Coastal Erosion, Sediment Transport, and Prioritization Management Strategy Assessment for Shoreline Protection

SCITUATE, MASSACHUSETTS
AUGUST, 2016

One of the primary issues facing the Town is the sustainability of its coastal development. The shoreline was extensively developed in the 1920's through the 1960's. High property values increased the pressure to develop the few remaining vacant lots on the shoreline. Today, many of the Town's highest priced homes are located there and these structures are becoming increasingly vulnerable. In addition to destruction of homes, storm conditions pose a significant danger to human life. During storm events, flood water and wind-swept debris may trap people preventing emergency personnel from providing assistance; these dangers make increased coastal development less and less sustainable.

Scituate's coastline is a classic example of a developed coastline that faces east or northeast and is vulnerable to nor'easters, which are common winter storms in Massachusetts. Existing foreshore protection stands landward of sediment starved beaches and is not capable of withstanding projected future conditions. Potential overwash, undermining, and collapse by higher sea levels and storm surge are serious concerns, particularly since at normal high tides there is no beach present in many areas to dissipate wave energy or to stabilize the structures.

In 2015, the Town of Scituate pursued a long-term planning effort to identify ongoing coastal erosion and the sediment transport pathways, screen potential shore protection strategies to determine their applicability, assess both historical storm damage and needed shore improvement costs by shoreline reach, and prioritize shore protection and/or other management strategies based on potential costs and storm protection benefits.

To help build coastal resiliency into the long-term Town planning efforts, a multi-disciplined approach has been performed to address both the scientific/engineering and economic concerns. The approach can be divided into six (6) major tasks, which are described in more detail below:

1. Analyze Coastal Change and Sediment Transport Processes
2. Assess Historical Storm Damage Based on Storm Severity
3. Develop Prioritization Criteria for Coastal Resiliency
4. Determine Appropriate Shore Protection and/or Coastal Management Approaches
5. Evaluate Shore Protection and/or Management Strategies by Shoreline Stretch
6. Disseminate Findings and Recommendations at Two Public Working Sessions

The overall goal of the planning analysis is to produce a "roadmap" that the Town can utilize to proactively plan for projects that will improve the coastal resiliency of the community. By basing

future shore protection decisions on a quantitative analysis of town-wide coastal processes, it is anticipated that more cost-effective and sustainable solutions can be developed as part of a long-term planning process.

Regionally, the Scituate shoreline consists of glacial till headlands, bedrock outcrops, and outwash deposits, as well as associated marine deposits in the form of barrier beaches. Glacial deposits historically provided the principal source of beach sediments, consisting of a broad range of sand, gravel, cobbles, and boulders, depending on the composition of the eroding glacial deposit. Many of these original sources of beach materials have been largely eliminated due to the construction of revetments and seawalls along the shoreline.

Shoreline change is typically minimal along stretches where coastal engineering structures have been built. In many of these areas, notably at North Scituate Beach and along Oceanside Drive, the fronting beaches are submerged at high tide. The heavily armored Scituate shoreline leaves only several areas where the shoreline migration is not limited by seawalls and revetments: Mann Hill Beach, Peggotty Beach, and Humarock Beach. Where the shoreline migration is limited by seawalls and revetments, the shoreline change rates may indicate that little or no horizontal change has occurred but the beach elevation (specifically beach lowering) may have lowered substantially over the same time period.

High water shorelines were obtained from 1950/1952 National Oceanic and Atmospheric Administration (NOAA) T-Sheets and by delineating the high water line from 2008 United States Geological Survey (USGS) aerial photographs. The result is a table of shoreline change magnitudes and rates for each shoreline area, where shoreline change denoted with a minus sign represents erosion.

Shoreline Change Rate

Area	Change Recorded Between 1950/1952 and 2008
Minot, North Scituate, Surfside, Egypt Beach, Oceanside Drive, Cedar Point, First Cliff, Third Cliff, Fourth Cliff	No horizontal change has occurred, but the beach elevation (specifically beach lowering) may have lowered substantially over the same time period
Mann Hill Beach (north)	Eroding 0.5' to 1.0' per/year
Mann Hill Beach (south) toward Egypt Beach	Eroding 1.5' to 2.0' per/year
Peggotty Beach	Eroding up to 4' per /year since the 1950s. This area shows the highest shoreline change rate along the developed portions of the coastline. Due to the low elevation, much of the erosion is caused by storm surge and wave action overtopping the barrier beach.
Humarock Beach	Eroding up to 4' per/year from the 1950s to 2008.

