends. This information, in concert with the existing uses and conditions will be used to define management options and shoreline stabilization in discrete stretches of the shoreline.

5.1 DATA SOURCES

Several different sources of information were gathered for use in the coastal analysis. These included aerial photographs, historic maps, and navigation charts. A complete list of data sources is provided in Appendix B. The 1994, 2001, and 2004 aerial photographs from the New York Geographic Clearinghouse were ortho-rectified and used to geo-rectify the older un-projected data in the GIS using photo identifiable points. Definition and resolution of the historic aerial photos and maps was typically less than the reference ortho-photos. This and the availability of similar features in the older photos resulted in positional errors. The average root mean squared (RMS) errors for each photo date are listed in Appendix B.

Maps and charts do not have assigned accuracies since the maps were geo-referenced based on locations of street intersections shown on maps (many of the present streets were present in 1837). Road work may have changed the absolute locations of intersections and unique road features, which makes any error estimates difficult. However, based on past experience with geo-referenced historic maps, the accuracy is generally within 50 feet. Judging on the location of historic bluff lines with present, this value appears to be a good approximation of accuracy.

5.2 METHODOLOGY

The data, including physiographic information, were analyzed in a GIS system (ESRI ArcMap®). The project included analyzing changes of both bluff and "shoreline" features. These line features were derived largely from aerial photographs and their spatial character (location) were analyzed using an end point (EP) technique that is similar to creation of "transects" to measure offset.

To maintain consistency with data defined in the field work, the HWL (shoreline) and toe of bluffs and dunes were defined in aerial photographs and on maps. Definition of the HWL from aerials is a commonly used technique and is defined as the change in gray-tones resulting from soil moisture variation (Honeycutt et al., 2001; Zhang et al., 2002), seaward debris lines (McCurdy, 1950) or extent of run-up during high tides (Fenster and Dolan, 1999). Although the historic photos were not time stamped, relative tide level could be discerned using reference structures (groins) as indicators.

Errors in interpreted shorelines from historic photos have been estimated at about 25 feet (Crowell, et al, 1991), however newer ortho-rectified photos have lower positional errors (Ruggiero, et al, 2003) and when used by a single analyst have low (2.0 meter / 6 feet) HWL identification errors. Based on the previous work, the older (pre-1994) shoreline data is assumed to be within 25 feet of actual, and the newer data (1994 to 2004) is assumed to be within 10 feet of actual.

Errors associated with dune locations are largely dependent on the level of vegetation and dune geometry; consistency was maintained by using the edge of vegetation as the "dune toe". Errors in dune location are likely consistent with the HWL since both rely on tonal changes in the photograph.

The toe of the bluff is a bit more difficult to define; in some locations with steep bluffs or fronting seawalls the location is easy to discern. Where bluffs are actively eroding or slumping the transition from bluff to dune can be difficult to define. Bluff toe location is conservatively estimated at twice the HWL error (50 feet for pre 1994 and 20 feet for post 1994 data).

The methodology of comparing and measuring feature location is somewhat similar to drawing imaginary lines (transects) across the beach and measuring the distance from the start of the transect to where the shoreline or bluff line intersects the transect. The only difference is that instead of a line, a 25 foot length of beach was used; the study area consisted of 578 sections of beach. The base-point for making measurements is the location of the 2005 GPS derived HWL shoreline (negative distance indicates locations offshore of the 2005 HWL, positive distance indicates locations onshore of the 2005 HWL). Using the calculated distances and known date of the shorelines and bluffs/vegetation lines, yearly change or total change can be determined for at each of the 578 sections for any combination of years.

This information can be queried or selected based on a set of conditions, such as shorelines with greater than 1 foot per year of erosion, 45 foot wide beaches, no shore protection, and/or bluff change since 1970 of more than 30 feet. These areas can then used to define different types of management strategies or erosion controls.

5.3 RESULTS

The results provide an insight as to the trends occurring along the study area, and form the basis of management strategies. An important distinction at the site is the definition of "long-term" as opposed to recent or "short-term" changes. There is a level of variability from season to season, if not from day to day, that must be accounted for in any short-term analysis. Long-term analysis is less sensitive to individual events such as storms, but the results can represent a mix of very different site conditions. For example, bluff erosion prior to any type of stabilization will be combined with bluff erosion following recent stabilization efforts. Long-term changes, say greater than 60 years, may also suffer from less exact data sources. With these caveats in mind, and with the necessity to provide historical as well as recent trends, the long-term trend is being defined as 1947 to 2004, the recent trend from 1972 to 2004, and the present trend from 2001 and 2004. 1972 was chosen as a mid-point because it represents the period when bluff stabilization became widespread over the study area. Shoreline stabilization structures, mainly groins, were in place since the 1940's.

5.3.1 Shoreline Change

Shoreline change is based on the previously described data sources and methodology. Shoreline erosion rates are based on the 2004 data set to standardize the approximate date of collection. Aerial photos were typically taken in the spring months (March to April); the field collected 2005 shoreline, however, represents a summer shoreline position.

5.3.1.1 Historic Trend

The overall change from the first reliable map (circa 1837) to present provides a perspective in the formation of the North Shore region. Based on the map and the present shoreline, retreat is an inherent component of the eastern portion of the study area. Specifically, there has been up to 500 feet of bluff and 250 feet of shoreline retreat at the Indian Hills Golf Course (Broken Ground) and Makamah Beach respectively (Figure 5.3-1).

In contrast, the shoreline just west of Crab Meadow Beach appears to have remained nearly constant for the past 170 years. The stability is partially a result of the nearshore reef exposed during low tide at this location (Photo 5.3-1) and the groins that have been effective at stopping or slowing longshore drift (Photo 5.3-2). This area appears to have a high longshore component to the sediment transport.

Another notable change is the relocation of the tidal channel (inlet) feeding Crab Meadow marsh; this highlights the inherent dynamic nature of the barrier spit. The jetty that was built along the inlet (early 1900's) has essentially stabilized the inlet location and no future change is expected.

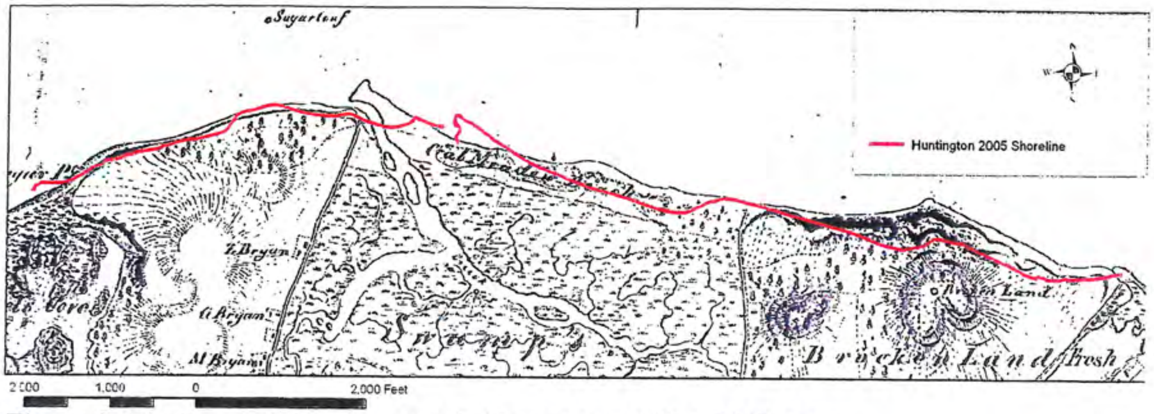


Figure 5.3-1: Present shoreline overlaid on geo-rectified 1837 map.

Photo 5.3-1: Offshore cobble reef (tidal flat) near the area of exceptionally stable beach just west of Crab Meadow Beach.

Photo 5.3-2: Groins west of Crab Meadow Beach (from USACE, 1969).

5.3.1.2 Long-Term Trend

Although the historic United States Coast and Geodetic maps are generally a good reference for long-term change rates (Shalowitz, 1964), confidence in geo-rectification was much higher with aerial photographs. For this reason, quantitative long-term shoreline change has been calculated between the 1947 and 2004 shorelines derived from aerial photographs.

The long-term change from 1947 to 2004 in the study area averages just over 1 foot per year (1.15 feet per year) with a standard deviation of 1 foot year. About 83 percent of the shoreline has retreated during the period; the notable exception is in the area of Crab Meadow Beach.

In regards to the standards as outlined in Article 34, Coastal Erosion Hazard Areas (O'Neil, 1998), which was adopted by the Town of Huntington, erosion of more than 1 foot per year is considered high and areas experiencing this level of shoreline retreat are classified as Structural Hazard Areas. Based on the calculated long-term rate, about 55 percent of the shoreline would be classified as such, and includes nearly the entire eastern half of the study area. To this point no Structural Hazard Areas have been defined on the Coastal Erosion Hazard Area maps (New York State Department of State, 1999).

Figure 5.3-2: Areas of erosion and stability over the past 57 years.

5.3.1.3 Recent Trend

"Recent change" is defined as the change between 1972 and 2004. Prior to about 1970 there were few areas with shoreline stabilization (New York State Department of State, 1999); following 1970 rapid increases in shoreline stabilization occurred. Therefore, this period typically provides the longest record of the changes associated with interactions between the natural processes and erosion control measures/structures. While the groins on the western section of the study area have been in place since at least the 1940s, bluff stabilization and shoreline stabilization on the eastern portion of the study area has increased substantially since 1970.

The average recent shoreline change between 1972 and 2004 is about half of the long-term rate (0.5 feet per year); this is likely a result of the widespread implementation of erosion control structures. The standard deviation during the period was nearly identical to the long-term at about 1.2 feet per year (fairly uniform change). During this period, 66 percent of the shoreline has some level of erosion at and 33 percent has retreated at a rate of more than 1 foot per year.

Figure 5.3-3: 1972 to 2004 shoreline change.

Comparison of the two 30+ year data sets (long-term and recent) clearly shows that the middle of the study area has a consistent erosional signature. Bluff stabilization on the eastern end near the Smithtown line resulted in a change from critical (more than 1 foot per year) to sub-critical erosion; however beach width reduction and limited dune formation are common associated outcomes.

5.3.1.4 Present Trend

The present shoreline change, between 2001 and 2004, actually shows an overall accretionary signature; the average yearly change is 1.75 feet per year. Since this data represents such a short period of time, however, the resolution of the data should be considered. Small errors, those within the range of the technique, are averaged over a limited period and become a larger percent of the result, which is indicated by a six-fold increase in the standard deviation (6.75 feet per year) over the previous data sets. It is more likely that an overall stability has been achieved because areas where the shoreline meets a shore protection structure can no longer retreat at historical rates and those areas with accretional trends, such as the spit at the western end of Makamah Beach and beach near the power plant, continue to advance seaward.

Figure 5.3-4: Shoreline change trends from 2001 to 2004.

Because this data is limited to the constraints of a short time period, 37 percent of the data is being considered as "negligible" change and corresponds to a change of between -2 and 2 feet per year. Of the remaining, 23 percent is eroding (> 2 feet per year) and 40 percent is accreting. The accretionary signature in the area of Geissler's Beach (just east of Makamah Road) is the most surprising and, however short-lived, a sign that sediment is being supplied to and staying on the beach. As with previous periods, a continued signature of erosion is evident on Makamah Beach.

Despite the fact that there are limitations with the data between 2001 and 2004, they are useful for establishing discrete erosion locations or "hot spots" that are vulnerable to episodic events. For example, an area adjacent to a shoreline structure that has experienced heightened erosion could be susceptible to increased storm damage even if it is located in an area showing no, or limited, long-term shoreline erosion. A specific example is on the western portion of the study area where there are multiple groins – some functioning, some not – and a long-term and recent trend of stability. There are areas within this groin field that have present erosion rates of more than 2 feet per year that probably represent episodic events. If the trend continues, episodic events or a series of events may begin to undercut erosion control structures (bulkheads) and destabilize the bluff.

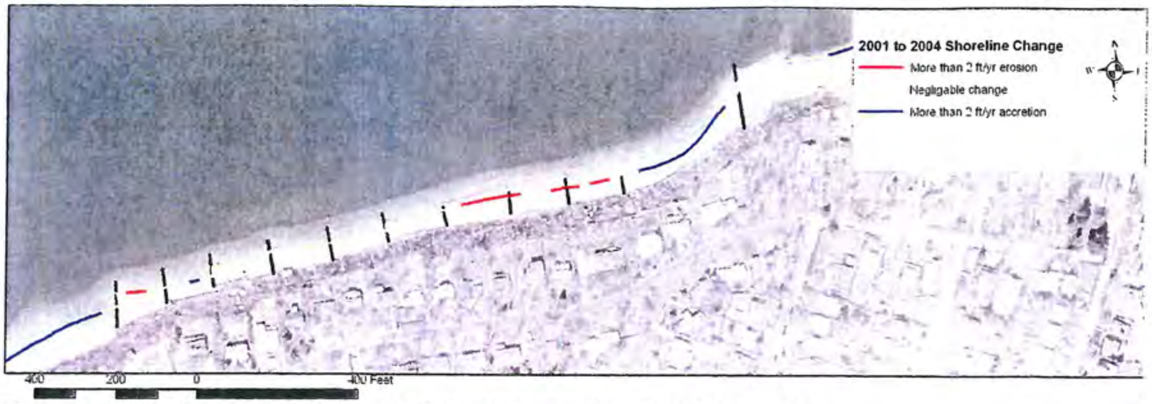


Figure 5.3-5: Discrete "hot-spots" in an area with multiple groins.

5.3.1.5 Chronic Erosion Areas

Sometimes shoreline trends can be skewed by short duration events that mask the actual shoreline change signature. To address this and to condense the shoreline change information, areas with a consistent erosion signature are being considered "chronic erosion areas" (Figure 5.3-6). These areas have long-term, recent, and present erosion signatures (erosional in all periods) and comprise 28 percent of the shoreline.

The areas of concern are clearly Makamah Beach and the eastern portion of the study area. The western portion of the study area may also experience erosion caused problems in discrete areas.

Figure 5.3-6: Areas with a consistent history of erosion.

5.3.2 Bluff Change

Bluff change is linked to shoreline change; shorelines with fortified bluffs can not erode appreciably landward nor, however, can they provide sediment to the system. In this way, bluff change is also a driving force in beach width changes, as beach widths are reduced and steepened in response to lower sediment inputs.

Bluff change was calculated from 1947 to 2004 (Figure 5.3-7) and from 1972 to 2004 (Figure 5.3-8). Bluffs with more than 2 feet per year of retreat are considered "severely eroding", bluffs with retreat between 1 and 2 feet per year are considered "moderately to severely eroding", and bluffs with less than 1 feet per year retreat are considered "moderate to slightly eroding".

Figure 5.3-7: Bluff erosion from 1947 to 2004.

Over the long-term, the highest or most severely eroding bluffs are concentrated in the eastern portion of the study area and correspond to the area known as the Broken Ground (Figure 5.3-1) and also to the area with melt-water glacial deposits, such as the west end of Geissler's Beach (Figure 4.2-1).

Figure 5.3-8: Bluff erosion from 1972 to 2004.

Moderate to severe bluff retreat in the 1972 to 2004 period (period of intense bluff stabilization and bulkheading; NYS Sec of State, 1999) is generally found in areas that either have failing structures or have no structural stabilization measures. The bluffs just east of Makamah Beach Road that are not stabilized are likely in the most jeopardy of continued severe bluff retreat. Bluffs with slight to moderate erosion have historically been protected (Waterview Street Beach) or are naturally stable. The bluffs on the eastern most end of Geissler's Beach are a good example of naturally stable bluffs.

5.3.3 Beach Widths

Adequate beach width is important for protection of residences, bluffs, dunes, and shore protection structures such as bulkheads. Reduced widths limit the beach's ability to dissipate wave energy and results in larger waves reaching the back shore. For example, during storms, beaches offer sacrificial shore protection. During the storm, sediment is moved offshore reducing offshore depths causing waves to break further offshore and steepening the beach. Gradually during periods without storms, sand moves back toward shore, rebuilding the beach and dune system. It is interesting to note that present beach slopes (during the field observation period) along much of the study area appear to have assumed a steep storm beach profile as the normal summer condition.

The relative importance of beach width in reducing loss during storms varies in the study area. Lower lying areas (barrier beaches and spits) such as Makamah Beach rely on beach width to dampen wave heights and runup and reduce catastrophic property damage; beach widths on bluffed shorelines are important for longevity of shore protection structures. For this reason, a sliding scale of beach widths is used to examine damage susceptibility (Table 5.3-1); beach width is calculated by measuring the distance between the HWL and first upland indicator (dunes, bluffs, or shore protection). As with the previous sections, beach width is examined during the past (1947) and present (2004).

Table 5.3-1: Beach width descriptions.

Width (ft)	Bluffed Shorelines	Barrier Beach / Spit Shorelines
0 to 30	Very Narrow	Critical
30 to 60	Narrow	Very Narrow to Narrow
60 to 100	Moderate	Narrow-Moderate
100+	Wide	Moderate to Wide

In 1947, narrow beaches primarily occurred in the area known as Broken Ground (Indian Hills Golf Course) probably because much of the sediment eroding from the bluffs consisted of clay sized grains, which are easily transported away in suspension. Of the barrier beach / spit sections of shoreline, only the area just west of Makamah Road is classified as narrow to moderate.

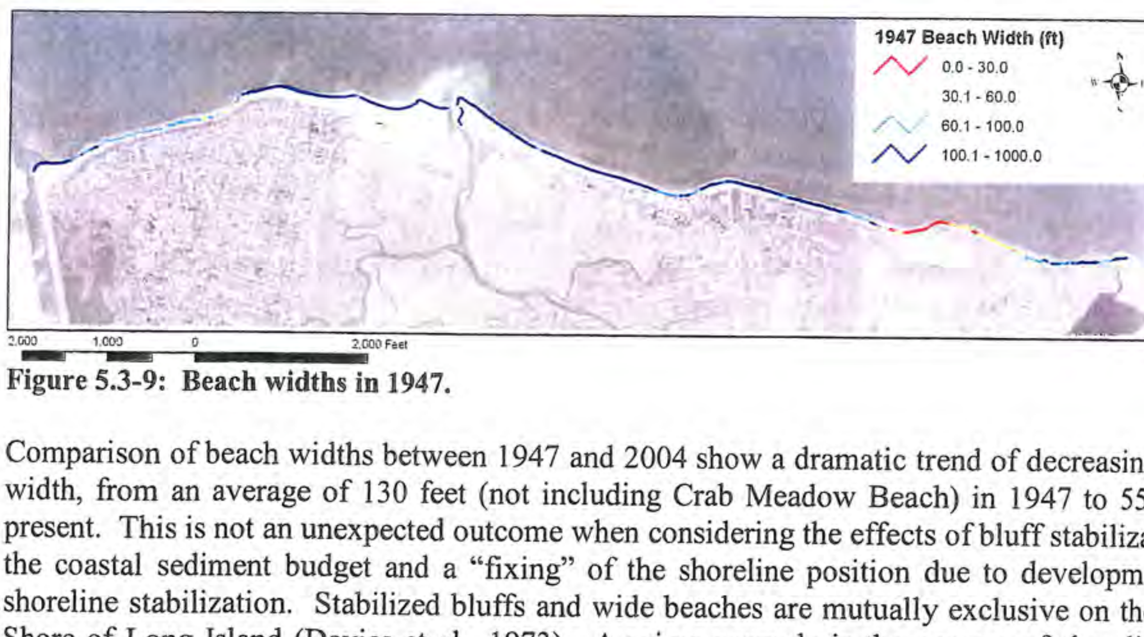


Figure 5.3-9: Beach widths in 1947.

Comparison of beach widths between 1947 and 2004 show a dramatic trend of decreasing beach width, from an average of 130 feet (not including Crab Meadow Beach) in 1947 to 55 feet at present. This is not an unexpected outcome when considering the effects of bluff stabilization on the coastal sediment budget and a "fixing" of the shoreline position due to development and shoreline stabilization. Stabilized bluffs and wide beaches are mutually exclusive on the North Shore of Long Island (Davies et al., 1973). A prime example is the percent of shoreline with beach width below 60 feet (narrow); in 1947, only 15 percent was below 60 feet; in 2005, 60 percent of the shoreline is classified as "narrow".

At present (2004), narrow to critical beach widths exist along most of the eastern portion of the study area. Of this area, the Makamah Beach portion is the most serious since adjacent properties are at low elevations. Property damage and loss due to storms are likely in this area.

Figure 5.3-10: Map of 2004 beach widths.

5.3.4 Overview of Coastal Change

The overriding trends of shrinking beach widths and long-term shoreline retreat coupled with recent bluff stability are indicators of a sand-starved shoreline. This condition can and appears to be offset by increasingly more robust shoreline protection and localized efforts to stabilize bluffs. A major advantage of the area is the stable nearshore which is composed largely of pebble to cobble to boulder sized material that is resistant to erosion; it helps create wide shallow wave buffer and a firm foundation for the shrinking beach. Once the beach width reaches a critical size, however, the constant interaction between shoreline structures (bulkheads) and the waves may render the present shore protection structures inadequate.

5.4 FUTURE TRENDS

Given the scope of the current project, a logical comparison between the natural trends and the present situation extrapolated out 25 years (2030) will help differentiate where the system would be naturally be and where it is currently restrained. This will offer a view into some of the more critical areas and also what the area may look like if the status quo is maintained. Although these scenarios are generated from a long history of data, they do not include any physical modeling such as the interaction between littoral processes and shoreline structures, which will modify the present wave climate as the fronting beaches recede.

5.4.1 Natural Long-term Trend

This is the baseline change scenario such that the long-term shoreline change rate (1947-2004) is projected into the future 25 years (Figure 5.4.-1) and whatever is in the path (bluff or bulkhead) is assumed to be overcome. Although this is not likely due to the existing shoreline protection and development, it does provide insight into where the system naturally wants to evolve to. It does not take into account the most recent trends (present day) and conditions, such as beaches becoming more reflective (steeper) than the broad beaches which characterized the study area when sediment supply was higher, or sea level rise.

Figure 5.4-1: Map of 2030 natural trend shoreline location and beach widths.

The long-term natural scenario suggests, not surprisingly, that much of the sediment present on the shoreline is sourced from the bluffs to the east. It may be inferred that the rate of retreat on the eastern bluffs is higher than at the western bluffs (Waterview Street) because there is a higher percent of fine grained sediments present in the eastern bluffs. The fine sediments (clay and silt) are moved out of the littoral system quickly and contribute little to the overall local sediment budget.

Figure 5.4-1 confirms that the homes along Makamah Beach are in a precarious position and subject to continued erosion and storm damage. The bluffs at Broken Ground and along Fresh Pond Beach are also highly susceptible to damage based on the historic erosion patterns.