Use of shoreline and bathymetric change information allows quantification of coastal processes by providing a measure of nearshore accretion or erosion.

Light Detection and Ranging (LiDAR) survey data was evaluated to provide a more detailed assessment of barrier beach migration, as storm-driven overwash appears to be the dominant process controlling long-term performance of these beach areas. LiDAR illustrates the land that lies under the water or underwater topography. Comparison of these topographic/bathymetric surfaces between years allowed for an analysis of sediment movement. Specifically for the barrier beach areas (i.e. Mann Hill/Egypt Beaches, Peggotty Beach, and Humarock Beach), the LiDAR comparisons allowed a more detailed assessment of recent time periods between 2000 and 2014. The series of LiDAR datasets available were utilized to the maximum extent possible to develop a clear understanding of the cross-shore sediment transport and barrier beach migration processes. Due to the anthropogenic (human) manipulation of sediments along many of the developed barrier beach areas after storms, it was not always possible to track the natural barrier beach dynamics. However, to the maximum extent possible, the LiDAR data was utilized to assess the influence of cross-shore processes during significant storm events.

Five cross-shore transects obtained from Mann Hill Beach, Egypt Beach, Peggotty Beach, the north section of Humarock Beach, and the south section of Humarock Beach were selected to represent characteristic areas of beach and dune width/elevation for these areas of the Scituate shoreline. The LiDAR datasets were also subsequently used in this study to analyze flooding extends, road and structure elevations, and dune volumes.

Topographic/Bathymetric Change Analysis

Area	Topographic/Bathymetric Change
Mann Hill Beach (Transect 1)	Beach has lowered 3' to 4' between 2000 and 2010. The dune along this area has been reshaped after moderate storms to maintain a crest elevation of approximately 21' NAVD88. The reshaping maintains the height of the dune but lowers the beach.
Egypt Beach (Transect 2)	Beach has lowered 1' to 2' between 2000 and 2010. Overwash of the cobble dune has reduced the crest elevation and moved material inland into Sheep's Pond, filling in the drainage path which connects the pond to Mushquashcut Pond.
Peggotty Beach (Transect 3)	Beach has lowered 5' between 2000 and 2010. The lower elevation allows for significant overtopping of the barrier beach during periods of moderate storm activity. It must be noted that Town Way Extension, once located at 10' NAVD88, has since been filled in by more than 3' of material. ***At present, the volume of beach sediments is not sufficient to withstand a typical storm.***
Humarock Beach (north, Transect 4)	Transect 4 is located at the base of 4th Cliff, shows retreat of 5' on the beach. Both the dune elevation/form and the roadway are maintained following every significant storm, where the material is removed from the road post storm.

Humarock Beach (south, Transect 5)	Transect 5 is located in the south section of Humarock Beach. The dune elevation along this stretch varies over the period from 2000 to 2010. In general, the beach width is greater than North Humarock and sufficient beach material exists to maintain seasonal beach fluctuations. Therefore, the beach tends to be steeper and narrower during the winter months.

As the main component for evaluating coastal processes, a shoreline modeling analysis was performed to assist in the development of shoreline management strategies for the Town of Scituate with a focus on areas of the coast where shore protection could be enhanced through beach and/or dune nourishment. To determine the local sediment transport pathways associated with the observed shoreline change, an in-depth scientific analysis was performed to quantitatively evaluate wave and longshore sediment transport processes that influence sand movement along the Town's shoreline.

Waves provide the driving forces governing erosion and the observed accretion/erosion along the Scituate shoreline. To predict areas of wave energy concentration and the direction of waves approaching the shoreline, a spectral wave refraction analysis was performed. This analysis computed the nearshore wave climate of the Scituate coastline based on offshore wave data. The wave modeling predicted the major effects of long-term average wave conditions on the beach areas and provided the basis for determining trends in sediment transport.

Extreme events (10-, 50-, and 100-year storms) were also modeled using SWAN to obtain design wave conditions for coastal engineering structures along the Scituate shoreline. The 10%, 2% and 1% annual chance (10-, 50- and 100-year return period) still water elevation (SWL) was based on the Plymouth County Flood Insurance Study (FEMA, 2012). In addition, evaluation of coastal engineering structures within the evaluation of approaches also included an anticipated sea level rise of 2 feet over the next 50 years.

It should be noted that simply increasing structure elevation by 2 feet might not address increased wave overtopping predictions over the next 50 years. Therefore, coastal engineering structure assessment also considered expansion of armor stone revetments fronting the structures to ensure appropriate designs under future sea level and storm wave conditions. For non-structural coastal engineering measures (e.g. beach and/or dune nourishment), the design life generally is on the order of 5 to 15 years; therefore, designs could be readjusted as sea levels increase in the future. These design modifications would become part of the ongoing maintenance requirement for the project.

As an integral part to the coastal processes that are at work to shape the shoreline of Scituate, an evaluation of sediment transport along the shoreline was necessary. The goal of this sediment transport and shoreline change analysis was first to predict measured shoreline change and long-shore sediment transport rates, and subsequently use the model to evaluate shoreline management approaches for the Scituate shoreline.

Sediment Transport

Area	Transport Direction	Transport Rate	Other notations
Minot	southerly drift	(*see notation below)	Wave diffraction in the northern section is to the north caused by rock outcrops.
North Scituate	north to south	Nearly zero, due to lack of available beach material	A reversal in transport direction can be observed near the northend caused by wave diffraction around the rock outcrops.
Oceanside Drive	north to south and bi-directional	Highest net transport rates are located in the vicinity of 10th Avenue and Turner Road.	Near the end of Oceanside Drive, the shallow cobble and boulder tend to re-direct waves, leading to variable net sediment transport directions. While 80% of the longshore transport is from n to s, this creates a constant loss of sediment from these segments.
Peggotty Beach	bi-directional	Sediment transport rate assumes the sand supply is unlimited	Sediment transport at the north end of the beach is relatively lower due to the wave sheltering effects of 2nd Cliff
Humarock Beach (north)	south to north		Sediments migrate towards 4th Cliff and the confluence of the North/South River
Humarock Beach	balanced in both directions (bi-directional)	Transport rates are very low	Bi-directional transport ensures a generally stable beach width, where the variable nearshore wave can continuously resupply the eroded area

Due to the lack of shoreline change data available as a result of the coastal armoring of this shoreline, it was not possible to develop a calibrated sediment transport model for the Minot Beach section.

Executive Summary

The Town has cataloged storm damage impacts for several decades; however, there has been a need to combine detailed storm damage data to the coastal infrastructure that protects this development. This data was utilized as the basis for prioritizing future actions to address coastal resiliency, it was critical to relate ongoing (and future, to the extent possible) storm damage costs to the overall costs of infrastructure improvements needed to address these concerns. As the extensive flood damage that occurs along the Scituate coast, a more detailed understanding of impact related to storm severity was warranted. Specifically, the relationship between storm parameters and the severity of damage is critical for establishing expectations for shore protection strategies. With this understanding, four characteristic storms were selected to analyze the spatial distribution of the residential damage claims and the financial costs to the Town: the Blizzard of 1978, the 1991 No-Name Storm, Winter Storm Nemo (2013), and Winter Storm Juno (2015).

The Blizzard of 1978 was included as the storm of record, with a return period of greater than once every 100 years. While substantial infrastructure damage occurred during this storm event, FEMA NFIP had not been officially implemented at the time of the event. Although slightly less severe, the 1991 No-Name Storm was selected because it represented the most significant storm event in the past 30 years and the most severe storm event that occurred since FEMA NFIP had been implemented. In addition, the more recent Winter Storms Nemo and Juno also were reviewed to represent "typical" events that occur on a relatively frequent basis and were well documented within the Town records. Overall, these four storms provide the full range of severity associated with nor'easters that impact the Scituate shoreline, with return periods ranging from once every 158 years (the Blizzard of 1978) to once every 4 years (Winter Storm Nemo in 2013). Understanding the geographical distribution of storm damage for relatively frequent, as well as more severe infrequent, storm events allowed for a detailed economic assessment of damages relative to storm severity for different locations along the coastline.