5.4.2 Hold the Line

This scenario is consistent with the present strategies of bluff and shore protection and is based on the assumptions that shoreline retreat will stop at the first line of structural shore protection such as a bulkhead (Figure 5.4-2). Shoreline change is based on a weighted combination of long-term, recent, and present change rates so that recent and present trends have greater influence than in the long-term trend scenario.

Figure 5.4-2: Map of 2030 Hold the Line shoreline location and beach widths.

Based on this scenario, about 1/3 of the study area will have no remaining beach fronting shoreline protection structures. Areas that have seen accretion will continue to do so, which may lead to a 'have and have-not' situation. Essentially all of the sediment on the beaches to the east will be lost. Some of the sediment from the eastern beaches will continue to feed the spit at the west end of Makamah Beach. Continued beach nourishment will benefit Crab Meadow Beach and the eastern portion of Waterview Street. Sporadic transport of sediment to the west will continue to feed the western portion of Waterview Street, but overall this section of the study area will experience shrinking beach widths. The decreased beach widths for the 'Holding the Line' scenario vs. the 'Natural' scenario on Waterview Street is a result of the bulkheads/bluff stabilization present (higher weight in model) reducing/precluding the local sediment source (bluffs).

Public access along the entire study area will be very restricted as the water will reach the shore protection structures during a significant portion of the tide cycle, limiting pedestrian passage.

6.0 REGULATORY EVALUATION

6.1 FEDERAL

Section 10 of the Rivers and Harbors Appropriation Act of 1899 and *Section 404 of the Clean Water Act (33 U.S.C. 1344)* define the U.S. Army Corps of Engineers' (USACE) responsibilities for coastal activities and grant regulatory authority for issuance of permits.

Section 10 of the Rivers and Harbors Appropriation Act of 1899 authorizes the USACE to regulate certain structures or work in or affecting navigable waters of the United States. Navigable waters of the United States are those waters that are subject to the ebb and flow of the tide shoreward to the mean high water elevation (MHW), including wetlands.

Section 404 of the Clean Water Act (33 U.S.C. 1344) authorizes the USACE to regulate the discharge of dredged or fill material into waters of the United States, including wetlands. Section 404 of the Federal Clean Water Act requires a permit for the placement of any fill or dredged material, or any excavation in waters of the United States.

Modifications and repairs to existing coastal structures or construction of new structures such as bulkheads, revetments or groins will require a permit under Section 10 and Section 404 regulations. Beach nourishment activities generally require a permit under Section 404 regulations. Structures or work outside the limits defined for navigable waters (MHW) may require a Section 10 permit if the structure or work affects the course, location, or condition of the water body. Therefore, structures such as revetments and bulkheads which are typically above the MHW line may still require a permit if they are viewed to impact Long Island Sound. There are also a number of "Nationwide Permits" which are general permits for activities such as bank stabilization, maintenance to existing structures, and wetland restoration activities.

Any activity affecting federally mapped wetlands would require a permit from USACE. Federally mapped wetlands are present along the shoreline and extend south to encompass areas such as the two KeySpan canals, Crab Meadow wetlands and Fresh Pond.

Typically, USACE permits are filed under a "Joint Application for Permit" with the New York State Department of Environmental Conservation (NYSDEC) with a single form and required attachments. In addition to the "Joint Application for Permit", USACE requires that a Federal

Consistency Assessment Form (FCAF) be submitted to the New York State Department of State (NYSDOS), Division of Coastal Resources. The federal Coastal Zone Management Act (CZMA) requires that actions conducted by, funded by or authorized by federal agencies are consistent with the New York State Coastal Management Program and/or the Long Island Sound Coastal Management Program. The federal regulations that implement the consistency provisions of the CZMA are found at 15CFR Part 930. Federal consistency provisions apply to activities in the State's coastal area and outside of the coastal area when the activities would affect coastal resources or coastal land and water uses. NYSDOS will review any proposals against the coastal policies of the Long Island Sound Coastal Management Program to ensure the project is consistent with the goals of this program (see Section 6.2.3 below).

The USACE also coordinates compliance with related federal laws including the National Environmental Policy Act, the Fish and Wildlife Coordination Act, the Endangered Species Act, National Flood Insurance Act of 1968 (as amended), Executive Order 11988 on Flood Management, and the Magnuson-Stevens Fishery Conservation and Management Act as amended by the Sustainable Fisheries Act of 1996.

The Federal Emergency Management Agency (FEMA), although not a regulatory branch, does play a role in determining where economically feasible development can occur. FEMA also establishes construction standards and restrictions for structures located with in a mapped flood zone. In addition, the Coastal Barrier Resources Act (CBRA) also applies to the study area in that it restricts federally sponsored activities, such as beach renourishment, that promote new development. The CRBA does have exceptions such as federal funding may be provided for nonstructural projects to restore natural stabilization of shorelines. Similarly, section 341 of the Omnibus Reconciliation Act of 1981 terminated Federal flood insurance after October 1, 1983, for new construction or substantial improvement of structures located on undeveloped coastal barriers. The CBRA zone includes Crab Meadow Beach and Marsh areas, however, there are no private properties in the, CBRA (Figure 6.1-1).

Figure 6.1-1: Coastal Barrier Resources Act zone.

6.2 STATE

The New York State Department of Environmental Conservation (NYSDEC) has authority under the Uniform Procedures Act of the Environmental Conservation Law to administer permits for coastal erosion control, excavation and fill in navigable waters, and activities affecting tidal wetlands. The Act provides time frames and procedures for filing and reviewing applications, providing public notice, holding public hearings and reaching final decisions. The Act is intended to ensure a fair, timely, thorough review, eliminate inconsistent procedures, and encourage public participation. The Division of Fish, Wildlife and Marine Resources of the NYSDEC has been granted authority under Article 25 of the Environmental Conservation Law (ECL) to regulate tidal wetlands. Regulatory jurisdiction over coastal erosion control structures and coastal erosion hazard areas has been granted to NYSDEC Division of Water under ECL Article 34. Additionally, NYSDEC enforces the State Environmental Quality Review Act (SEQRA) (NYCRR Part 617) to determine if an action may or may not have a significant effect on the environment. Finally, the New York State Department of State (NYSDOS) ensures that actions are consistent with State Coastal Policies and in the case of this study area, the Long Island Regional Coastal Management Program policies (19 NYCRR Part 600.6).

6.2.1 Tidal Wetland Land Use Regulations

NYSDEC has the authority to preserve and protect tidal wetlands, and to prevent their despoliation and destruction under the regulations of 6 NYCRR Part 661. As defined in this section, "Tidal Wetlands" shall mean any lands delineated as tidal wetlands on an inventory map and consist of marshes, shoals, bars, mudflats, and littoral zone. As such, the entire shoreline of the study area is considered to be within this regulatory zone or an "adjacent area". Specifically the boundary defining adjacent areas is set by four different categories: distance from wetland zone (300 feet), elevation above wetland zone (10 feet), top of a bluff or cliff (may be greater than 10 feet), and existence of structures adjacent to wetland zone.

The adjacent boundary on shorelines in the study area with bulkheads, seawalls, or revetments that existed prior to 1977 is located at the seaward limit of the respective structures. For the bluffed shorelines, the boundary is at the top of the feature even if it is above the 10 feet elevation line. For Crab Meadow Beach, Makamah Beach, and unprotected spit shorelines the boundary is the 300 foot buffer, 10 foot elevation, or location of shore-parallel road, whichever is nearer the wetland boundary.

Regulated activities which typically require a permit include: placement of fill, dredging, excavation, beach re-grading, construction of buildings, septic systems, bulkheads, docks, catwalks, piers and floating docks. Restoration, reconstruction, expansion, or modification of existing functional structures is also regulated under this section and requires a permit. In-kind, in-place replacement of existing bulkheads, revetments, or seawalls is generally a compatible activity that will most likely be considered to be a "minor" activity. Construction of new shoreline stabilization structures may be considered "major" projects if vegetated tidal wetlands are involved. Beach nourishment is typically considered "fill" and is less favorable in the classification of uses. As such, the activities associated with nourishment, placement of dredge material and dredging are considered "major" projects and require permits. Routine beach re-grading and cleaning, not located in the intertidal marsh or high marsh areas, does not require a wetland permit.

Permitting requirements for both "minor" and "major" projects are generally the same. In most cases, the "Joint Application for Permit" and required attachments discussed in the Section 6.1 will be sufficient for the types of shore protection projects anticipated for the study area. Generally, minor projects have shorter review time frames and require less public review. Notice of all major projects must be published in both the Environmental Notice Bulletin (ENB) and a designated local newspaper to allow for public review and comment.

6.2.2 Coastal Erosion Management

NYSDEC has authority under ECL Article 34 6 NYCRR Part 505 to protect and preserve the natural protective features such as dunes and bluffs of coastal areas, limit erosion, and ensure that erosion control structures are properly constructed in accordance with the regulations of 6 NYCRR Part 505. Article 34 also allows the regulations to be executed at the local level; and Huntington has adopted the authority to implement this program.

The NYSDEC has defined and mapped Coastal Erosion Hazard Areas (CEHA) in support of Article 34. Two distinct areas were noted, "Natural Protective Feature Areas" (NPFAs) and "Structural Hazard Areas" (SHAs). NPFAs include the nearshore, beaches, bluffs, primary dunes, and secondary dunes that inherently provide coastal protection. SHAs are located landward of the NPF's and are found on shorelines which have a long-term average annual recession rate of one foot per year or greater. The SHA is determined by multiplying the recession rate by 40 and is measured from the landward limit of the NPFA. If the recession rate is less than one foot per year or cannot be accurately established, then there is no SHA.

The study area is encompassed by the CEHA zone as shown in Figure 6.2-1; however, the only development within the zone is along Makamah Beach.

Based on Part 505, development in SHA zones is limited to moveable structures and development in NFPAs is contingent on limiting adjacent or ancillary erosion. It should be noted that no portion of the studied shoreline is defined as a SHA, even though long-term erosion of more than 1 foot per year have been calculated as part of this study. Therefore, further discussions will be relevant to NFPAs. All of the proposed management and stabilization techniques should be consistent with NFPA guidelines at present, with an understanding that SHA zones may be expanded to include some areas of the study area. A partial listing of regulated activities in NFPAs, determined by landform or physiographic location, is presented below. A coastal erosion management permit is still required for "acceptable" activities.

Figure 6.2-1: Map of Coastal Erosion Hazard Area zone within the study area.

- Nearshore areas: New construction, modification or restoration of groins, jetties, seawalls, bulkheads, breakwaters, revetments and artificial beach nourishment are generally acceptable, with a permit. Clean sand, or gravel of an equivalent or slightly larger grain size, is the only material which may be deposited within nearshore areas for beach nourishment.

- Beaches: New construction, modification or restoration of groins, jetties, seawalls, bulkheads, breakwaters, revetments and artificial beach nourishment are generally acceptable with a permit. A permit for deposition of material on beaches will be issued only for expansion or stabilization of beaches; clean sand, or gravel of an equivalent or slightly larger grain size, must be used. Beach grooming or clean-up operations typically do not require a permit. Active bird nesting and breeding areas must not be disturbed and vehicular traffic is prohibited.

- Bluffs: Bluffs are defined in Section 505.2 as "any bank or cliff with a precipitous or steeply sloped face adjoining a beach or body of water. The seaward limit of a bluff is the landward limit of its seaward natural protective feature. Where no beach is present the seaward limit of a bluff is mean low water. The landward limit is 25 feet landward of the bluff's receding edge, or in those cases where there is no discernable line of active erosion to identify the receding edge, 25 feet landward of the point of inflection on the top of the bluff (The point of inflection is that point along the top of the bluff where the trend of the land slope changes to begin its descent to the shoreline)." Excavating, grading or mining of bluffs is generally prohibited, except when a permit is obtained to provide shoreline access. Vehicular traffic is also prohibited on bluffs. New construction, modification or restoration of erosion protection structures, walkways or stairways requires a permit. However, elevated walkways or stairways constructed solely for pedestrian use and built by or for an individual property owner for providing noncommercial access to the beach are exempt from this permit requirement. Non-major additions to existing structures may be allowed on bluffs pursuant to a permit. Any grading, excavating, or other soil disturbance conducted on a bluff must not direct surface water runoff over a bluff face.

- Primary dunes: Excavating, grading or mining of primary dunes is prohibited. Vehicular traffic is prohibited on primary dunes, except in those areas designated for dune crossing. Non-major additions to existing structures are allowed on primary dunes pursuant to a permit and subject to conditions concerning the location, design and potential impacts of the structure on the primary dune. Foot traffic which causes sufficient damage to primary dunes to diminish the erosion protection afforded by them is prohibited. Pedestrian passage across primary dunes must utilize elevated walkways and stairways. A permit is required for new construction, modification or restoration of stone revetments or other erosion-protection structures compatible with primary dunes. Such erosion-protection structures will only be allowed at the seaward toe of primary dunes and must not interfere with the exchange of sand between primary dunes and their fronting beaches. Likewise, a permit is required for new construction, modification or restoration of elevated walkways or stairways. Elevated walkways or stairways constructed solely for pedestrian use and built by an individual property owner for providing noncommercial access to the beach are exempted from this permit requirement. Clean sand obtained from excavation, dredging or beach grading may be deposited on a primary dune, or on an area formerly a primary dune, to increase its size or restore it (with a permit). Such deposition must be vegetatively stabilized using native species tolerant to salt spray and sand burial. Vegetative planting and sand fencing, to stabilize or entrap sand in order to maintain or increase the height and width of dunes, generally does not require a permit. Active bird nesting and breeding areas must not be disturbed.

- Secondary dune: The regulations for primary dunes also apply to secondary dunes. Additionally, permit requirements for the construction, modification, or restoration of a structure, or major addition to an existing structure include that it must be built on adequately anchored pilings such that at least three feet of open space exists between the lowest, horizontal structural members, e. g., floor joists, and the surface of the secondary dune; and the space below the lowest horizontal structural members must be left open and free of obstructions.

Erosion protection structures are generally discouraged by the regulatory agencies. However, a permit may be obtained for the construction, modification or restoration of these structures if the following requirements are met:

- All erosion protection structures must be designed and constructed according to generally accepted engineering principles which have demonstrated success or a likelihood of success in controlling long-term erosion. The protective measures must have a design life of at least 30 years.

- A long-term maintenance program must be prepared for construction, modification or restoration of an erosion protection structure. That program must include specifications for normal maintenance of degradable materials and the periodic replacement of removable materials.

- All materials used in such structures must be durable and capable of withstanding inundation, wave impacts, weathering, and other effects of storm conditions. Individual component materials may have a working life of less than 30 years only when a maintenance program ensures that they will be regularly maintained and replaced as necessary to attain the required 30 years of erosion protection.

- The construction, modification or restoration of erosion protection structures must not be likely to cause any measurable increase in erosion at the development site or other locations; and minimize, and if possible prevent, adverse effects to natural protective features, existing erosion protection structures, and natural resources such as significant fish and wildlife habitats.

- Also noteworthy, is that a permit is required for the modification or restoration of erosion protection structures that were constructed without a coastal erosion management permit.

Coordination will be required between the Tidal Wetlands and Coastal Erosion Management programs in order to determine permissible erosion control structures or other management alternatives that are consistent with both sets of regulations. Currently, fixed structural methods that meet the design criteria above should be able to be authorized under both programs. Vegetative erosion control measures may require a wetland permit although not a CEHA permit.

6.2.3 State Environmental Quality Review Act (SEQR)

New York's State Environmental Quality Review Act (SEQR) requires all state and local government agencies to consider environmental impacts equally with social and economic factors during discretionary decision-making. This means these agencies must assess the environmental significance of all actions they have discretion to approve, fund or directly undertake. SEQR requires the agencies to balance the environmental impacts with social and economic factors when deciding to approve or undertake an "Action".

If an action is determined not to have significant adverse environmental impacts, a determination of nonsignificance (Negative Declaration) is prepared. If an action is determined to have potentially significant adverse environmental impacts, an Environmental Impact Statement (EIS) is required. The SEQR process uses the EIS to examine ways to avoid or reduce adverse environmental impacts related to a proposed action. This includes an analysis of all reasonable alternatives to the action. The SEQR "decision making process" encourages communication among government agencies, project sponsors and the general public (NYSDEC website, October 2005).

It is anticipated that most of the proposed coastal erosion management projects would be considered "Type II" and a "Negative Declaration" would be required rather than an EIS. Major beach nourishment projects located seaward of the spring high tide line may require an Environmental Assessment (EA) or EIS if they are particularly complex or controversial. OCC believes that the proposed management recommendations that include beach nourishment will not be considered major or controversial. However, it is recommended that a pre-application meeting with the agencies be held during the early stages of planning to determine potential permitting issues and assessment requirements.

6.2.4 Long Island Sound Coastal Management Program

The Long Island Sound Coastal Management Program is administered by the New York State Department of State (NYSDOS) and consists of a collection of policies to consider the economic, environmental, and cultural characteristics of the Long Island Sound coastal region. These policies take the place of the statewide policies of the New York State Coastal Management Program for projects located on the Long Island Sound shoreline. NYSDOS requires state and federal agencies and anyone who applies for a federal agency permit or license, including authorizations, certifications, approvals, leases or other forms of permission, to submit a certification that the proposed activity is consistent with all applicable State coastal policies. The consistency certification must include: a federal consistency assessment form, identification of coastal policies affected; a brief assessment of the effects of the activity on the applicable policies; and a statement how the activity is consistent with each applicable policy (NYSDOS website, October 2005). Also, actions are also assessed for their compatibility with State approved Local Waterfront Revitalization Programs (LWRPs). At the time of this report, the Town of Huntington has developed a Draft LWRP.

The policies reflect existing state laws and authorities and provide a balance between preservation and development helping to maximize the beneficial uses and minimize adverse impacts. The policies are the basis for federal and state consistency determinations (as discussed in previous sections) for activities affecting the Long Island Sound coastal area. Of specific importance to the study area are 9 policies detailing areas defined as Developed, Natural, and Public Coasts (New York Department of State, 1999). These include:

Developed Coast Policies

- Policy 1. Foster a pattern of development in the Long Island Sound coastal area that enhances community character, preserves open space, makes efficient use of infrastructure, makes beneficial use of a coastal location, and minimizes adverse effects of development.
- Policy 2. Preserve historic resources of the Long Island Sound coastal area.
- Policy 3. Enhance visual quality and protect scenic resources throughout Long Island Sound.

Natural Coast Policies

- Policy 4. Minimize loss of life, structures, and natural resources from flooding and erosion.
- Policy 5. Protect and improve water quality and supply in the Long Island Sound coastal area.
- Policy 6. Protect and restore the quality and function of the Long Island Sound ecosystem.
- Policy 7. Protect and improve air quality in the Long Island Sound coastal area.
- Policy 8. Minimize environmental degradation in the Long Island Sound coastal area from solid waste and hazardous substances and wastes.

Public Coast Policies

- Policy 9. Provide for public access to, and recreational use of, coastal waters, public lands, and public resources of the Long Island Sound coastal area.

In support of the policies, recommendations for consistent implementation strategies are provided and a section on respecting the dynamics of shoreline change is particularly important for the study area. The recommendations in this section include the need to monitor critical erosion hazard areas, of which part of the study area is identified (Makamah Beach), to better define SHA zones; and to "manage development in flood and erosion prone areas, through erosion management plans that include a post-storm redevelopment component".

6.3 LOCAL

Local regulations have largely been adopted from Article 34 (O'Neill, 1989) as Local Law No. 7-1989 "Coastal Erosion Management Regulations". The regulations contained within are consistent with those of Part 505 of the State regulations. With regards to the coastal resources of Huntington, Chapter 137, Marine Conservation, of the Code of the Town of Huntington New York is intended to provide regulations for ensuring protection, preservation, proper maintenance, and use of coastal habitats. The primary entity responsible for implementing the codes is the Department of Engineering. The Department of Maritime Services, Division of Marine Conservation, and the Town's Conservation Board also review permit applications and submit their comments to the Department of Engineering. The Town Board issues a Chapter 137 permit via a Town Board resolution. Chapter 120, Harbors and Waterways, of the Town of Huntington, New York is intended to provide regulations for safe usage of all harbors and waterways within the Town; regulation of the usage of docks, floats and the Town marina; and pollution of waterways. The primary entity responsible for this code is the Department of Maritime Services.

7.0 SHORELINE STABILIZATION ALTERNATIVES

Erosion and flood damage shoreline stabilization alternatives range from doing nothing to constructing various structures for modifying the behavior or supply of coastal sediments. All shoreline stabilization alternatives fall into the five groups listed below which consist of both engineering and management approaches (Pope, 1997):

1.) Abstention
2.) Adaptation
3.) Armoring
4.) Moderation
5.) Restoration

7.1 ABSTENTION

The "Abstention" or "No-Action" alternative would be just that - no new stabilization measures would be implemented and existing structures would not be repaired. Mankind abstains from any protective or compensatory activity and the shoreline would be left as-is to erode (or accrete) at natural rates. Homes and other structures, as well as public access may be impacted or lost altogether. This alternative would result in a shoreline similar to that modeled in Figure 5.4.1.

This alternative fails to incorporate policies of the Long Island Sound Coastal Management Program and the long-term stability of the area will not be sustained. Therefore, this alternative is not recommended and will not be given further consideration.

7.2 ADAPTATION

The "Adaptation" alternative is a management approach in which policies and restrictions are implemented to force the human population to adapt to the coastal system rather than attempt to modify it. However, unlike abstention, actions are taken to protect the human investment such as implementing set-back restrictions, development limitations, flood-proofing, and relocation (Pope, 1997). This alternative is also referred to as "retreat" throughout the coastal zone management community.

Retreat attempts to have structures located behind a setback line that accommodates the predicted long-term recession rate of the beach. This planning solution has three steps:

1.) Predict how far back the beach will erode in the future (30 to 50 years from now).
2.) Identify this line on maps.
3.) Prohibit any further building (including rebuilding or expansion) seaward of this line (Clark, 1996).

In terms of the study area, this would mean essentially adopting the regulations and definition of the buffer area associated with Structural Hazard Areas outlined in Article 34. Development of permanent structures would be prohibited and strict standards used to limit moveable structures. The retreat approach is most effective where no development yet exists. Buy-outs through eminent domain or purchase would also be a component of this alternative in order to relocate existing structures further inland.

Based on the long-term shoreline change rates computed in this study, there are areas where the SHA or other adaptation type approach could be applied. However, Implementation of this change in regulatory control will be an unpopular, difficult and potentially expensive task.

The most likely area where this alternative could be implemented is the eastern end of Makamah Beach. However, implementing the SHA or other adaptation approach would greatly reduce the ability of the homeowners in this area to protect their properties from on-going storm damage. In addition, storm damaged properties would not be reconstructed. Given the history of this area and on-going beach erosion, implementing this alternative would result in the loss of property in the near term.

This type of approach is viable and has been successfully implemented in many areas. However, as it has a high likelihood of resulting in the loss of property, it is not the recommended alternative for Makamah Beach. It is recommended that contingencies for this alternative start to be developed for the most susceptible properties in cooperation with the Long Island Sound Coastal Management Program and Federal partners. If other alternatives are not effective, adaptation may be necessary.

Implementing a SHA area for the currently undeveloped (or minimally developed) portions of the Broken Ground area would help ensure that new development does not occur on the unstable and erosional bluff.

7.3 ARMORING

Coastal armoring is often a last resort approach used to stabilize the shoreline where the primary problem is one of storm-induced damages rather than chronic erosion. Typically, armoring is used where substantial human investments are at risk and where the purpose of the project is to protect the upper portion of the beach profile and structures landward from storm-induced erosion and flooding (Pope, 1997). Coastal armoring is an attempt to "draw the line" along the shore with shore-parallel structural measures such as seawalls, revetments, and bulkheads.

These structures protect the land behind them but the area in front of and adjacent to the structure continues its natural erosion processes. When the natural fronting buffer such as a beach, dune, or wetland erodes, the structure may be undermined and fail. Additionally, these structures may be flanked if adjacent, non-armored areas continue to erode. Therefore, armoring alone is not always effective for overall shoreline management. Other shoreline stabilization techniques can be implemented in conjunction with armoring to improve effectiveness. Section 8.0, Management Recommendations, will further describe combinations for erosion control measures on a site specific basis.

7.4 MODERATION

This alternative consists of a number of beach erosion control techniques that are designed to reduce the rate of sediment loss from a project area and "moderate" erosion damages. The moderation approach is most appropriate for areas where the problem is chronic erosion due to diminished sediment supply (Pope, 1997). Erosion control measures in this category include structural, vegetative and bioengineering methods.

7.4.1 Structural Measures

Structural measures in the moderation category primarily consist of two types: shore-perpendicular and shore-parallel structures.

- Traditional Shore-perpendicular structures such as jetties and groins are solely meant to block or trap longshore sediment transport. They are of little use in areas with limited longshore transport (such as the eastern portion of the study area). In addition, their use and design should be examined closely so as not to create offsetting sediment starvation in downdrift areas. As a typical result, they are often used in multiples, i.e. a groin field, to stabilize a section of beach. Pre-filling groins to entrapment capacity can initiate sediment by-passing and reduce adverse impacts to downdrift beaches. Recent innovations in the design of shore-perpendicular structures include low profile structures which result in sand bypassing at a much lower threshold, porous groins and notched groins, all of which have a lower impact on downdrift beaches and stabilizing the envelope of shoreline change.

  The groin field along the western section of Waterview Street Beach is an example of shore-perpendicular shoreline stabilization technique that has been successful in minimizing erosion over a 50 plus year period.

- Seaward, shore-parallel structures such as continuous and segmented breakwaters are designed to work within the littoral system and are most appropriate for areas where cross-shore transport is the dominant mechanism for sediment losses in the system.

These structures modify wave conditions to protect the beach. They also help to build the beach by enhancing sediment deposition in their lee and preventing offshore movement past the structure. They do not prevent flooding conditions, so they are often used in conjunction with inland structures. Offshore, shore-parallel structures have also been used in combination with sand placement and vegetative stabilization.

- Shore parallel structures also include dune core reinforcement through the use of sand-filled geotextile tubes or cobble berms to dissipate energy during high water elevation during a storm.

  At the eastern end of Waterview Street Beach there is a natural formation, a shore parallel bar or flat composed on cobble, that acts as a shore parallel structure (see Photo 5.3-1). This natural formation has historically helped provide a stable beach shoreward of the flat.

7.4.2 Vegetative and Bioengineering Measures

Vegetative and bioengineering measures can also be implemented to moderate erosion damages. Vegetative measures for shoreline stabilization generally include installation of adapted plants or seed mixtures applied alone on shallow slopes, flatter than 3 foot horizontal to 1 foot vertical. On steeper slopes, plants are typically used in conjunction with soil bioengineering systems or other means of soil erosion control. Soil bioengineering is a system that utilizes living plant materials as structural components. Under this technique, adapted types of woody vegetation are installed in specified configurations that offer immediate soil protection and reinforcement. Additionally, soil bioengineering systems create resistance to sliding or shear displacement as they develop fibrous root systems (USDA Natural Resources Conservation Service, 1996). These systems are particularly well suited for streambank and bluff stabilization techniques.

As with any best management practice, consideration must be given to the immediate cost of installation, as well as, the long-term costs associated with maintenance of the shoreline stabilization practice. This should be weighed against the benefits associated with the anticipated/structural life of the practice. To extend the project life on all vegetative measures, foot traffic must be eliminated or directed to designated paths, stairways or elevated walkovers on dunes. Priority should also be given to measures that are:

- Self-sustaining or reduce requirements for future maintenance; and
- Utilize native, living plant materials for stabilization (USDA Natural Resources Conservation Service, 1996).

Practice selection, design, sizing and installation are site specific. The techniques described in this section are for informational purposes only, and do not imply endorsement for any particular method over another. Some examples techniques are described below. Specific recommendations for the project area are included in Section 8.0 and are organized by specific sections or reaches of the project area.

7.4.2.1 Salt Marsh Establishment

The objective of establishing a tidal wetland fringe along the shorefront would be to minimize the wave energy striking the shorefront and eroding bank. Once salt marsh vegetation gets established, it helps trap additional sediment along the shorefront, thereby raising the wetland elevation and pushing the seaward edge further away from the beach (Miller, Undated). The dominant plant species occupying tidal wetlands in the northeast are smooth cordgrass (*Spartina alterniflora*) in the intertidal zone (between the mid-to high tide line), saltmeadow cordgrass (*Spartina patens*) and spike grass (*Distichlis spicata*) in the high marsh above mean high water to the spring/storm tide elevation.

The NRCS developed a site rating form to help determine the potential success for vegetative treatment of eroding tidal shorelines in the Mid-Atlantic States. It considers the following factors:

- Fetch (distance of open water measured perpendicular to the shoreline);
- General shoreline shape;
- Shoreline orientation (e.g., N, S, E and W);
- Proximity and frequency of boat traffic;
- Beach width;
- Potential planting width;
- On-shore gradient;
- Depth of sand; and
- Presence of existing vegetation.

Sites with a fetch in excess of 5 miles, which applies throughout the study area, are not recommended for vegetative treatment alone in the intertidal zone, since wave energies would be considered too great to warrant planting. The lack of typical salt marsh vegetation fringing the Long Island Sound shoreline throughout the study area bares this out. Therefore, salt marsh establishment on the Sound shorefront is not recommended.

7.4.2.2 Bluff Stabilization Techniques

As mentioned briefly in the "Coastal Vegetation" section, the effectiveness of landscape treatments at controlling long-term bluff erosion is dependant upon a number of factors, including but not limited to: the degree of toe protection, the slope of the bluff, soil and drainage characteristics, proper plant selection, and maintenance activities both on the bluff face and above the bluff crest. One critical factor in stabilizing an eroding bluff is to control and/or divert stormwater runoff generated from the areas above the bluff crest away from the bluff face. Concentrated flows and supplemental irrigation that runs over the bluff face, or saturates the soils at the edge of the bluff crest can create or exacerbate rill and gully erosion, or result in slump failures. The goal is to allow only the precipitation that falls on the bluff face to nourish the planted materials. Therefore, the plants selected must be able to withstand the anticipated harsh conditions of dry soils, high wind exposure and tolerance of salt spray. If diversion of runoff from above is not practical or feasible, then stormwater runoff must be dissipated prior to reaching the bluff face, or collected and conveyed down the bluff face in an engineered and controlled manner and discharged in a non-erosive fashion.

The types of vegetation that can be established successfully on bluff faces are highly dependent upon the soil types and slope angle. Structural stabilization must be accomplished first, including provisions for adequate toe protection, followed by vegetative plantings to stabilize the bare soils. Toe protection is another critical factor in stabilizing a bluff. Even a well-vegetated bluff can fail if storm tides carve away the base of the bluff and create failure planes.. Slopes flatter than 3 horizontal on 1 vertical can be planted with grasses, while slopes steeper than 1 horizontal on 1 vertical generally preclude successful vegetation without additional treatments (USACE, 1981). Erosion control blankets/fabrics may be also be necessary on steeper slopes to preserve moisture, protect underlying seedlings and to hold the soil in place while newly seeded areas become established. An integrated approach utilizes a combination of quick establishing, shallow rooted herbaceous and woody plant species to prevent surficial soil erosion, along with slower developing, deeper rooted species to protect against shallow slope failures (Miller, Undated). Table C-1 in Appendix C provides a list of plant species that are recommended for shoreline and bluff stabilization, and distinguishes the fast-growing temporary cover species from the slower growing, permanent species. While some listed species have been identified as well adapted, and growing within the project area, they may not be recommended for planting for several reasons including:

- Considered as a noxious weed, non-native or invasive species; and
- Ready seed sources and propagules are available naturally and don't require planting.

The USDA NRCS cites that shrub willows and shrub dogwoods are the "keystone" species for bioengineering with regard to rooting success, 70 to100 percent and 30 to 60 percent, respectively (Miller, Undated). The willows are considered as early successional species that provide quick stabilization and growth, and are replaced over time by indigenous species. The following are general descriptions of several bioengineering systems that are adaptable to coastal stabilization (USDA NRCS, 1996; Miller, Undated).

Live stakes are green cuttings of shrub species, approximately 2 to 3 feet long and 2 to 3 feet apart, which are inserted into the ground and are expected to root and grow. The stakes are typically installed along with seeding, and inserted through an erosion control blanket on a relatively shallow slope, as a treatment for overbank runoff and simple erosion problem areas. Groundsel-bush and indigobush are well suited for this type of practice.

Live fascines/wattles are long bundles of branch cuttings bound together into a cylinder and placed in shallow contour trenches across the slope. Fascines are anchored in place with live stakes. Similar to live stakes, fascines or wattles are typically installed with erosion control fabric and seeding. This upper slope treatment reduces the slope length and can facilitate drainage when installed at a slight angle across the slope. Young willows, shrub dogwoods, groundsel-bush and sand cherry are well suited for this application.

Brush mattresses a combination of live stakes, live fascines and branch cuttings installed to cover and stabilize the bank up to the storm tide elevation. Installation begins at the toe of the slope with a fascine bundle; then branch cuttings, 2 pieces thick, are layered vertically up the slope on the surface. The system is anchored with dead and live stakes and tied down with wire. The brush mattress provides immediate low-level protective cover at the toe of a slope, and captures sediment during flooding conditions.

Rock revetment joint plantings is also called vegetated riprap, where live stakes are tamped into the joints or crevices between previously placed rocks. This practice reinforces toe protection and prevents the loss or migration of fine soil particles through the stone riprap.

Vegetative bluff stabilization techniques can be successfully applied to some bluff erosion problems in the study area. There are currently areas of natural and landscaped bluff stabilization techniques observed in the study area, the condition and effectiveness of which varies.

7.5 RESTORATION

"Restoration" consists of bringing sediment into an area from another source to mitigate chronic erosion or to provide a buffer to protect the upper beach from storm-induced erosion and flooding. Like vegetative techniques, restoration is a soft stabilization technique that is nearly always preferable (from a regulatory perspective) to structural methods when economically viable. Restoration is the only management alternative that actually adds sand back into the littoral system (Pope, 1997). A large number of factors must be taken into account for economic analysis, planning and design of beach restoration projects since these projects are usually only temporary and periodic replacement of material will be required at a rate equal to natural losses caused by erosion forces. In general, restoration can take two forms depending upon where the sediment is placed, beaches or dunes.

7.5.1 Beach Nourishment

In traditional beach nourishment, sediment, from a source outside of the beach system, is placed onto the existing beach. Traditionally, the sediment grain size for the nourishment material matches or is slightly coarser than the native sediment. The nourishment sediment can be placed anywhere within the littoral system, depending on several factors including the purpose of the nourishment project. Use of varying sizes of material, as well as placement along the profile, can increase the ability to design for a higher level of storm protection. For example, if the purpose is to prevent storm flooding, the best place to put sand is high as possible on the beach. If the purpose is to combat recurring erosion, the best place is in the breaker zone (Clark, 1996).

Use of beach nourishment (re-nourishment) at Crab Meadow beach appears to have benefited both the beach (public use) itself and the down-drift Waterview Street area. Maintaining this practice at a fairly nominal cost is an example of a successfully implemented beach nourishment program.

The beaches in the study are heterogeneous deposits of many grain sizes as opposed to the homogenous (uniform grain size) beaches on the South Shore. A wide variety of sediment types are present along each beach segment, such that sand, gravel, pebble, and cobble sediments are native to the beach profile. During storms, the coarse sediments (gravel, pebbles, and cobbles) remain on the beach profile even as smaller grain sized sediment (sand) is transported along or offshore. This "storm" beach is quite steep (reflective) and provides a high level of protection by dissipating wave energy. Coarse sediments, in turn, also help lower backwash and/or wave swash velocities by allowing the water to percolate down-ward; this reduces offshore sediment loss and helps trap sand sized material on the beach following storm passage.

Inland sediment sources abound on Long Island, however, offshore sources may be more difficult to assess. The ability to size sediment for nourishment is also an advantage of inland sources. Transportation, however, is the major cost and logistic drawback of terrestrial sources.

As evidenced by Crab Meadow Beach, beach nourishment can be part of a successful management program. In addition, beach nourishment can help mitigate some of the negative impacts of structural control measures. It should be noted that beach nourishment typically needs to be part of an on-going program in order to be most effective.

7.5.2 Dune Nourishment

Sand dunes form naturally on barrier islands, where there is an adequate source of wind blown sand to form ridges parallel to the shoreline. Dunes can be created or enhanced through nourishment. In this case, medium to fine sand is used, sand fences are often installed, and vegetation is planted to help stabilize the deposit. A wide beach is often necessary for dune creation and long-term survivability; wave attack on narrow beaches will undermine the dune and the fine sediment will likely be lost offshore. Depending on location, the use of sacrificial dunes may have some application, if only to temporarily protect shore-parallel structures and add sand into the littoral system.

Sand dunes stabilized with vegetation can provide protection from moderate storms and tides (Miller & Skaradek, Undated). American beachgrass (*Ammophila breviligulata*) is the dominant native plant that pioneers on developing sand dunes in the project region. As dunes widen and become stabilized, the plant diversity naturally increases to include such common species as beach pea (*Lathyrus maritimus*), dusty miller (*Artemisia stelleriana*), and seaside goldenrod (*Solidago sempervirens*) (USACE, 2005).

Dune creation can be accomplished by: planting vegetation alone; employing sand trapping measures; or using earth-moving machinery and sand from an upland source or offshore dredging to construct a dune (listed in order of increasing cost). American beachgrass is generally used for dune plantings, installing dormant culms at 12 to 24 inches on-center spacing from November through April during unfrozen ground conditions. An alternative means of building temporary sand dunes is by erecting a series of two sand fences (typical snow fence), 30 to 40 feet apart, oriented parallel to the waterline and 140 feet back from the mean high tide line. Planting parallel rows of beachgrass seaward and landward of the outer snow fence increases the effectiveness of this method. Finally, the physical construction of sand dunes employing earth-moving equipment is typically reserved for large-scale governmental, public flood and erosion control projects. The Town of Hempstead Department of Conservation and Waterways constructed a successful sand dune creation project in the 1980's at Lido Beach that incorporated a compacted soil core.

The narrow beaches that characterize most of the study area preclude extensive use of this alternative. However, there are opportunities to utilize dune nourishment to enhance some of the smaller dune systems that are currently found in the study area.

8.0 MANAGEMENT RECOMMENDATIONS

One of the primary goals of this study was to develop management recommendations for erosion control along the entire study area. While the original intended purpose of the study was to provide erosion management recommendations for the entire study area as a whole, during the course of the work it became apparent that there is a need for distinct "management areas" within the study area. As outlined in Section 8.2, the management areas were primarily defined based on physical conditions and upland uses. As the physical condition of the beach system and upland use changes, different management approaches are required. As outlined in Section 8.1, each management area was evaluated based on nine (9) characteristic features which were identified during the course of the study. Specific management recommendations for each management area are presented in Section 8.2 and are summarized in Figure 1 in the Executive Summary.

The spatial characteristics of the study area are important considerations for consistent coastal management decisions (New York Secretary of State, 1999). Management of safe development is contingent on characterizing both the coastal "climate" (long-term genetic trends) and spatially specific trends such as the effects of groins and seawalls on localized erosion or bluff retreat. Since shore and bluff protection structures are prevalent in the study area they represent an important management concern. It will be increasingly important to document the types of structures, location, and condition. As the shoreline erodes structures will incur more wave energy and the potential for failure will increase.

The spatial variables detailed in the previous sections, Historic Coastal Trends Analysis and Existing Uses and Conditions, have been combined with pertinent information from the Regulatory Climate and Options for Shoreline Stabilization sections to define management recommendations. The amount of variables examined in the study has been condensed to provide a workable management scale. The data supports property level management recommendations; however, this level is not-appropriate for application of regionally consistent management decisions. The matrix of Management Areas, Coastal Concerns, and Management Recommendations (Executive Summary) is an overview of the findings and recommendations.

8.1 CHARACTERIZATION OF COASTAL CONCERNS

8.1.1 Geologic Feature/Geomorphology

From a landform or geomorphologic (geologic) perspective there are two distinct feature types. Much of the shoreline is backed by bluffs of varying heights that are part of the glacial landforms found throughout the region. The remaining shoreline consists of low lying barrier beach-type spits that have developed from longshore transport of sediment eroded from bluffs. Effective coastal management of these two landforms (erosional and depositional) requires a combination of proactive regulations, incentives, and emergency contingencies.

8.1.1.1 Barrier Spit Shorelines

Development on barrier spit shorelines presents several management challenges. As previously discussed, long term erosion, sediment deficits, and rising sea level makes sustainable development difficult without a long-term commitment to maintaining an adequate beach. Development on barrier shorelines also creates the potential for life and property loss during storms such as yearly Northeaster's that affect the area. Ground elevations on spit shorelines in the study area are rarely above 10 feet based on the available topographic data while the still water elevations for the 1- and 2-percent chance annual storms straddle this elevation. For this reason, shore protection and/or a large buffer between the shoreline and infrastructure are important in limiting storm damage. In the longer term, there is the issue of sustainability; those areas that have consistent recent trends of shoreline retreat at or above 1 foot per year are in jeopardy of being exposed to, and incurring constant damage from increasing wave attack as the beaches continue to diminish. If, as reports suggest (Heinz Center, 2000), FEMA becomes increasingly stretched thin, the cost of flood insurance for this category of properties may place it beyond the means of all but a few home owners in coming years.

8.1.1.2 Bluffed Shorelines

Bluffs represent the bulk of the local sediment source. They are also naturally protective features and residences located behind them are much more protected from storms than those on barrier spits; in all but a few cases the residences are out of the 100 year (1 percent chance annual occurrence) flood zones. An important safety issue is protection of bluffs from rapid failure, which is contingent on continued toe protection (revetments and bulkheads). This must be tempered by the long-term supply of sediment to the system that would naturally occur from bluff erosion.

8.1.2 Shoreline Stabilization Structures

Shoreline stabilization structures are common along residential portions of the study area. Their existence and continued use is an important management consideration. For example, permitting new or modified structures in areas with limited shoreline stabilization should be approached differently than those areas where they are currently pervasive.

8.1.3 Beach Erosion

Beach erosion is and will be an ongoing problem given the lack of sediment sources and relative sea-level rise. The general trend of erosion has slowed, but the amount of buffer in front of many properties has dropped to a level where each foot is important. Areas with chronic erosion trends will require some sort of beach stabilization within the next decade. For other portions of the study area, erosion may only represent a long-term problem.

8.1.4 Beach Width

Beach width is a short-term safety consideration and indicator of upland infrastructure damage potential. The level of infrastructure damage caused by direct wave attack, even areas with limited shoreline change, is a function of beach width. Beach width is also an indirect measure of beach elevation, such that the bases of most bluffs, dunes, or shoreline structures on wide beaches is greater than those for narrow beaches.

An important consideration for human safety and property damage in the near-term is the location of habitable structures in relation to upland, bluff, or shoreline protection structures and their first-floor elevation. A generalized assessment of structure location has been performed, however, a detailed analysis is beyond the scope of the present project; it is recommended that follow-on work include this metric.

Beach width is also an important consideration for public access. Wider beaches allow for more public use (wide areas below mean high water). As beach width narrows, there is less time during a tide cycle when pedestrians can pass.

8.1.5 Bluff Erosion

Bluff erosion is a natural process in the study area which has been greatly reduced in the past 30 years. Bluff erosion is a function of soil type, elevation, and underlying geology. High rates of retreat are associated with the glacial out-wash deposits and areas with underlying clay. Areas with high retreat rates are critical management areas, such that building on or modifications to the bluff slopes have safety implications.

8.1.6 Building Setback from Shoreline

Building setback distances are extremely important from a safety perspective. Not only are geologic feature/geomorphology management decisions based on this measurement, but there is human safety as well as infrastructure damage implications. For bluff areas, low setbacks from the shoreline indicate high slopes; on spit areas, low setbacks have high wave-impact potential. Decisions on protective and/or management techniques should be tailored to encourage increased shoreline setbacks.

8.1.7 Dunes

Dunes are both protective and habitat features in the study area. The west end of Makamah Beach has the largest dunes and property owners rely on their existence for protection. In other areas, the dunes primarily provide habitat and are highly sacrificial, providing sediment to the system during storm periods.

8.1.8 Storm Damage Risk

Storm damage risk is a qualitative assessment of the overall conditions as they relate to short-term risks; this is the single-most important management measure. Areas with a high storm damage risk have associated human safety concerns. Location of emergency personnel during storms and/or mandatory evacuation priority is an example of the types of management decisions that can be defined based on the overall risk. Quantitative storm damage assessment can be obtained through the use of numerical models to predict the impact of storm damage on structures, roads and other utilities on a probabilistic basis.

8.1.9 Public Beach Access

At the other end of the spectrum from storm damage risk, beach access is a public interest issue. Areas with limited beach width can restrict pedestrian use of public lands. A good example is the eastern end of Makamah Beach, which is bounded on both ends by public property. Parking and public crossover to the beach are also important.

8.2 MANAGEMENT AREAS

Management areas have been defined (Figures 8.2-1, 8.2-2, 8.2-3 and 8.2-4) to promote practical use of management recommendations based on location and unique combinations of coastal concerns as discussed above. The management matrix (see Executive Summary) has been divided into areas that reflect these zones.