FEMA defines a repetitive loss property as any insurable building for which two or more claims of more than $1,000 were paid by FEMA NFIP within any rolling ten-year period, since 1978. Repetitive loss property data was obtained from FEMA NFIP from 1978 to 2015; the information in the dataset included: the location/address of the properties, number of FEMA claims, the associated claim dates and claim amounts. It is acknowledged that the repetitive loss data does not include all claims to FEMA and does not take into account damages that property owners decided to not claim; however, the data gives an indication of the spatial distribution and the relative scale of damage costs. To maintain confidentiality, the exact locations of the repetitive loss properties were obscured.

Historic Storm Damage

Storm event	Seawall/ Revetments	Road Damage	Debris clearing	Public utilities	Public buildings	Emergency	Total
Blizzard of 1978	$22,000	$650,000	$1,500,000	$700,000	$130,000	$1,700,000	$26,700,000
1991 No Name Storm	$2,400,000	$130,000	$140,000	$100,000	$90,000	$90,000	$3,000,000
Nemo (2013) and Juno (2015) (approximate)	x	x	x	x	x	x	$11,300,000

Executive Summary

Based on available information during the Blizzard of 1978, over 300 people in Scituate were evacuated and 189 homes destroyed with over 400 homes sustaining major damage (MCZM, 1993). During the 1991 No Name Storm, widespread damage was recorded along the entire Scituate shoreline, with the exception of the Cliffs. In total, 446 FEMA repetitive loss claims were filed totaling over $34 million. Compared to the extent of damages of the 1991 No-Name Storm, the damages for the smaller storms, Winter Storm Nemo (2013) and Juno (2015), are concentrated in several areas: Oceanside Drive and Turner Road, Cedar Point, and the north part of Humarock. The Town estimates that a total of $11.3 million in damages were sustained by the publically-owned coastal engineering structures as a result of the two winter storms in 2013 and 2015. During storms of similar magnitude, the road clearing costs incurred by the Town are approximately: $12,000 for Surfside Road, $10,000 for Peggotty Beach, $30,000 for Central Avenue (Humarock).

Development of prioritization criteria for evaluating vulnerability of both private and public infrastructure is a critical initial step for developing a meaningful assessment of management strategies for shore protection. The overall goal was to create an objective set of technical criteria that could be utilized to create a rating system for the different sections of the Scituate coast. Prioritization of infrastructure protection for a particular portion of shoreline depended upon potential damage to both private and public assets, as well as existing condition parameters. Development of prioritization criteria in this manner provides baseline information that the Town of Scituate can utilize to focus efforts on the most vulnerable areas. Factors included in the prioritization criteria were: ***Damage susceptibility of private properties, Landform evaluation, damage susceptibility of public utilities, emergency egress, breaching potential, and coastal engineering structure condition.***

Understanding that the specific type of shoreline can be linked to its vulnerability to storm impacts, the coast was divided into characteristic sections that allowed for site-specific evaluation of appropriate prioritization criteria for addressing coastal resiliency concerns. Prioritization criteria could be evaluated for each of these shoreline sections, which then could be summed together to create an overall prioritization ranking. In this manner, a comparative analysis between different sections of the Scituate shoreline could be provided to inform the Town decision-making process.

It should be noted that the prioritization criteria were developed to help differentiate the different shoreline sections from each other. Therefore, the analysis did not include potential criterion that would be identical or nearly identical for all sections of the Scituate coast. For example, there was no criterion for vulnerability to impacts from large storm waves, as the entire coastal area evaluated is subjected to storm waves generated in the North Atlantic Ocean. Instead, prioritization criteria focused on the varying natural and anthropogenic features along the shoreline that increase the vulnerability to storm impacts.

Study area limits along the Scituate shoreline.