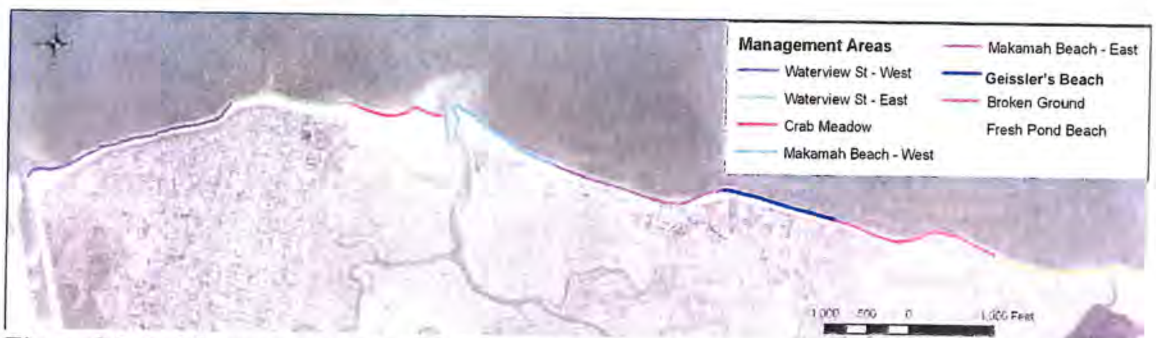


Figure 8.2-1: Management zone overview map.

8.2.1 Waterview Street West

8.2.1.1 General Management Conditions

This area has some of the highest bluffs, a fairly stable beach, and a high degree of shoreline stabilization structures including groins. The area, however, has a narrow beach and a low building setback. The storm damage risk is moderate and reflects the potential for slope failure if shoreline stabilization structures are damaged by waves.

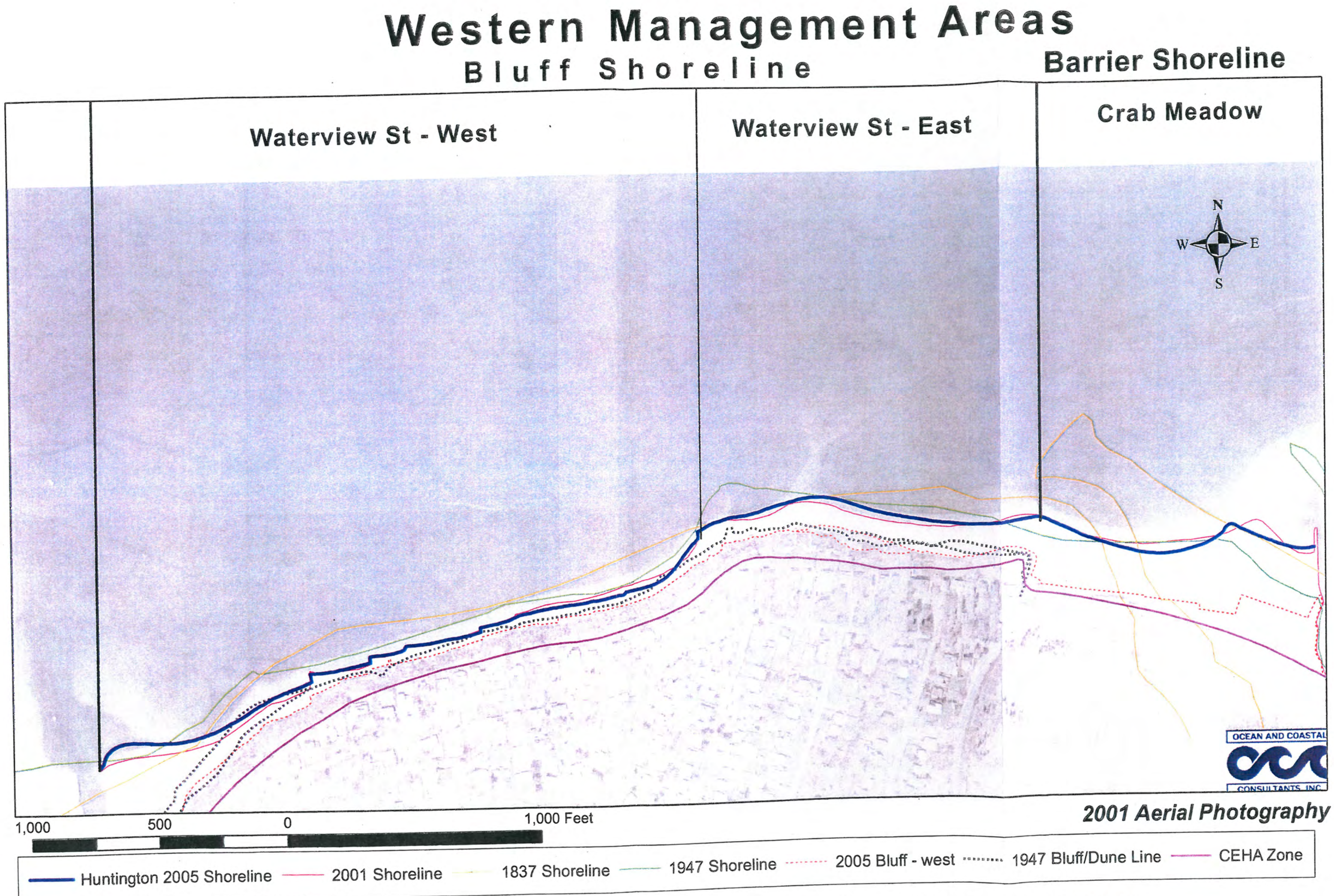
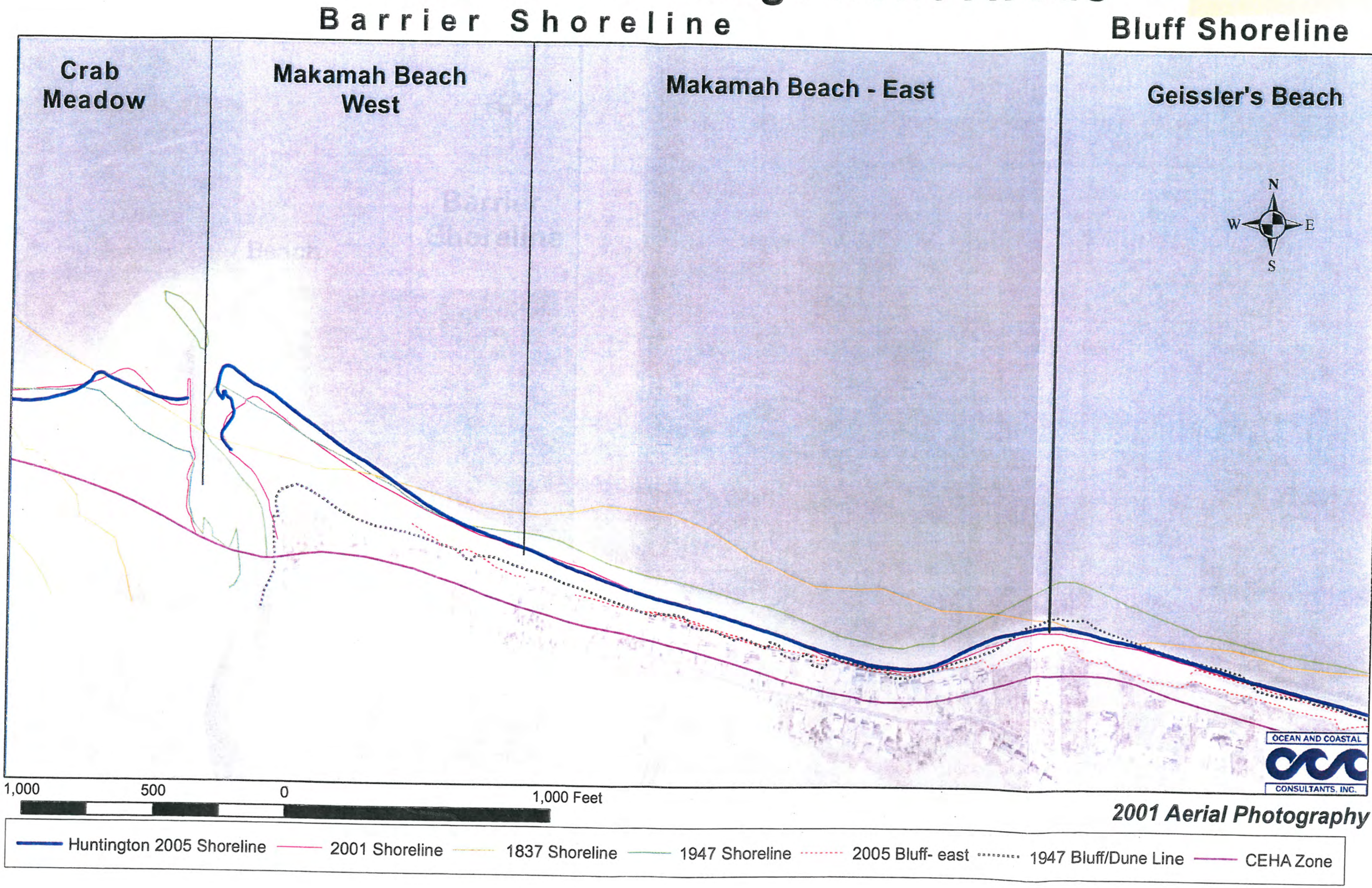


Figure 8.2-2: Western Management Areas.

Central Management Areas



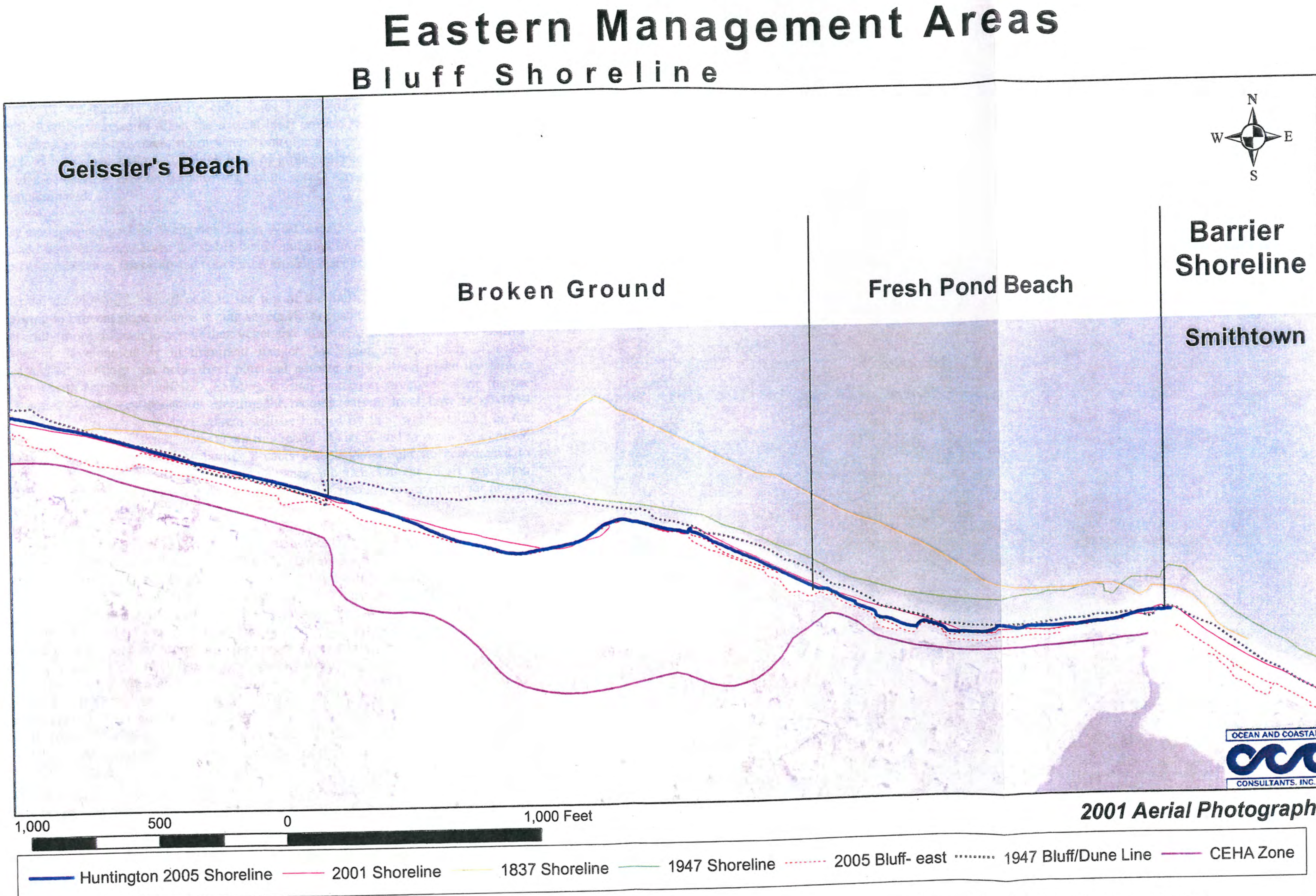


Figure 8.2-4: Eastern Management Areas.

8.2.1.2 Management Recommendations

It is important that the shore protection structures are maintained. As a requisite for building new structures or substantially repairing older ones, beach material mitigation (small scale nourishment) is recommended to offset the natural bluff erosion process. Since the bluffs are among the highest in the study area, storm water control and vegetative stabilization should be encouraged to reduce slope failure. The high level of groin construction in the area may restrict public use of the beach. A method for allowing public access across some of the larger groins should be implemented.

The primary management goal for Waterview Street West is maintaining shore protection for the existing upland development. Given the stable beach and high level of existing development, a combination of moderation, armoring and restoration erosion management appears best.

With residential development located near to the top of the bluffs, the toe of the bluffs will require armoring to prevent slope failures during severe storm conditions. Although armoring of bluffs is generally more difficult to permit than vegetative measures, it can, at times, be justified when residential development is in imminent danger. Mitigation in the form of beach nourishment and/or plantings can help offset potential adverse impacts and make the project more consistent with regulatory policies. Existing erosion protection structures along the toe should be maintained and new structures meeting the requirements of local Law No. 7-1989 should be allowed. The toe protection system will be limited by the "weakest link" or the structure most susceptible to storm damage along this reach. As such, and to promote a unified shore protection approach, the local properties owners association should be encouraged to develop and implement an inspection and maintenance program for the bluff protection structures (see Section 8.3). An inspection and maintenance program is a requirement for new or reconstructed erosion control structures under the regulations of 6 NYCRR Part 505.

As part of the restoration program, repairs to, reconstruction of and new structures should have a requirement for beach material mitigation. Bluff toe protection structures should be required to place a volume of material equivalent to the volume of bluff material that the structure would prevent from entering the system over the design life of the structure. With the CEHA requirement for a 30 year design life, an historic bluff erosion rate of about 1 foot per year and an assumed bluff height of 30 feet, the required mitigation volume would be 900 cubic feet of beach material per linear foot of shore protection structure. Repairs to or reconstruction of groins should have a requirement for adding beach material equivalent to the entrapment capacity of the groin. This will minimize down drift impacts from the groins. The beach material utilized for this management area should be sand, with a grain size equal to or slightly larger than the existing beach material. Placement of material as mitigation to offset potential adverse impacts of structures is generally consistent with best practices of NYSDEC and USACE. This type of mitigation is often a special condition requirement of a permit.

Appropriate moderation measures including vegetative slope stabilization measures such as live stakes, live fascines and brush mattresses should be encouraged, as should storm water and irrigation runoff controls to prevent slope failures. There is good vegetative coverage throughout this reach. Avoid planting non-native trees and shrubs on or near the bluff face, particularly on the western end to avoid escape of horticultural varieties into natural communities. If a woody plant dies, consider replacement with a native species.

As previously discussed repairs and/or reconstruction of the existing groins should be allowed as part of the moderation erosion control methods. In some cases, modification of the groin to bypass more sand should be encouraged.

Repairs to or reconstruction of groins should also include provision for public access at the mean high water line. This will improve public access and use along this section of beach. Since maintaining public access is an important provision of most regulatory agencies policies, incorporating means to increase public access with reconstruction and/or new construction of coastal structures should facilitate the permitting of these structures.

New or expansions of existing residential development should not occur within the Coastal Erosion Hazard Area, as defined in NYSDEC Article 34 and Local Law No. 7-1989.

8.2.2 Waterview Street East

8.2.2.1 General Management Conditions

This area has high bluffs, a stable beach, a moderate level of set-back shoreline stabilization, and several large groins. The area has a wide beach and a considerable building setback. The storm damage risk is low and reflects the wide beach, set-back, and stable long-term erosion trend.

8.2.2.2 Management Recommendations

Given the stable beach and high level of exist development, a combination of moderation and restoration erosion management appears best. The primary management goal for Waterview Street East is improving the natural shore protection features to provide adequate erosion protection for the existing upland development.

Soft shoreline stabilization is preferred in this area given its natural character. As a requisite for building new structures or substantially repairing older ones, beach material mitigation (small scale nourishment) is recommended to offset the natural bluff/dune erosion process. The dune system should be protected and enhanced (i.e. use of dune walkovers and temporary snow fencing). Soft stabilization including beach nourishment and dune enhancement is generally a permittable activity that is favored over structural solutions by the regulatory agencies as long as vegetation and wildlife are not adversely impacted.

With residential development located behind the top of the bluffs, the toe of the bluff requires protection to prevent slope failures during severe storm conditions. The existing dune system, wide beach and some bluff protection structures along the toe provide the required protection. Projects to enhance the dunes should be encouraged. Dune enhancement can include dune nourishment, dune vegetation planting, dune fence installation, and installation of dune walkovers. Enhance maritime dunes by planting beachgrass, coastal panicgrass, beach pea, seaside goldenrod, and dusty miller; and extend snow fencing. Protect dunes by installing elevated walkways, rather than cutting paths through the dunes.

Existing bluff and shore protection structures should be maintained and new structures meeting the requirements of local Law No. 7-1989 may be allowed. The toe protection system can be limited by losses of beach material or dune damage. As such, and to promote a unified shore protection, the local properties owners association should be encouraged to develop and implement an inspection and maintenance program (see Section 8.3). An inspection and maintenance program is a requirement for new or reconstructed erosion control structures under the regulations of 6 NYCRR Part 505.

As part of the restoration program, repairs and reconstruction of existing structures and new structures should have a requirement for beach material mitigation. Bluff toe protection structures should be required to place a volume of material equivalent to the volume of bluff material that the structure would prevent from entering the system over the design life of the structure. With the CEHA requirement for a 30 year design life, an historic bluff erosion rate of about 1 foot per year and an assumed average bluff height of 15 feet, the required mitigation volume would be 450 cubic feet of beach material per linear foot of shore protection structure. The beach material utilized for this management area should be sand, with a grain size equal to or slightly larger than the existing beach material. It is anticipated that the mitigation material would be used to nourish the existing dune system.

Repairs to and reconstruction of groins that are still functional are generally permittable by NYSDEC and USACE if adverse impacts are eliminated or minimized. Therefore, repairs to or reconstruction of groins should have a requirement for adding beach material equivalent to the entrapment capacity of the groin. This will minimize down drift impacts from the groins.

Appropriate moderation measures include vegetative slope stabilization measures, such as live stakes, live fascines and brush mattresses, should be encouraged, as should storm water and irrigation runoff control to prevent slope failures.

As previously discussed repairs and/or reconstruction of the existing groins should be allowed as part of the moderation erosion control methods. Repairs or reconstruction of groins should also include provision for public access at the mean high water line.

New or expansions of existing residential development should not occur within the coastal erosion hazard area, as defined in NYSDEC Article 34 and Local Law No. 7-1989.

8.2.3 Crab Meadow Beach

8.2.3.1 General Management Conditions

This area is a public barrier beach with a stable beach, no residential development, the highest level of public access, a history of renourishment, and several large "terminal" groins to reduce longshore transport. The storm damage risk is the lowest in the study area and reflects the wide beach, lack of private development, and stable long-term erosion trend, which is a function of the renourishment program.

8.2.3.2 Management Recommendations

Given the stable beach and high level of public use, a restoration erosion management program appears best. The primary management goal for Crab Meadow Beach is maintaining the public access beach. This area represents a valuable public holding and should be maintained as such. The nominal costs of yearly renourishment should continue to ensure public access and damage mitigation (beach pavilion).

The critical component of the erosion management program will be the continuation of annual beach nourishment. The beach nourishment program provides a wide stable beach to support the public access activities. In addition, the wide beach provides storm protection to the upland public infrastructure and to the adjacent Crab Meadow marsh.

New shore protection structures are not anticipated to be required if the nourishment program is maintained. The existing groins should be maintained as they provide stability to the beach and help retain the sediment.

Maximize use of native plants in park landscaping, and label natives to increase public awareness and education.

New or expansions of existing commercial development should not occur within the coastal erosion hazard area, as defined in NYSDEC Article 34 and Local Law No. 7-1989.

The proposed beach nourishment recommendation is appropriate given the best practices and policies of the NYSDEC and USACE and consistent with activities typically permitted.

8.2.4 Makamah Beach - West

8.2.4.1 General Management Conditions

This barrier beach is mostly public; it has a stable beach, limited residential development, public access, and a considerable coastal dune habitat. The storm damage risk is low and reflects the wide beach, lack of private development, and accretional to minimally erosional long-term trend.

8.2.4.2 Management Recommendations

Given the relatively stable beach, developed dune system and low level of existing development, a combination of moderation and restoration erosion management appears best. The primary management goal for Makamah Beach West is maintaining the natural shore protection features that promote both erosion protection for the existing upland development and habitat for the rare and endangered species that nest in this portion of the beach.

Any shoreline stabilization should be required to be soft (nourishment, dune stabilization) given this area's natural character. The dune system should be protected (limit dune crossing) and enhanced (use of temporary snow fencing).

With residential development located behind the dunes, measures to protect and enhance the dune system should be a priority. Dune enhancement can include dune nourishment, dune vegetation planting, dune fence installation, and installation of dune walkovers. Enhance maritime dunes by planting beachgrass and extend snow fencing. Protect dunes by installing elevated walkways, rather than cutting paths through the dunes. Restrict foot traffic through the dunes and maintain piping plover and least tern protection and monitoring protocols.

New shore protection structures should be discouraged, unless there is a justified need. Maintenance of existing shore protection structures and any necessary new structures should meet the requirements of Local Law No. 7-1989. As such, and to promote a unified shore protection, the local properties owners association should be encouraged to develop and implement an inspection and maintenance program (see Section 8.3). An inspection and maintenance program is a requirement for new or reconstructed erosion control structures under the regulations of 6 NYCRR Part 505.

As part of the restoration program, repairs to, reconstruction of and new structures should have a requirement for beach material mitigation. Shore protection structures should be required to place a volume of material equivalent to the volume of upland or dune material that the structure would prevent from entering the system over the design life of the structure. With the CEHA requirement for a 30 year design life, a historic beach erosion rate of about 1 foot per year and an assumed average dune height of 10 feet, the required mitigation volume would be 400 cubic feet of beach material per linear foot of shore protection structure. The beach material utilized for this management area should be sand, with a grain size equal to or slightly larger than the existing beach material. It is anticipated that the mitigation material would be used to nourish the existing dune system.

Appropriate moderation measures include dune enhancement with snow fence installation, vegetation plantings and / or dune nourishment.

New or expansions of existing residential development should not occur within the coastal erosion hazard area, as defined in NYSDEC Article 34 and Local Law No. 7-1989.

This combination of management recommendations has been made in light of the best practices and policies generally accepted by the regulatory agencies. In particular, dune enhancement and beach nourishment are preferred over structural solutions whenever possible.

8.2.5 Makamah Beach – East

8.2.5.1 General Management Conditions

This part of the barrier beach is mostly private and unlike the western portion it has a highly erosional beach, high residential development and shoreline stabilization structures, limited public access, a very narrow beach, and a shrinking coastal dune habitat. The storm damage risk is the highest in the study area and reflects the narrow beach, low building set-back, and high erosional long-term trend.

8.2.5.2 Management Recommendations

Makamah Beach East is the most critical management area in terms of immediate erosion control. The chronic erosion of the beach, narrow beach width and minimal setback for the residential development has resulted in a situation where damage to property can be expected on a regular basis. Armoring has been employed to provide some protection for the residents. However, given the sand starved condition of the beach, armoring alone is not likely to provide a long term erosion control solution. A combination of armoring, moderation, restoration, and possibly adaptation will be required to provide long term erosion management. The primary management goal for Makamah Beach East is to provide sustainable, long term shore protection for the existing upland development.

The management recommendations in this area are geared toward human safety and infrastructure protection. It is important that the shore protection structures are maintained. As a requisite for building new structures or substantially repairing older ones, beach material mitigation (small scale nourishment) is recommended to offset the natural dune erosion process. Since the long-term sustainability of the area is limited, residents of the area should begin to investigate larger scale (compatible) shore protection techniques that include innovative as well as contemporary measures. The western portion of the area is public and may benefit from nourishment such as is occurring at Crab Meadow.

With residential development located close to the high water line, the existing development will require armoring to reduce structural failures and potential safety issues during severe storm conditions. Existing erosion protection structures should be maintained and new structures meeting the requirements of Local Law No. 7-1989 should be allowed. The shore protection system will be limited by the "weakest link" or the structure most susceptible to storm damage along this reach. As such, and to promote a unified shore protection approach, the local properties owners association should be encouraged to develop and implement an inspection and maintenance program, which would be consistent with the requirements of 6 NYCRR Part 505 for erosion control structures(see Section 8.3).

As previously noted, armoring alone will not provide long term protection to the existing residential structures due to the chronic erosion problem and lack of beach sediment in the system. Armoring alone is also likely to be discouraged by the regulatory agencies. A combination of management techniques will be more consistent with the policies of NYSDEC and USACE.

As part of the restoration program, repairs and reconstruction of existing structures and new structures should have a requirement for beach material mitigation. Shore protection structures should be required to place a volume of material equivalent to the volume of dune material that the structure would prevent from entering the system over the design life of the structure. With the CEHA requirement for a 30 year design life, a historic erosion rate of about 1.5 feet per year and an assumed dune height of 10 feet, the required mitigation volume would be 800 cubic feet of beach material per linear foot of shore protection structure. The beach material utilized for this management area should be a mix of sand, gravel and cobble, matching the existing beach material. The mixed beach material will provide additional erosion protection over pure sand nourishment.

Another restoration measure that should be given serious consideration is a beach nourishment program for the public access area at the end of Makamah Road. The beach nourishment program would have a dual purpose: improve public beach access at this under-utilized access point; and introduce sediment into a sand starved section of shoreline. For a minimal annual cost, public access and shore protection could be improved. Without some form of beach nourishment, public access along this section of shoreline will continue to diminish and eventually there will be almost no public access due to a reduced beach width.

Due to the severe nature of the existing shoreline erosion problem, structural moderation measures should also be considered. Offshore submerged or segmented breakwaters would provide much needed shore protection and would also help to retain sand on the beach by limiting cross and long shore sediment transport. These type of structures are expensive to construct and difficult to permit. However, as the erosion and storm damage problems in this management area worsen, substantial, non-traditional protection measures will be required. Another structural moderation measure that may be considered is groins. A groin field in combination with a substantial beach nourishment program would also improve the existing erosion problem. New groin fields will be difficult to permit unless proper studies are provided to justify their need and to show that adverse impacts have been minimized with the addition of beach nourishment.

While a strict adaptation approach is not recommended, some adaptation measures may be incorporated as part of a long term approach. Raising flood prone structures to reduce storm damage risk and implementing recommendations of the FEMA Coastal Construction Manual should be encouraged as part of the management program. It should be noted that if the recommended mitigation and restoration measures are not implemented, an adaptation approach, such as outlined in the Article 34 "Structural Hazard Areas", may be the only long term alternative.

New or expansions of existing residential development should not occur within the coastal erosion hazard area, as defined in NYSDEC Article 34 and Local Law No. 7-1989.

Due to the on-going critical erosion, limited vegetative opportunities exist, except for promoting use of native species instead of horticultural varieties. Xeriscapes should be encouraged in home gardening along this reach as well.

8.2.6 Geissler's Beach

8.2.6.1 General Management Conditions

This area has high, mainly unprotected bluffs, a long-term erosional trend, a high level of building set-back, and is largely public. The area, however, has a fairly narrow beach and a high bluff retreat signature. The storm damage risk is moderate and reflects the narrow beach, long-term erosion trend, and presence of unstable soils in bluffs.

8.2.6.2 Management Recommendations

Given the relatively low level of existing development, a large setback for existing structures, but a narrow beach and unstable bluff sediments, a combination of moderation and restoration erosion management appears best. The primary management goals for Geissler's Beach are to improve the natural shore protection features to provide erosion protection for the existing upland development and to continue public access to the beach.

Soft shoreline stabilization is preferred in this area given its natural character. As a requisite for building new structures or substantially repairing older ones, beach material mitigation (small scale nourishment) is recommended to offset the natural bluff/dune erosion process. Since the bluffs are in areas of, or near known areas of high bluff retreat, storm water control and vegetative stabilization should be encouraged to reduce slope failure. The dune system, where existing, should be enhanced through plantings and use of temporary snow fencing. Any toe protection afforded by dunes will help slow the bluff erosion process. Dune enhancement is consistent with the shore protection and best management policies of the NYSDEC and USACE.

With residential development located behind the top of the bluffs, the toe of the bluff requires protection to prevent slope failures during severe storm conditions. The existing dune system and some bluff protection structures along the toe provide limited erosion protection. Projects to enhance the dunes should be encouraged. Dune enhancement can include dune nourishment, dune vegetation planting, dune fence installation, and installation of dune walkovers. Dead Christmas trees have been placed along the toe of the eroded bank through this section, and provided limited success for bluff stabilization. Consider enhancing toe protection by installing a brush mattress that is properly tied down, using groundsel-bush for live stakes. Cut away the overhanging lip at the bluff crest to establish a flatter slope angle and plant a native grass mixture, erosion control blanket, vines, live stakes and/or facscines on the bluff face above. Plant wetland species (i.e., pussy willow, gray dogwood, highbush blueberry, groundsel-bush, chokeberries) on the lower portion of the bluff face and toe of the bluff where clay slumps occur. Eliminate lawn irrigation at the edge of the bluff face that throws water down over the crest.

New shore protection structures should be discouraged, unless there is a justified need. Maintenance of existing shore protection structures and any necessary new structures should meet the requirements of local Law No. 7-1989. As such, and to promote a unified shore protection, the local properties owners association should be encouraged to develop and implement an inspection and maintenance program, which is consistent with the requirements of 6 NYCRR Part 505 for new or reconstructed erosion control structures (see Section 8.3).

As part of the restoration program, repair and reconstruction of existing structures and new structures should have a requirement for beach material mitigation. Shore protection structures should be required to place a volume of material equivalent to the volume of upland or dune material that the structure would prevent from entering the system over the design life of the structure. With the CEHA requirement for a 30 year design life, an assumed bluff erosion rate of about 1 foot per year and an assumed average bluff height of 20 feet, the required mitigation volume would be 600 cubic feet of beach material per linear foot of shore protection structure. The beach material utilized for this management area should be sand, with a grain size equal to or slightly larger than the existing beach material. It is anticipated that the mitigation material would be used to nourish the existing dune system. Placement of material as mitigation to offset potential adverse impacts of structures is generally consistent with the best practices of NYSDEC and USACE and is often a special condition of the permit.

Appropriate moderation measures include dune enhancement with snow fence installation, vegetation plantings and / or dune nourishment. Other important moderation measures include vegetative bluff stabilization, bluff storm water controls and limiting irrigation at the top of the bluff.

New or expansions of existing residential development should not occur within the coastal erosion hazard area, as defined in NYSDEC article 34 and Local Law No. 7-1989.

8.2.7 Broken Ground

8.2.7.1 General Management Conditions

This area has high set-back bluffs, a history of massive slope failures, a long-term erosional trend, and very little beach fronting the bluffs. Most of the area, however, has been armored with revetments and there is a significant building set-back. The storm damage risk is high and reflects the narrow beach, long-term erosion trend, presence of unstable soils in bluffs, and high wave exposure.

8.2.7.2 Management Recommendations

Broken Ground is a critical management area in terms of bluff erosion. The chronic bluff failure and erosion problem has been exacerbated by the erosion of the beach and resulting narrow beach width. The primary management goal for Broken Ground should be to minimize the frequency and severity of soil movement and bluff failures which are likely to occur over time. Further investigation would be necessary to arrive at viable engineering solutions to minimize soil movement. A combination of armoring, moderation, restoration, and adaptation is recommended to provide long term erosion management.

It is important that shore protection structures are maintained where present. As a requisite for building new structures or substantially repairing older ones, beach material mitigation (small scale nourishment) is recommended to offset the natural bluff erosion process. Since the bluffs are the most unstable in the study area, storm water and ground water controls should be used in conjunction with vegetative stabilization to reduce slope failure. Excess water between the clay layer and overlying glacial moraine acts like a lubricant that increases slope failure risk. The long groin extending from the golf course may be excessive and rob down-drift areas of protective beach material and may help public access in front of the western portion of the revetment.

Armoring has been employed on portions of the bluff toe to provide some protection bluff erosion protection. Vegetative stabilization and runoff control has also been implemented to some degree with varying levels of success. However, given the historic bluff erosion rates, unstable underlying soil, continuing movement of the bluff, and sand starved condition of the beach, armoring and mitigation are not likely to provide a long term erosion control solution. There are engineering techniques that could be applied to stabilize the underlying clay layers. These include installing drilled shafts or caissons through the failure plane, excavation and re-grading to a stable slope, replacement of low strength material, installation of drains, and experimental techniques such as electro-osmosis to dewater and strengthen the clay layer. Further engineering study would be required to determine the cost and effectiveness of these techniques.

The existing erosion protection structures do provide some protection and should be maintained and new structures meeting the requirements of Local Law No. 7-1989 should be allowed to slow toe erosion. The local properties owners association should be encouraged to develop and implement an inspection and maintenance program to ensure long term viability of the shore protection structures (see Section 8.3). An inspection and maintenance program is a requirement for new or reconstructed erosion control structures under the regulations of 6 NYCRR Part 505.

As previously noted, armoring alone will not provide long term protection due to the chronic erosion problem and lack of beach sediment in the system. Armoring alone is also not likely to be favored by the regulatory agencies. A combination of management techniques including nourishment for mitigation as described below will be more consistent with the policies of NYSDEC and USACE.

As part of the restoration program, repair and reconstruction of existing structures and construction of new structures should have a requirement for beach material mitigation. Shore protection structures should be required to place a volume of material equivalent to the volume of bluff material that the structure would prevent from entering the system over the design life of the structure. With the CEHA requirement for a 30 year design life, an assumed bluff erosion rate of about 2 feet per year and an assumed bluff height of 30 feet, the required mitigation volume would be 1800 cubic feet of beach material per linear foot of shore protection structure. This would be a substantial volume of material to place on the beach, and would provide additional storm protection. The beach material utilized for this management area should be a mix of sand, gravel and cobble, matching the existing beach material. The mixed beach material will provide additional erosion protection over pure sand nourishment.

Beach material mitigation will also improve public beach access. Without some form of beach nourishment, public access along this section of shoreline will continue to diminish and eventually there will be almost no public access due to a reduced beach width.

Moderation measures should also be continued and improved to lessen bluff erosion. The existing vegetative stabilization is ineffective in some areas, and better storm water control is needed. Specific moderation recommendations include: Repair the gully at western end of golf course. Divert and/or dissipate runoff above the bluff face to reduce overland flow. Eliminate irrigation in low-lying areas above the gully and in close proximity to bluff crest elsewhere. Raise the height at the center of the rock revetment to eliminate overwash during storm events. Plant woody wetland species at the top of the revetment to function as joint plantings. Re-grade rills above the center of the revetment, seed to a warm season grass mixture, apply thin erosion control blanket or jute net and install fascines. Install toe protection at eastern end of reach; investigate feasibility of brush mattress technique or rock revetment with joint plantings, versus other structural measures such as a low profile bulkhead. While we understand the some irrigation controls have been implemented, these should be reviewed to ensure that minimal amount of water reaches the bluff face and underlying unstable sediments.

The groin located near the eastern limit of this management area is another moderation measure that actually may be contributing to the erosion problem on the western end of the management area. The current length of the groin appears to be longer than is needed. The additional length effectively prevents any long shore sediment transport, keep sand from moving to the western end of the management area. If the length of the groin was reduced, some bypassing of sand would occur. It should be noted that the groin does provide shore protection for the eastern end of the management area by retaining sediment. As such, the length of the groin should be a balance between retaining sediment on the east side and allowing some movement of sediment to the west. Reducing the length of the groin would most likely be seen as a positive endeavor and is likely to be easily permitted by NYSDEC and USACE.

A strict adaptation approach should also be considered for this area. Preventing future development on the unstable and erosion prone bluff areas by implementing an adaptation approach, such as outlined in the Article 34 "Structural Hazard Areas", is recommended.

8.2.8 Fresh Pond Beach

8.2.8.1 General Management Conditions

The area has fairly large bluffs that decrease in height from the west to east, significant use of shoreline stabilization, and a very narrow beach. Shoreline erosion is moderate to high and there is also limited building setback. Unlike the Broken Ground area, the bluffs have remained fairly stable in the long-term. Accordingly, the storm damage risk is moderate and reflects the potential for slope failure if shoreline stabilization structures fail.

8.2.8.2 Management Recommendations

The primary management goal for Fresh Pond Beach is maintaining shore protection for the existing upland development. Given the narrow beach and high level of exist development, a combination of moderation, armoring and restoration erosion management appears best.

It is important that the existing shore protection structures are maintained. As with other bluffed shorelines with narrow beaches, building new structures or substantially repairing older ones should be accompanied by beach material mitigation (small scale nourishment). Since the bluffs are relatively high and residences are built on or near their edge, storm water control and vegetative stabilization should be encouraged to reduce slope failure. The use of groins should be discouraged in this area as longshore transport is limited. Vegetative stabilization and storm water control are likely to be the preferred alternative for bluff stabilization by the regulatory agencies, although it is understood that structural measures cannot be avoided in all cases. Placement of material as mitigation to offset the perceived potential adverse impacts of structures is generally consistent with the best practices of the NYSDEC and USACE.

With residential development located near to the top of the bluffs, the toe of the bluffs will require armoring to prevent slope failures during severe storm conditions. Existing erosion protection structures along the toe should be maintained and new structures meeting the requirements of Local Law No. 7-1989 should be allowed. The toe protection system will be limited by the "weakest link" or the structure most susceptible to storm damage along this reach. As such, and to promote a unified shore protection approach, the local properties owners association should be encouraged to develop and implement an inspection and maintenance program for the bluff protection structures (see Section 8.3). An inspection and maintenance program is a requirement for new or reconstructed erosion control structures under the regulations of 6 NYCRR Part 505.

As part of the restoration program, repair and reconstruction of existing structures and construction of new structures should have a requirement for beach material mitigation. Bluff toe protection structures should be required to place a volume of material equivalent to the volume of bluff material that the structure would prevent from entering the system over the design life of the structure. With the CEHA requirement for a 30 year design life, a historic bluff erosion rate of about 1 foot per year and an assumed bluff height of 20 feet, the required mitigation volume would be 600 cubic feet of beach material per linear foot of shore protection structure. The beach material utilized for this management area should be a mix of sand, gravel and cobble, matching the existing beach material. The mixed beach material will provide additional erosion protection over pure sand nourishment. If efforts are not made to introduce additional sand into the system at this location, this area could face future problems similar to what the east end of Makamah Beach is currently experiencing.

Beach material mitigation will also improve public beach access. Without some form of beach nourishment, public access along this section of shoreline will continue to diminish and eventually there will be almost no public access due to a reduced beach width. Public access is an important provision of most regulatory policies; therefore, the nourishment should be viewed favorably.

Appropriate moderation measures including vegetative slope stabilization measures such as live stakes, live fascines and brush mattresses should be encouraged, as should storm water and irrigation runoff controls to prevent slope failures. Avoid planting non-native trees and shrubs at the eastern end adjacent to Fresh Pond, to avoid escape of horticultural varieties into natural communities. If a woody plant dies, consider replacement with a native species. Maintain good vegetative coverage on bluff faces.

The existing groins do not appear to be providing a substantial shore protection benefit as there was no obvious long shore transport in this area. As such, repairs, reconstruction or new groins should be discouraged.

New or expansions of existing residential development should not occur within the Coastal Erosion Hazard Area, as defined in NYSDEC article 34 and Local Law No. 7-1989.

8.3 INSPECTION PROGRAM

As outlined in the Article 34 regulations (6 NYCRR Part 505), inspection and maintenance is a key component of a successful long term structural erosion measure. While it is important for new structures permitted under the Article 34 regulations, inspection and maintenance is even more important for existing, older structures.

The inspection and maintenance program should include at a minimum: an annual visual inspection of all structures and a survey of dunes; a visual inspection of the dunes and all structures following significant storm events; inspection of all structures every 5 years by a licensed professional engineer with experience in the inspection and design of coastal protection structures, addressing structural deficiencies or sediment loss as soon as possible; and emergency/contingency planning.

8.4 SEDIMENT MITIGATION PROGRAM

The sediment mitigation program is an important component of the overall erosion management system. Many of the beaches in the study area exhibit a sand starved profile, even during the summer months. As such, a source of sediment needs to be identified and added back to the system. With the increasing stabilization of the shoreline, beach material that was once available from bluffs and dunes, is no longer available to the beach system. A sediment mitigation program can balance the loss of material from the system with the increased shoreline stability that the structures offer.

The previous management recommendations sections contain recommended volumes of sediment to mitigate structure construction for each management area. It may be more practical that the mitigation volume be placed on the beach in increments rather than all at one time. For example one half of the required volume could be placed at the time of structure construction and the remaining volume place on the beach 5 to 10 years after structure construction.

9.0 CONCLUSIONS

The following conclusions are drawn from the data gathered and analyzed in the previous sections.

- Much of the study area exhibits properties that indicate a sand deficit, especially in the eastern half of the study area.
- Bluff stabilization measures along with natural processes have contributed to the sand deficit in the study area.
- Beach and bluff erosion are part of a historic pattern of shoreline change in the study area and North Shore of Long Island in general.
- Underlying geology contributes to high bluff erosion rates especially along Geissler's Beach and at Broken Ground.
- The eastern end of Makamah Beach has a critical beach erosion problem and additional storm damage to the adjacent residential properties can be expected unless significant shore protection management strategies are implemented.
- The beach nourishment program at Crab Meadow Beach is a success in providing both public beach access and shore protection.
- The Broken Ground area, including the bluff at Indian Hills Golf Course, is expected to continue to have soil movement issues. The observed scarp is likely the result of a deep seated failure along a clay layer. While there are measures that can be implemented to minimize the severity, rate and frequency of soil movement in the Broken Ground area, achieving long term stability is questionable.
- Public access to the beach is currently limited by narrow beach widths in many areas. This trend is expected to become worse unless additional beach material can be added to the system.
- Erosion management for the existing shoreline should consist of a combination of management techniques including armoring, moderation and restoration.
- Given the sand deficit along the eastern portion of the study area, some level of beach nourishment will be required for long term stability of the area.
- No single management solution is appropriate for the entire study area, as different portions of the study area have different physical characteristics and uses.
- An important component of the management program will be replacing sediment lost to the system by bluff and shore protection structures. OCC recommends a program of sediment mitigation to offset these losses.
- Dune protection and enhancement measures should include a combination of strategies including elevated walkway replacing paths cutting through the dune, extensions or additions of snow fencing to promote dune creation; dune plantings; restrictions on foot traffic;
- Landscaping with drought-resistant native plants tolerant of salt spray should be promoted throughout the study area to avoid the escape of horticultural and non-native varieties into natural plant communities and to minimize erosion caused by irrigation.
- Long term stability of the shoreline may be achieved by implementing Local Law No. 7-1989

A combination of the armoring, moderation and restoration alternatives described in Section 8.0 can be viewed as a multidimensional regional approach such that actions to slow or halt erosion are flexible depending on location and erosion processes such that the entire shoreline ultimately functions as a system. Given the variable land-use (residential, commercial, and public), collective coordination of individual stakeholders is a difficult task; however, documentation of the regional shoreline character included in this report is an important first-step in unifying the coastal residents. Without a concentrated management effort, continued erosion is imminent over most of the developed shoreline in the study area.

The management recommendations outlined for each area were developed in light of and commensurate with the best practices and policies typically deemed acceptable by NYSDEC and USACE. However, it is recommended that a pre-application meeting with the agencies be held during the early stages of planning to determine potential permitting issues and assessment requirements of individual shore protection measures.

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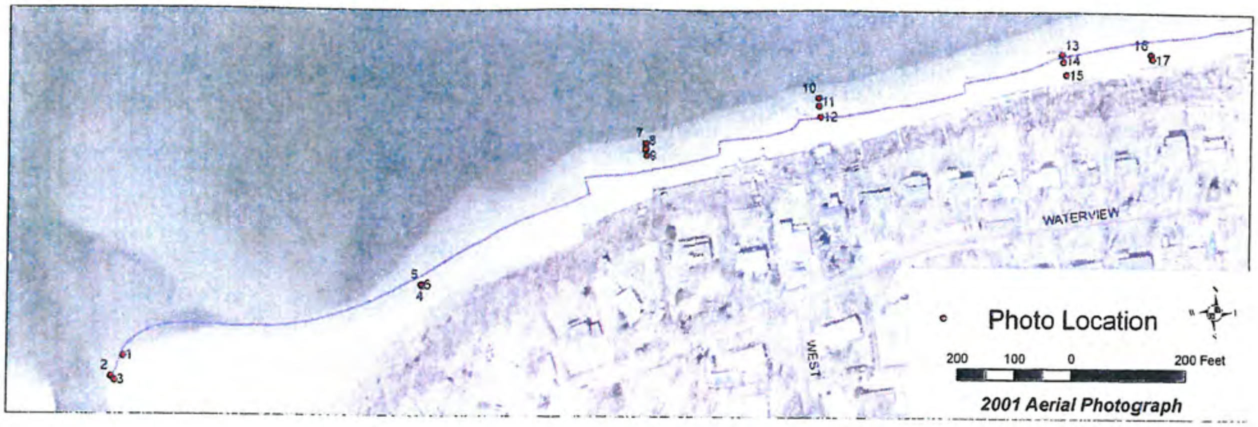
APPENDIX A
Ground Photos

Appendix A – Field Photos

Photograph numbers and direction of photograph are listed.

Overview, Photos 1 – 17



Photos 1 – 17

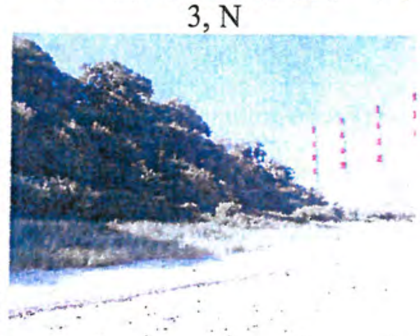

1, W


2, N

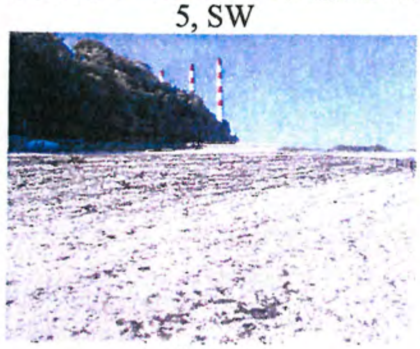

3, N


4, W


5, SW


6, SW


7, W


8, SW


9, S

10, W

11, SW

12, S

13, W

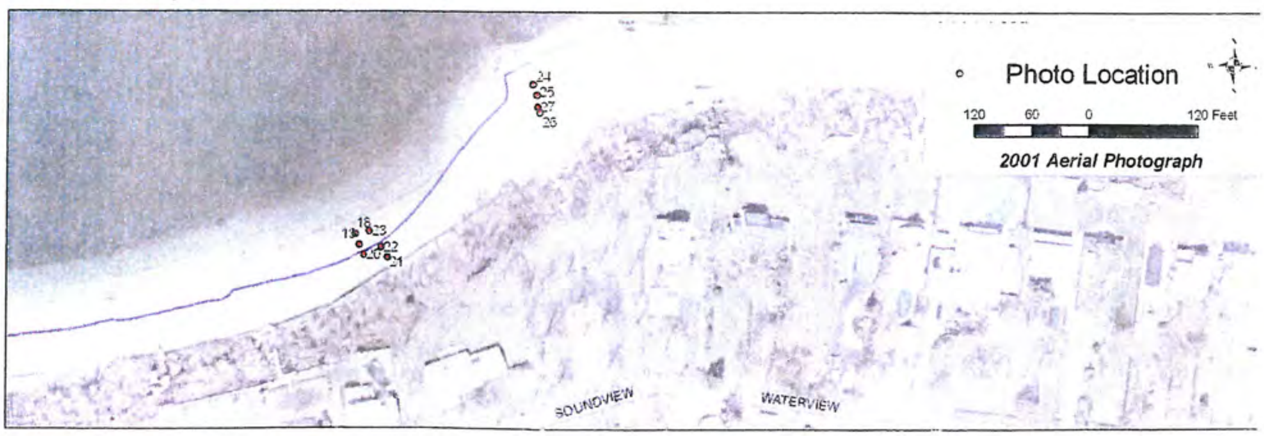
14, W

15, W

16, W

17, W

Overview, Photos 18 – 26



Photos 18 – 26

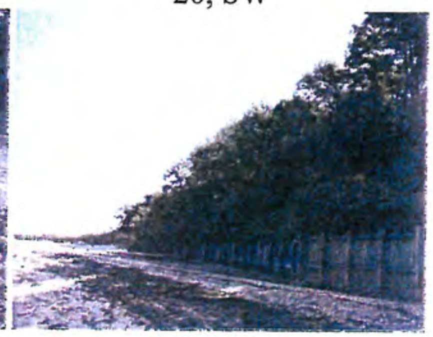
18, W

19, W

20, SW

21, NE

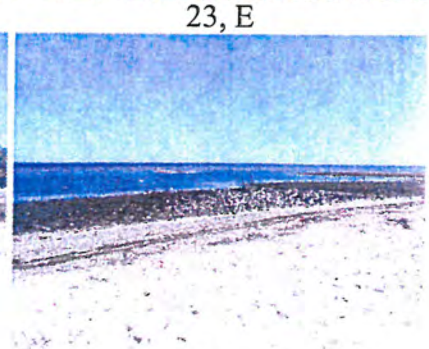
22, E



23, E

24, W

25, W



26, E

Overview, Photos 27 – 48

Photos 27 – 48


27, E


28, SW


29, W


30, NW


31, N


32, N


33, E


34, E


35, NE


36, SW


37, S


38, S


39, SE


40, N


41, S


42, SW


43, W


44, N

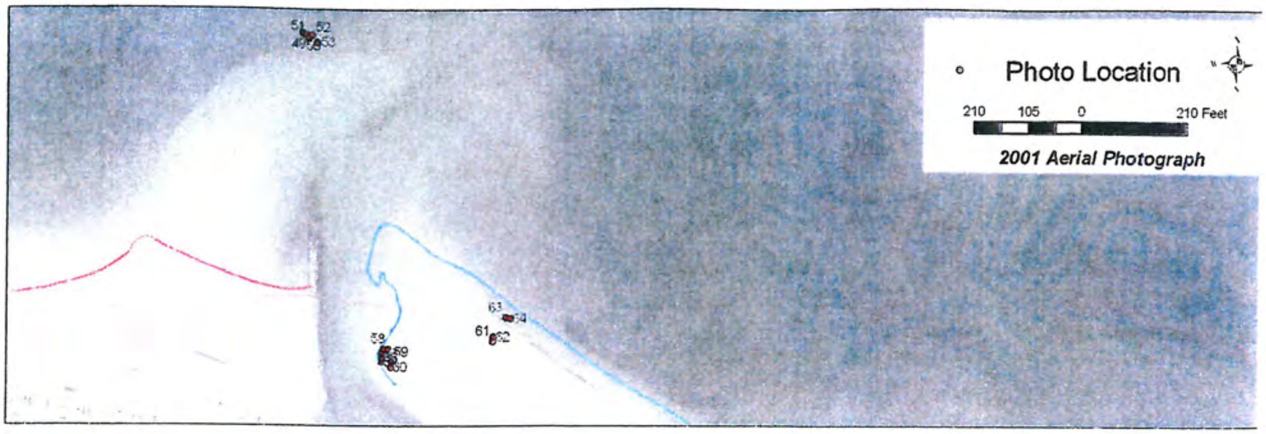

45, NE


46, E


47, SE


48, E

Overview, Photos 49 – 64



Photos 49 – 64


49, W


50, S

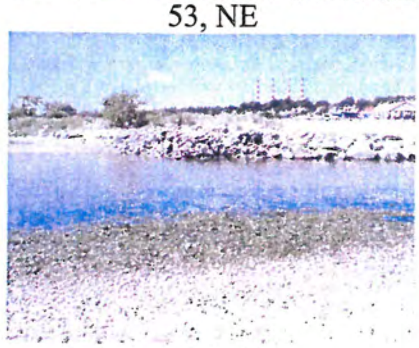

51, S


52, E


53, NE


54, SE


55, S


56, SW


57, W


58, NW

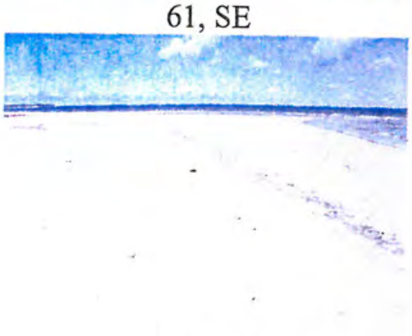

59, E


60, SE

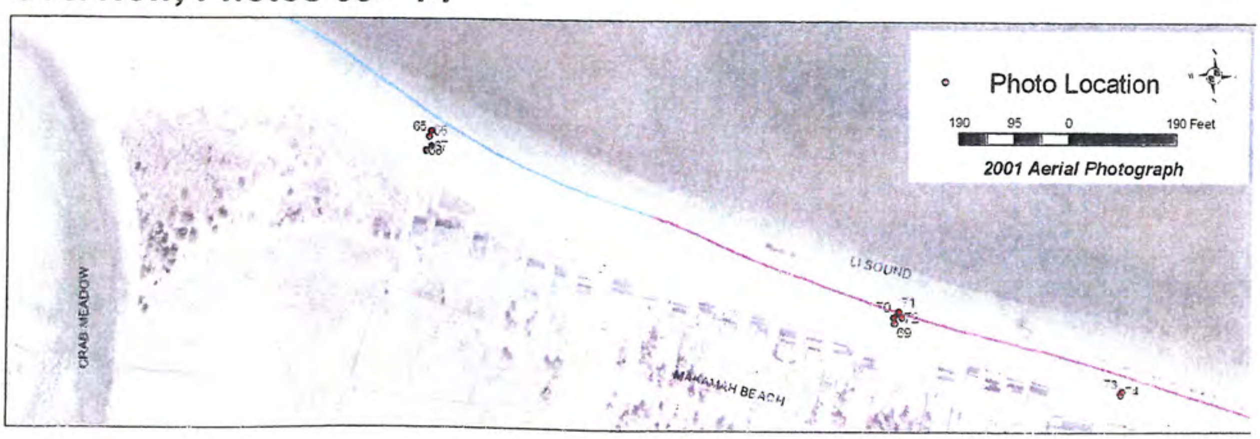

61, SE


62, E


63, E


64, WNW

Overview, Photos 65 – 74



Photos 65 – 74


65, W


66, E


67, W


68, E


69, W


70, E

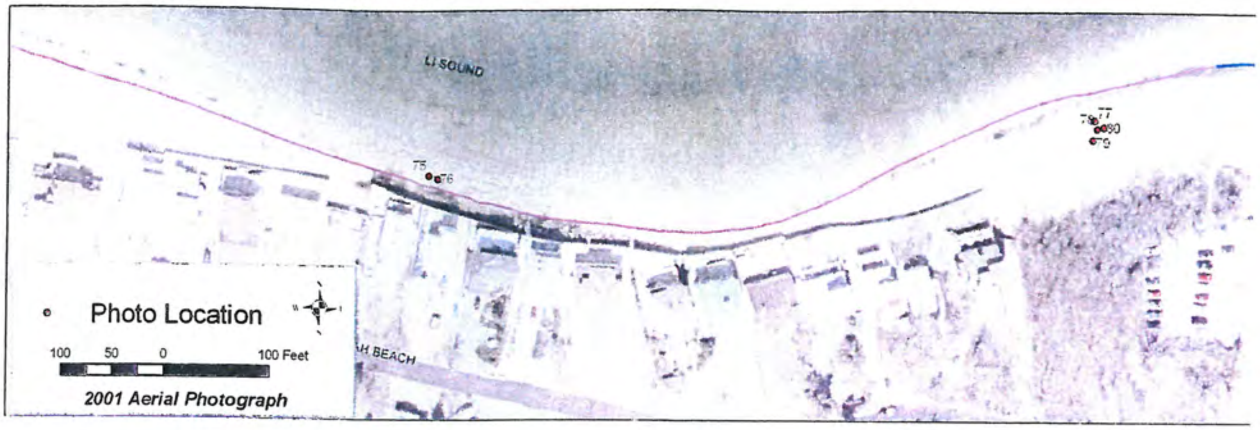

71, W


72, E


73, E


74, W

Overview, Photos 75 – 80



Photos 75 – 80

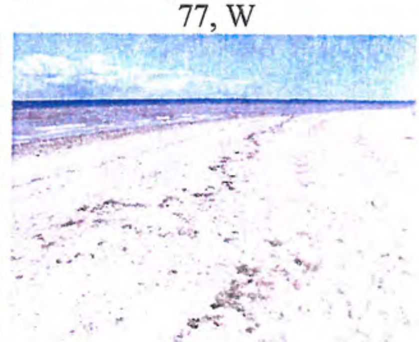

75, E


76, W

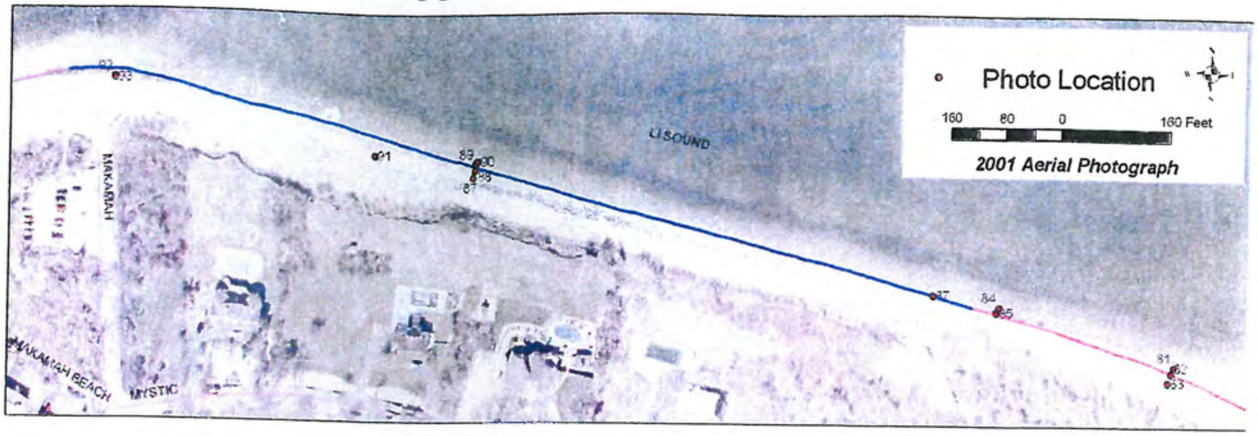

77, W


78, W


79, E


80, E

Overview, Photos 81 – 93



Photos 81 – 93

81, W

82, SW

83, S

84, W

85, SW

86, S

87, E

88, SE

89, SW

90, W

91, S

92, E

93, SE

Overview, Photos 94 – 105 (East End of Study Area)

Photos 94 – 105

94, S

95, SW

96, NW

97, SW

98, W

99, W

100, S

101, SW

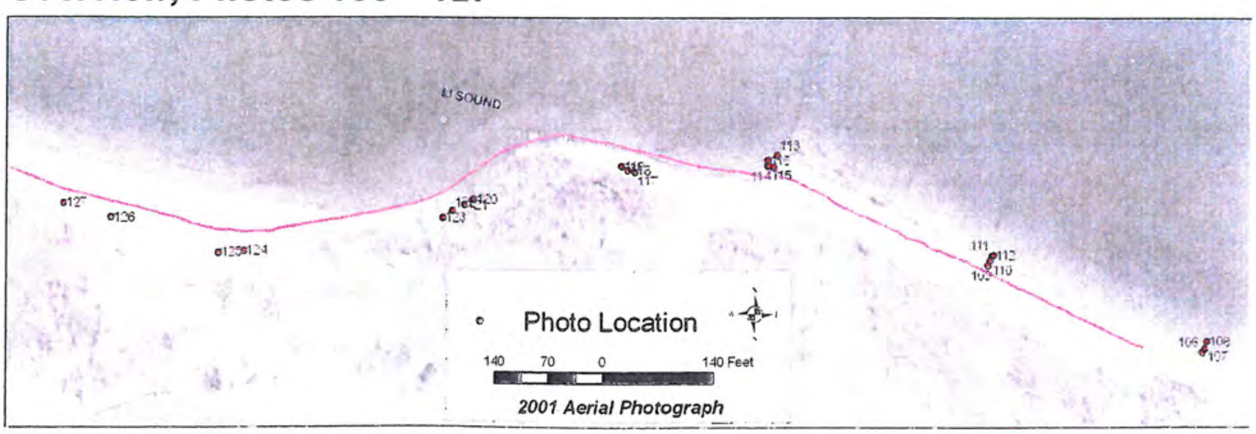
102, W

103, S

104, SW

105, W

Overview, Photos 106 – 127



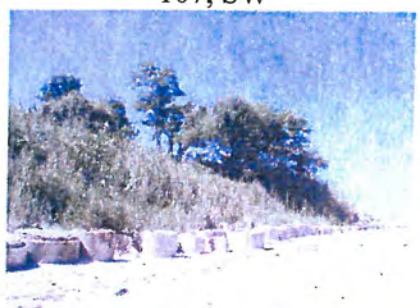
Photos 106 – 127

106, S

107, SW

108, W

109, S



110, SW

111, W

112, N

113 (Cretaceous clay outcrop)

114, S

115, SW

116, W

117, S

118, SW

119, W

120, S

121, SW

122, W

123, N

124, NW

125, W

126, SW

127, NW

APPENDIX B
Aerial Images and Historic Maps

Appendix B – Historic Data Sources

Shoreline change and bluff change calculations were performed based on the following historic data sets. Root Mean Square (RMS) values were calculated in ArcMap (Environmental Systems Research Institute) for aerial photographs; orthographic photographs were processed by NYS Office of Cyber Security & Critical Infrastructure Coordination. RMS values were not calculated for maps as the line work accuracy is unknown.

Aerial Photographs

Year	Date	RMS (ft)	Tide	Notes	Source
1938	July	20	Unknown	Difficult to assess features	EEA, Inc.
1947	August	18	Mid	B&W	EEA, Inc.
1962	March	20	Low	After Ash-Wendsday storm	EEA, Inc.
1972	April	5	Low	B&W	EEA, Inc.
1977	April	15	Low	B&W	EEA, Inc.
1984	March	10	Low	B&W	EEA, Inc.
1994	April	15	Mid	Ortho Photo; Color IR	NYS Office of Cyber Security & Critical Infrastructure Coordination
2001	April	2	High	Ortho Photo; Color	NYS Office of Cyber Security & Critical Infrastructure Coordination
2004	April	2	Low	Ortho Photo; Color	NYS Office of Cyber Security & Critical Infrastructure Coordination

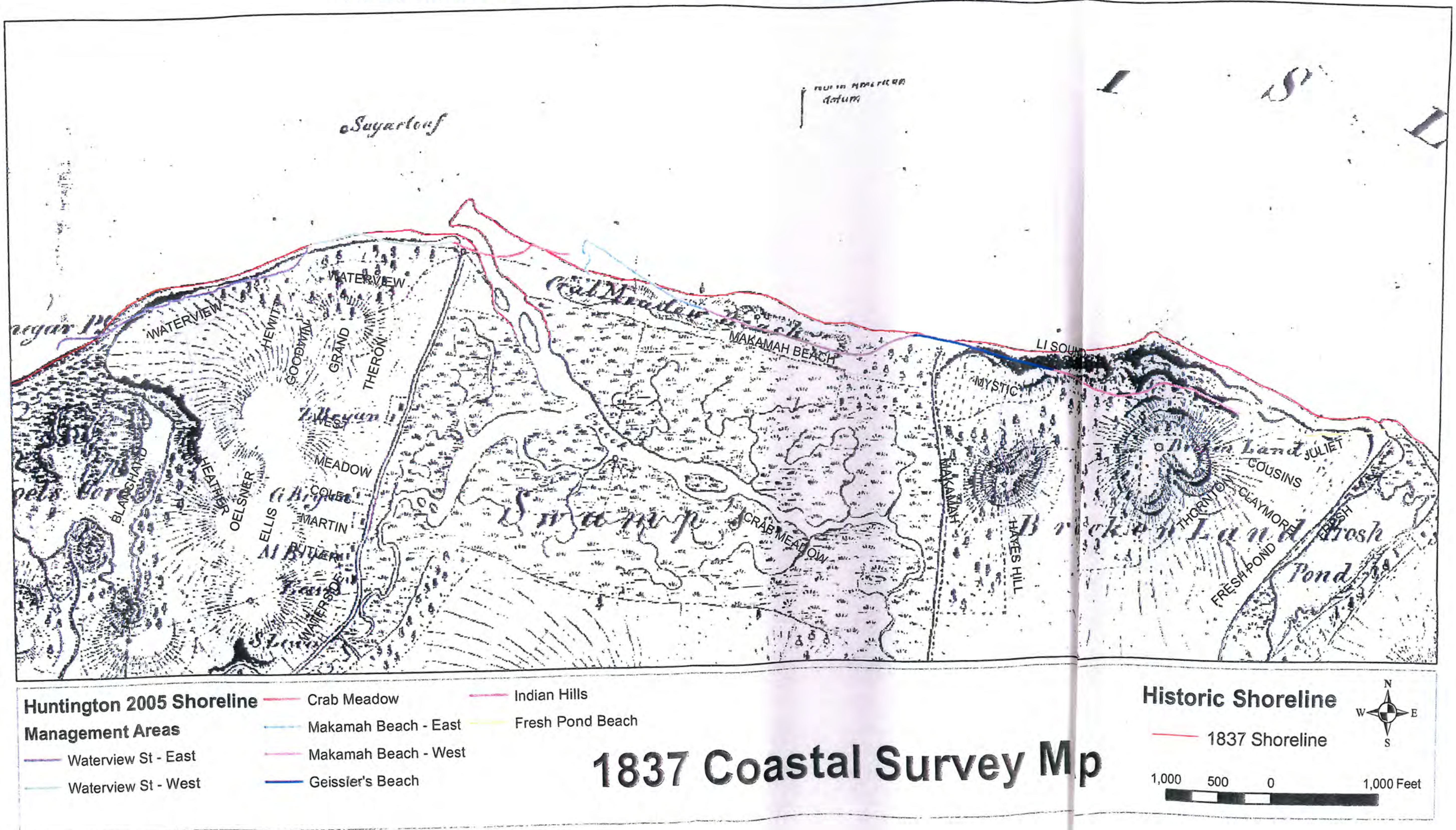
Maps

Year	Type	Source
1837	Coastal Survey	National Ocean Service
1885-86	T-Sheet	National Ocean Service
1917	T-Sheet	National Ocean Service
CEHA	Regulatory	NY State Dept of Env Conservation

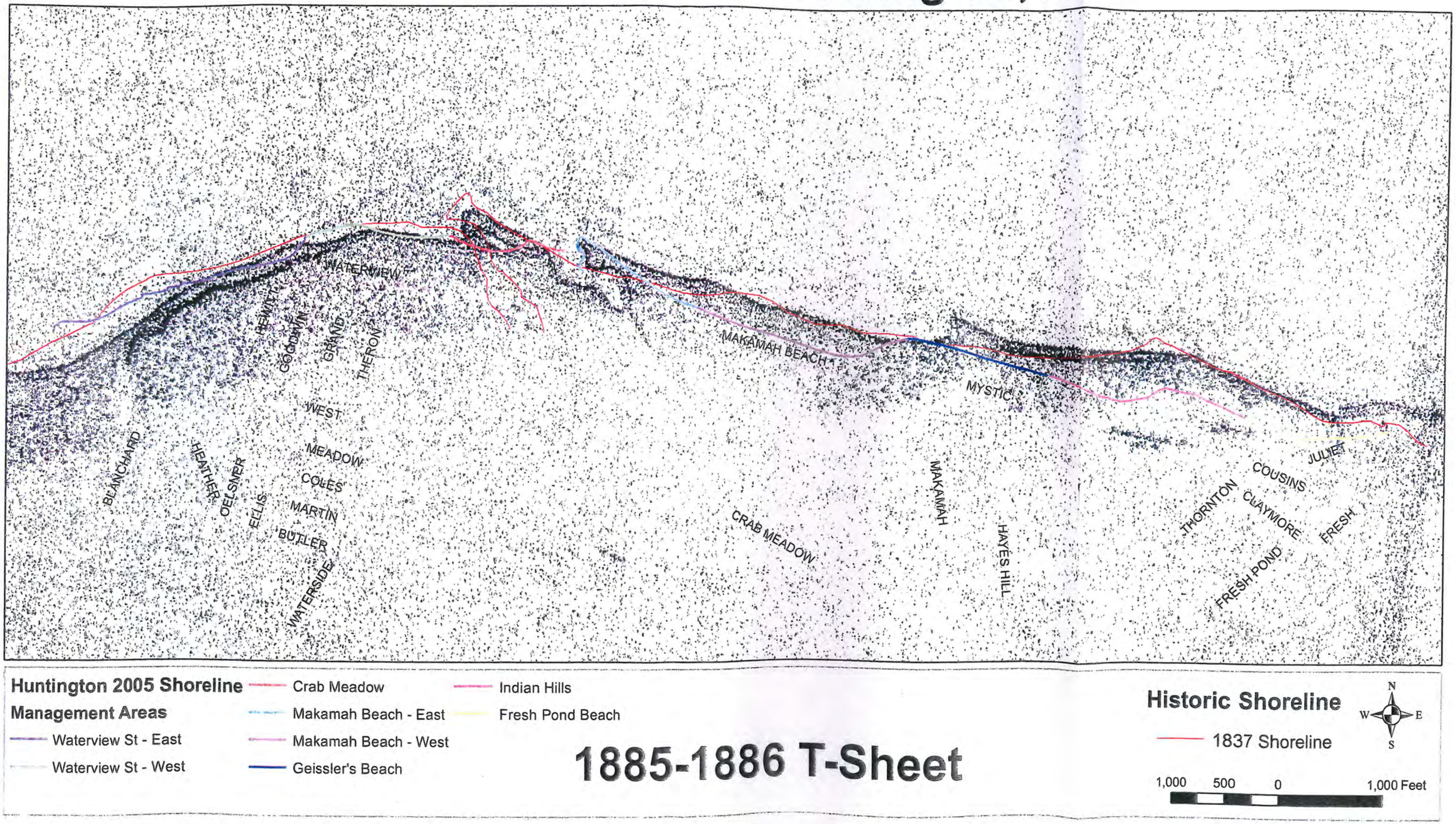
The geo-referenced data is illustrated on the following pages and provided on the data CD as geo-tiff images (NY State Plane, Long Island); metadata is included. The ortho-rectified data is available from the NYS GIS website (http://www.nysgis.state.ny.us/gateway/mg/).

Corresponding historic shoreline and bluff location data is provided as Shapefiles (.shp) on CD; metadata is included.

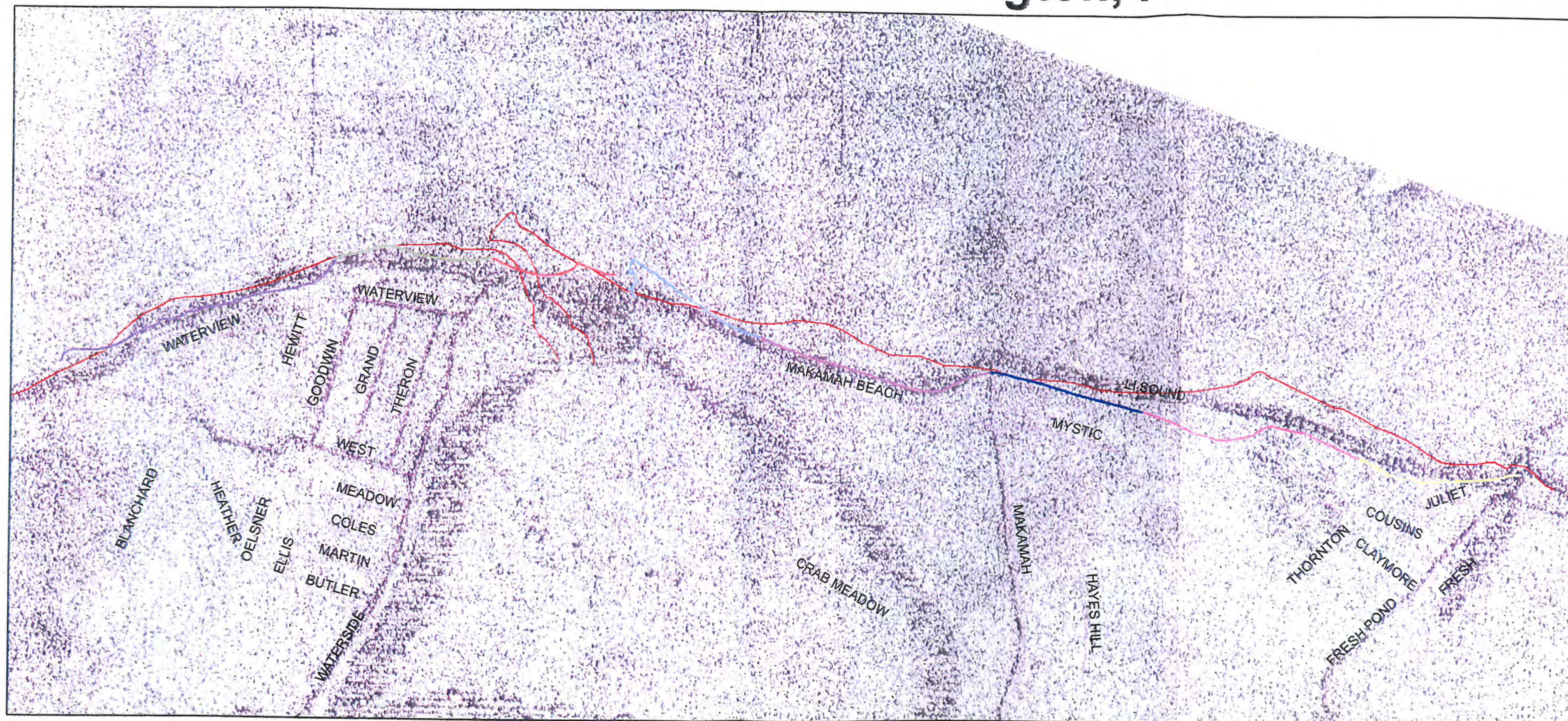
Historic Shoreline - Huntington, NY



Historic Shoreline - Huntington, NY



Historic Shoreline - Huntington, NY



Huntington 2005 Shoreline Management Areas

- Waterview St - East
- Waterview St - West
- Crab Meadow
- Makamah Beach - East
- Makamah Beach - West
- Geissler's Beach
- Indian Hills
- Fresh Pond Beach

1917 T-Sheet

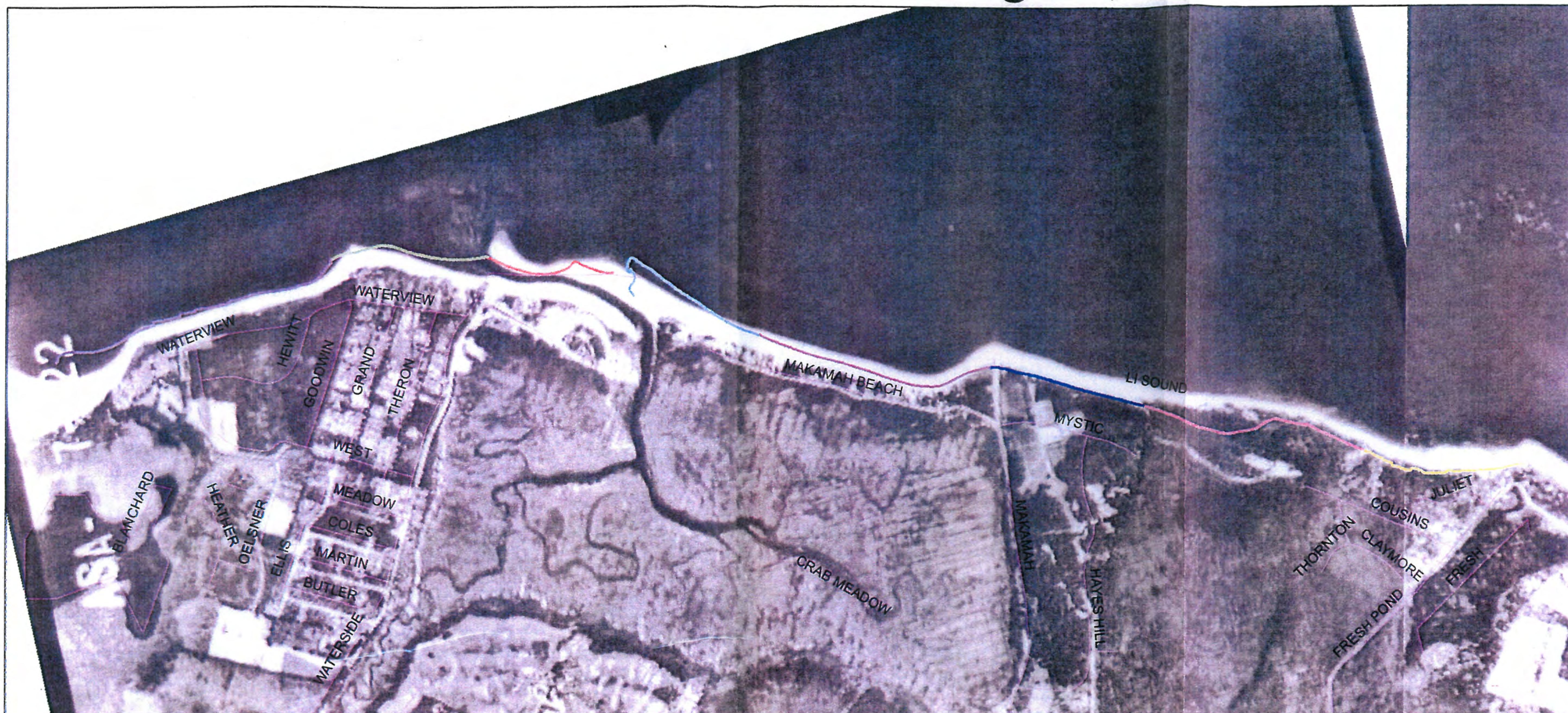
Historic Shoreline

- 1837 Shoreline

1,000 500 0 1,000 Feet

N E S W

Historic Shoreline - Huntington, NY



Huntington 2005 Shoreline Management Areas

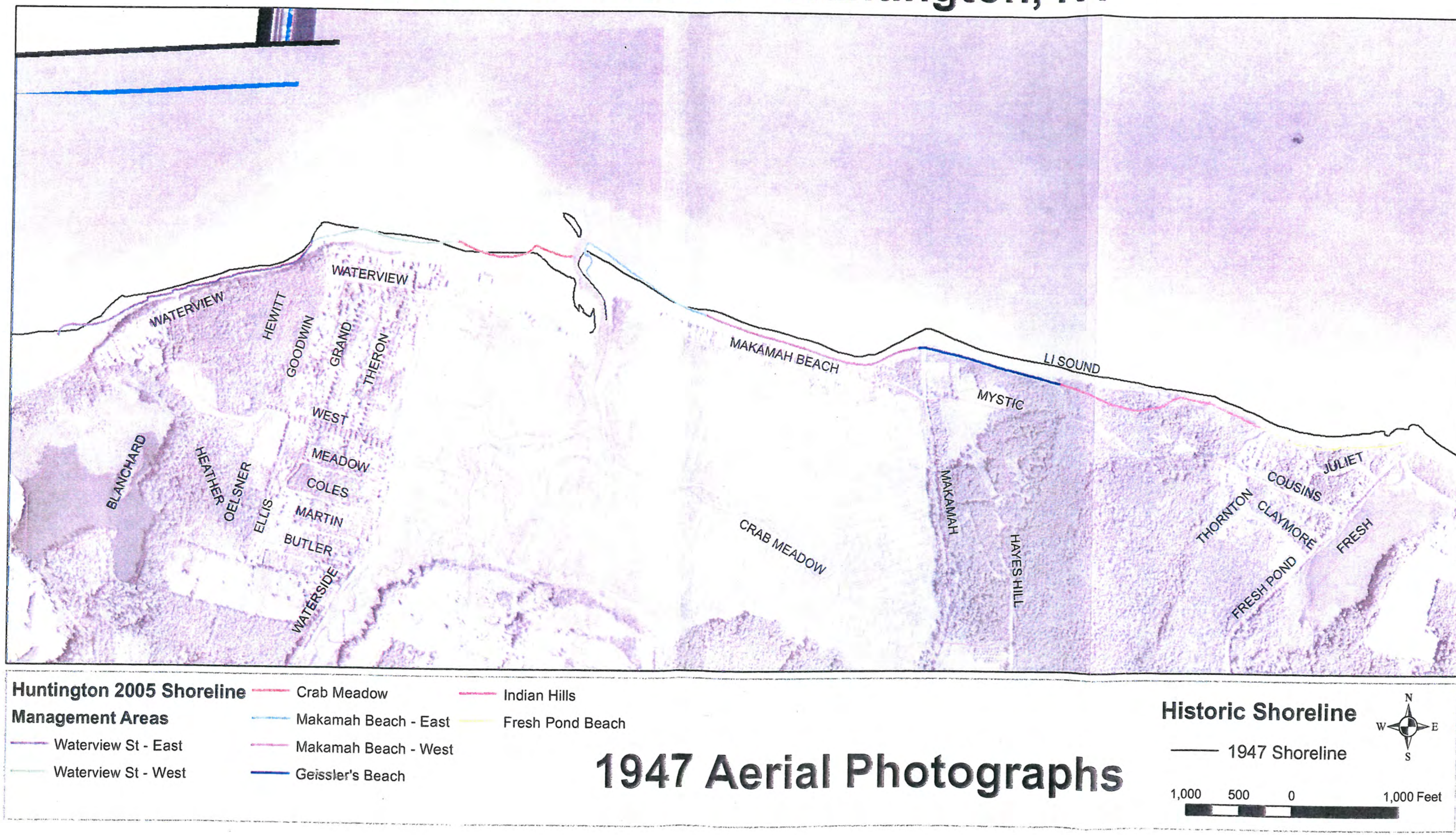
- Waterview St - East
- Waterview St - West
- Crab Meadow
- Makamah Beach - East
- Makamah Beach - West
- Geissler's Beach
- Indian Hills
- Fresh Pond Beach

1938 Aerial Photographs

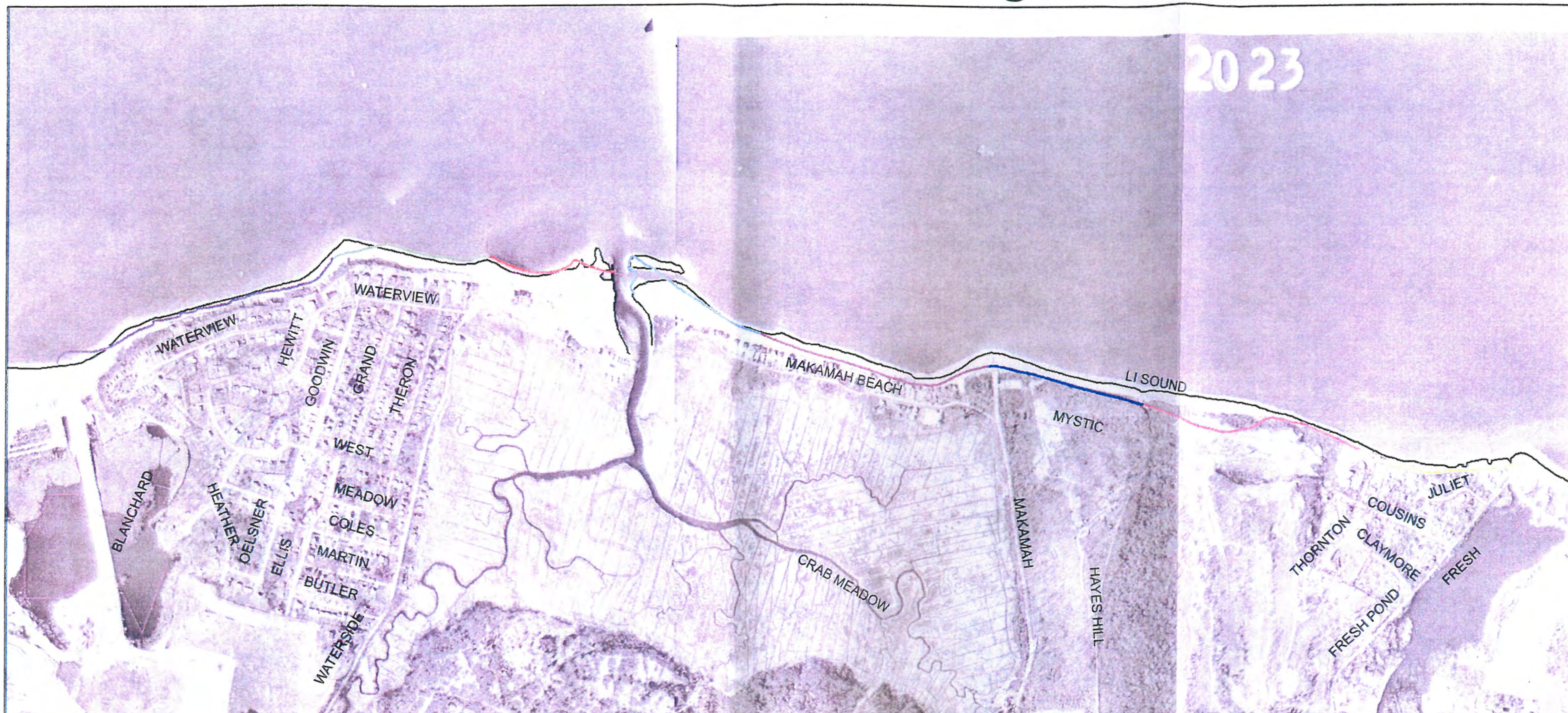
N W E S

1,000 500 0 1,000 Feet

Historic Shoreline - Huntington, NY



Historic Shoreline - Huntington, NY



Huntington 2005 Shoreline Management Areas

- Waterview St - East
- Waterview St - West
- Crab Meadow
- Makamah Beach - East
- Makamah Beach - West
- Geissler's Beach
- Indian Hills
- Fresh Pond Beach

1962 Aerial Photographs

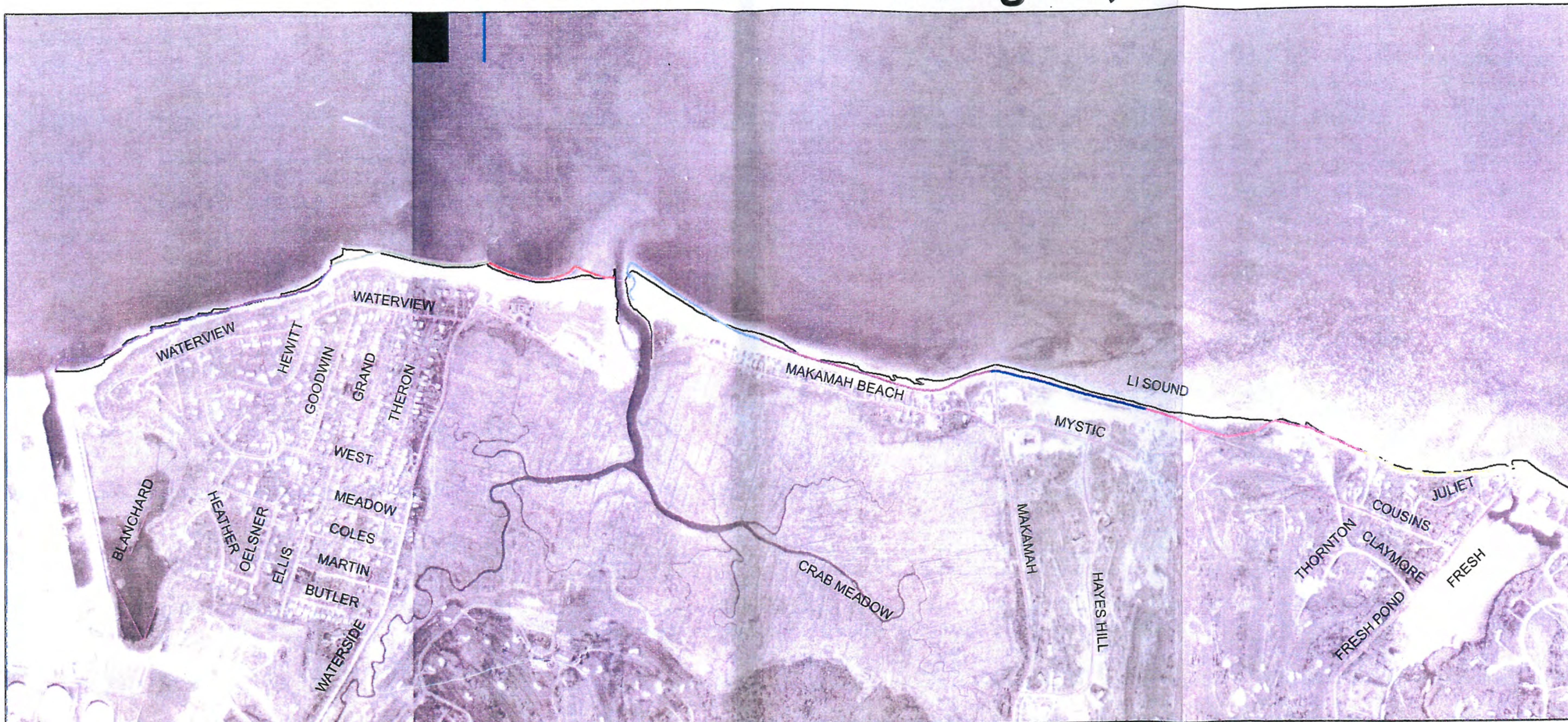
Historic Shoreline

- 1962 Shoreline

N W E S

1,000 500 0 1,000 Feet

Historic Shoreline - Huntington, NY



Huntington 2005 Shoreline Management Areas

- Waterview St - East
- Waterview St - West
- Crab Meadow
- Makamah Beach - East
- Makamah Beach - West
- Geissler's Beach
- Indian Hills
- Fresh Pond Beach

1972 Aerial Photographs

Historic Shoreline

- 1972 Shoreline

N W E S

1,000 500 0 1,000 Feet

Historic Shoreline - Huntington, NY

Huntington 2005 Shoreline Management Areas

- Waterview St - East
- Waterview St - West
- Crab Meadow
- Makamah Beach - East
- Makamah Beach - West
- Geissler's Beach
- Indian Hills
- Fresh Pond Beach

1977 Aerial Photographs

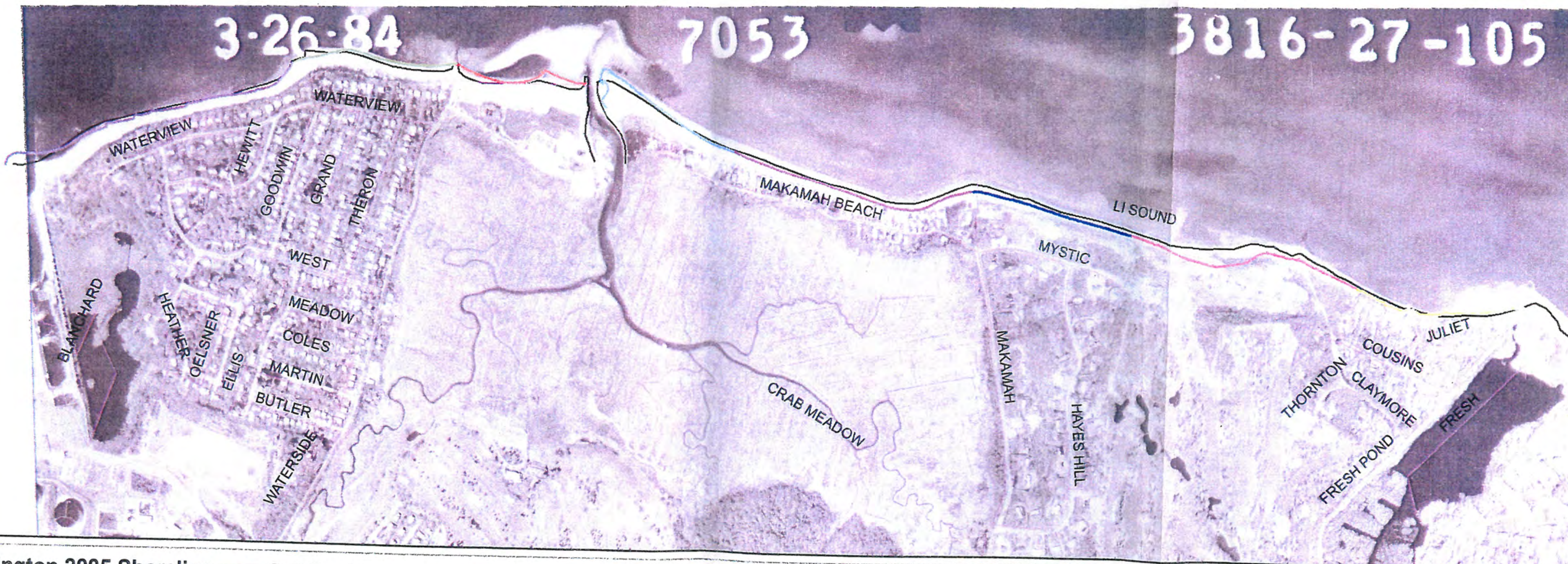
Historic Shoreline

— 1977 Shoreline

N W E S

1,000 500 0 1,000 Feet

Historic Shoreline - Huntington, NY



Huntington 2005 Shoreline Management Areas

- Waterview St - East
- Waterview St - West
- Crab Meadow
- Makamah Beach - East
- Makamah Beach - West
- Geissler's Beach
- Indian Hills
- Fresh Pond Beach

1984 Aerial Photographs

Historic Shoreline

- 1984 Shoreline

N W E S

1,000 500 0 1,000 Feet

Historic Shoreline - Huntington, NY

Huntington 2005 Shoreline Management Areas

- Waterview St - East
- Waterview St - West
- Crab Meadow
- Makamah Beach - East
- Makamah Beach - West
- Geissler's Beach
- Indian Hills
- Fresh Pond Beach

Historic Shoreline

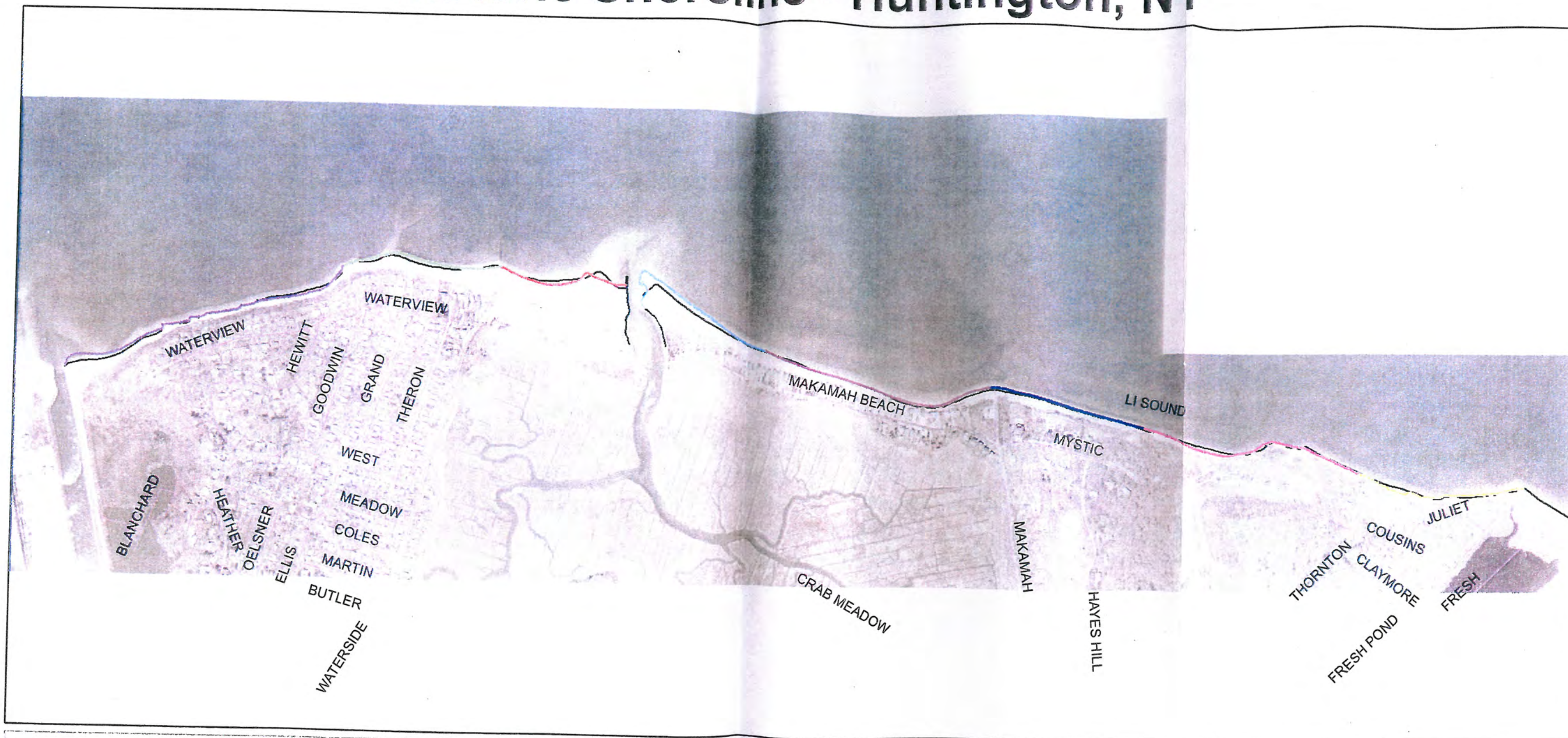
- 1994 Shoreline

N W E S

1,000 500 0 1,000 Feet

1994 Aerial Photographs

Historic Shoreline - Huntington, NY



Huntington 2005 Shoreline Management Areas

- Waterview St - East
- Waterview St - West
- Crab Meadow
- Makamah Beach - East
- Makamah Beach - West
- Geissler's Beach
- Indian Hills
- Fresh Pond Beach

2001 Aerial Photographs

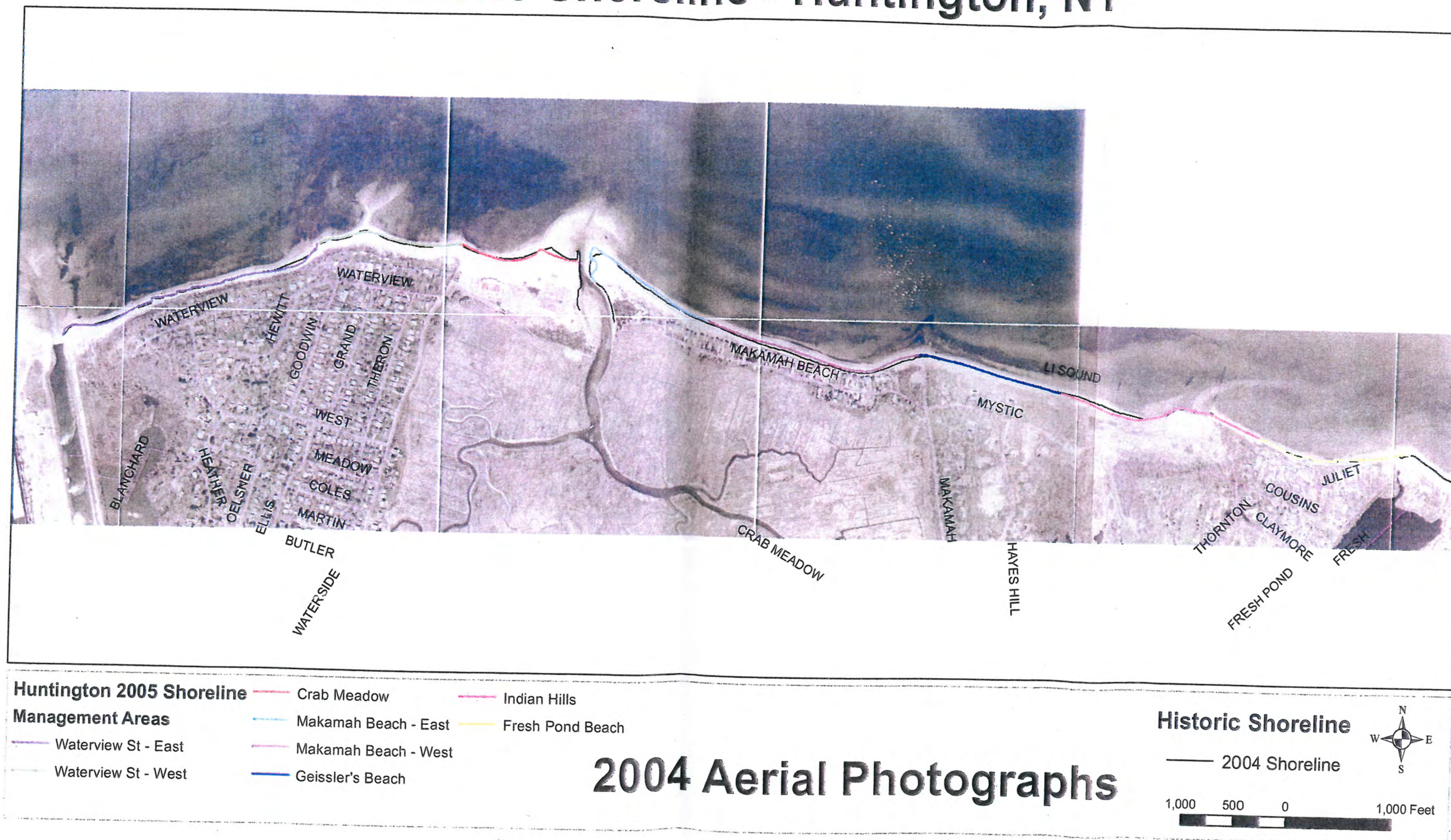
Historic Shoreline

- 2001 Shoreline

1,000 500 0 1,000 Feet

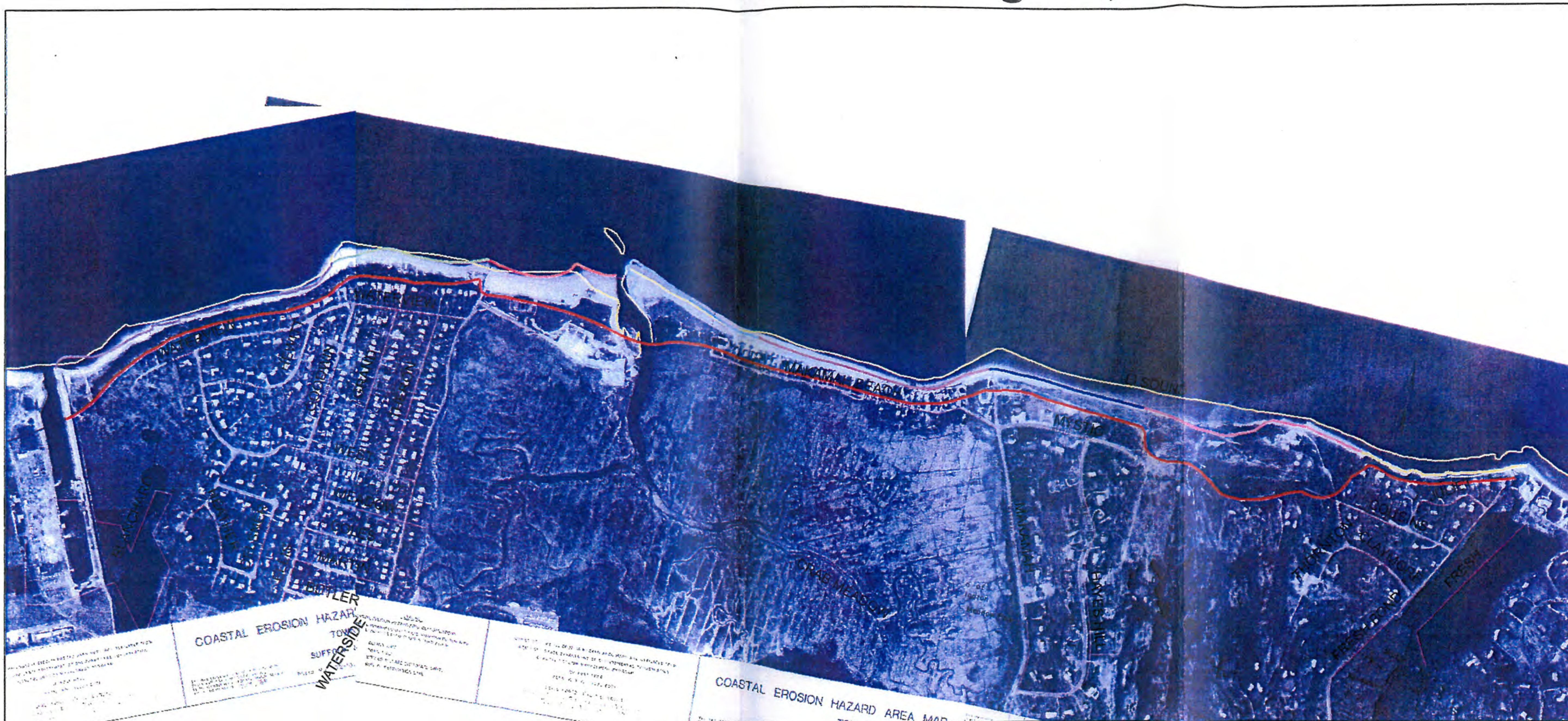
N W E S

Historic Shoreline - Huntington, NY



2004 Aerial Photographs

Historic Shoreline - Huntington, NY



Huntington 2005 Shoreline Management Areas

- Waterview St - East
- Waterview St - West
- Crab Meadow
- Makamah Beach - East
- Makamah Beach - West
- Geissler's Beach
- Indian Hills
- Fresh Pond Beach

Coastal Erosion Hazard Area Map

Historic Shoreline

- 1947 Shoreline

N W E S

1,000 500 0 1,000 Feet

APPENDIX C
Shorefront Vegetation Table

Table C-1: Shorefront Vegetation in the Huntington project area.

COMMON NAME	BOTANICAL NAME	OBS.	RECOMMENDED
	Trees		
American holly	*Ilex opaca*		R: Btop
Black cherry	*Prunus serotina*	O	NR
Black locust	*Robinia pseudoacacia*	O	NR
Black willow	*Salix nigra*	O	NR
Eastern cottonwood	*Populus deltoides*	O	NR
Eastern redbud	*Cercis canadensis*		R: Btop
Limber pine	*Pinus flexilis*		R: Btop
Norway maple	*Acer platanoides*	O	NR
Pitch pine	*Pinus rigida*		R: Btop, HB
Sassafras	*Sassafras albidum*	O	R: Btop
Scrub Pine	*Pinus virginiana*		R: Btop, HB
Shadbush	*Amelanchier spp.*	O	R: Btop, BF
	Shrubs		
Autumn olive	*Elaeagnus umbellata*	O	NR
Beach plum	*Prunus maritima*	O	R: Btop, BF, Btoe, HB
Beach rose	*Rosa rugosa*	O	R: Btop, BF, Btoe, HB
Black chokeberry	*Aronia melanocarpa*		R: BF, Btoe
Bristly locust	*Robinia fertilis*		R: Btop, BF
Carolina rose	*Rosa carolina*		R: Btop, BF
Coastal juneberry	*Amelanchier obovalis*		R: Btop, BF, Btoe
Common blackberry	*Rubus allegheniensis*		R: Btop, BF
Dwarf sand cherry	*Prunus pumila var. depressa*		R: Btop, BF, HB
Eastern redcedar	*Juniperus virginiana*	O	R: Btop, HB
Elderberry	*Sambucus canadensis*		R: Btop, Btoe
Gray dogwood	*Cornus racemosa*		R: Btop, BF
Groundsel-bush	*Baccharis halimifolia*		R: BF; Btoe, HB, HM
Highbush blueberry	*Vaccinium corymbosum*		R: Btop, Btoe
Indigobush	*Amorpha fruticosa*		R: Btop, BF
Inkberry	*Ilex glabra*		R: Btop, Btoe
Marsh elder	*Iva frutescens*		R: Btoe, HM
New Jersey tea	*Ceanothus americanus*		R: Btop
Northern bayberry	*Myrica pensylvanica*	O	R: Btop, BF, Btoe, HB
Pasture rose	*Rosa virginiana*	O	R: Btop, BF, Btoe, HB
Purple-leaved sand cherry	*Prunus x cistena*		R: Btop
Pussy willow	*Salix discolor*	O	R: BF, Btoe
Red chokeberry	*Aronia arbutifolia*		R: BF, Btoe
Running juneberry	*Amelanchier stolonifera*		R: Btop, BF, Btoe
Shore juniper	*Juniperus conferta*		R: Btop, HB
Winged sumac	*Rhus copallinum*	O	R: Btop, BF, Btoe, HB

Vines & Groundcovers			
Annual ryegrass*	*Lolium multiflorum*		R: Btop, BF
Asiatic bittersweet	*Celastrus orbiculatus*	O	NR
Beach heather	*Hudsonia tomentosa*		R: Btop, BF
Beach pea	*Lathyrus japonicus*	O	R: BF, Btoe, HB
Beachgrass*	*Ammophila breviligulata*	O	R: Btop, BF, Btoe, HB
Bearberry	*Arctostaphylos uva-ursi*		R: Btop, HB
Big bluestem	*Andropogon gerardii*		R: Btop, BF
Big cordgrass	*Spartina cynosuroides*		R: Btoe
Broom sedge	*Andropogon virginicus*		R: Btop, BF, Btoe, HB
Canada wildrye*	*Elymus canadenseis*		R: Btop, BF
Chewings Fescue	*Festuca rubra var. commutata*		R: Btop, BF
Coastal panicgrass	*Panicum amarum var. amarulum*		R: Btop, BF, Btoe, HB
Common reed	*Phragmites australis*	O	NR
Creeping red fescue	*Festuca rubra*	O	R: Btop, BF
Crownvetch	*Coronilla varia*	O	NR
Deertongue	*Dichanthelium clandestinum*		R: Btop, BF
Dusty miller	*Artemisia stelleriana*		R: Btop, BF, Btoe, HB
Golden heather	*Hudsonia ericoides*		R: Btop, BF
Greenbrier	*Smilax spp.*	O	R: BF, HB
Grey goldenrod	*Solidago nemoralis*		R: Btop, BF
Hard fescue	*Festuca brevipila*		R: Btop, BF
Horsetails	*Equisetum* spp.	O	NR
Japanese wisteria	*Wisteria floribunda*	O	NR
Little/seacoast bluestem	*Schizachyrium scoparium var. littoralis*		R: Btop, BF, HB
Montauk daisy	*Chrysanthemum nipponicum*	O	R: Btop, BF
Oats*	*Avena sativa*		R: Btop, BF
Partridge pea*	*Chamaecrista fasciculata*		R: Btop, BF, HB
Poison Ivy	*Toxicodendron radicans*	O	NR
Prairie cordgrass	*Spartina pectinata*		R: Btoe
Purple lovegrass	*Eragrostis spectabilis*		R: Btop, BF, HB
Redtop	*Agrostis gigantea*		R: Btop, BF
Riverbank grape	*Vitis riparia*		R: Btop, BF, Btoe
Round-headed bush clover	*Lespedeza capitata*		R: Btop, BF, HB
Saltmeadow cordgrass	*Spartina patens*		R: HB, HM
Sand bluestem	*Andropogon hallii*		R: Btop, BF, HB
Sand lovegrass	*Eragrostis trichodes*		R: Btop, BF, HB
Seaside Goldenrod	*Solidago sempervirens*	O	R: Btop, BF, Btoe, HB

Sedges	*Cyperus* and *Scirpus* spp.	O	R: Btop
Sheep fescue	*Festuca ovina*		R: Btop, BF
Sideoats grama	*Bouteloua curtipendula*		R: Btop, BF, Btoe, HB
Spike grass	*Distichlis spicata*		R: HM
Sweetfern	*Comptonia peregrina*		R: Btop, BF
Switchgrass	*Panicum virgatum*		R: Btop, BF, Btoe, HB
Trumpet creeper	*Campsis radicans*		R: Btop; BF
Virginia creeper	*Parthenocissus quinquefolia*	O	R: Btop, BF, HB
White boneset	*Eupatorium album*	O	NR
Wild indigo	*Baptisia tinctoria*		R: Btop, BF

Where:
* = Quick-establishing short-lived (3-5 years) plants
OBS. = Observed
R = Recommended; NR = Not Recommended for Planting
BTop = Top of Bluff; BF = Bluff face; BToe = Bluff toe
HB = High Beach; HM = High Marsh

Sources:
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Petrides, G.A. 1972. A Field Guide to Trees and Shrubs;
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