Study Area	**North Limit**	**South Limit**	**Length (feet)**

Minot Beach	163 Glades Road	100 Glades Road	2,037
North Scituate Beach	96 Glades Road	4-6 Gannett Road	2,653
Surfside Road	1 Gannett Road	91 Surfside road	2,978
Mann Hill Beach	South Property Line of 91 Surfside Road	4 Stanton Lane	2,663
Egypt Beach	South Property Line of 4 Stanton Lane	30 Standish Ave	3,686
Oceanside Drive	146 Oceanside Drive	183 Turner Road	5,662
Cedar Point	11 Lighthouse Road	Scituate Lighthouse	2,828
First Cliff	184 Edward Foster Road	152 Edward Foster Road	1,762
Edward Foster Road	138 Edward Foster Road	114 Edward Foster Road	1,079
Second Cliff	108 Edward Foster Road	52 Peggotty Beach Road	2,295
Peggotty Beach	4 Peggotty Beach	6 Town Way Extension	1,932
Third Cliff	1 Dickens Road	53 Collier Road	4,853
Fourth Cliff	Fourth Cliff Military Reservation	16 Cliff Road South	1,735
Humarock North	10 Cliff Road South	130 Central Avenue	4,746
Humarock South	128 Central Avenue	9 Old Mouth Road	8,282

Based upon the analysis of the different prioritization criteria, it was possible to generate an overall rating for each section of shoreline. This rating scheme attempts to provide an objective process to assist the Town with focusing planning efforts to address shore protection along the Scituate shoreline. A summary of the results of the prioritization analysis ranked the study areas from high to low priority.

It should be noted that the prioritization ranking utilized different weighting of the criteria based upon importance relative to the overall storm damage concerns. Specifically, damage susceptibility of private properties had scores that ranged from 0 to 15 and damage susceptibility to public utilities had scores ranging from 1 to 13. The remaining categories received maximum scores of 5. Based on this approach, observed and potential susceptibility of direct damage to private infrastructure and public utilities were deemed most critical for prioritizing shore protection needs. The overall ranking scheme returned values between 0 and 1, with higher values deemed to represent the highest priority shoreline areas.

Prioritization Matrix (high to low)

Priority	Study Area	Priority Rating Value
1	Oceanside Drive	0.813
2	Humarock (north)	0.767
3	Cedar Point	0.708
4	Peggotty Beach	0.651
5	Surfside Road	0.646
6	Egypt Beach	0.628
7	Humarock (south)	0.542
8	North Scituate Beach	0.419
9	Minot Beach	0.417
10	Mann Hill Beach	0.354
11	First Cliff	0.313
12	Third Cliff	0.313
13	Edward Foster Road	0.292
14	Fourth Cliff	0.292
15	Second Cliff	0.271

A number of potential shore protection options were evaluated to provide the basis for the site-specific assessment of alternative for each shoreline sections. The list of alternative shore protection strategies includes numerous "hard" (e.g. seawall) and "soft" (e.g. beach and dune nourishment) coastal engineering techniques, as well as potential innovative approaches (e.g. boulder dikes). In addition, the baseline alternative consists of maintaining the *status quo* of continuing to repair infrastructure as needed following storm damage and/or demonstrable failure. ***Various types of shore protection options evaluated include: Maintain status quo, seawalls and revetments, beach nourishment, constructed dunes, offshore breakwaters, boulder dike, elevated road(s), drainage improvements for the basins, protection and improvements for pump stations, managed retreat, elevate buildings, and other innovative approaches.***

Initially, each shore protection strategy was broadly reviewed relative to its applicability for the Scituate shoreline. Within this context, the shore protection options were evaluated relative for (a) the ability to provide the necessary level of shore protection, (b) the anticipated environmental impacts and associated ability to advance the option through the environmental regulatory process, and (c) the overall cost of the alternative including both initial construction and maintenance costs. Due to geological framework of the natural coastline, as well as anthropogenic changes that have occurred to provide shore protection, a wide variety of approaches exist for addressing coastal sustainability issues. The goal of providing an initial assessment of this broader range of shore protection approaches was to ensure that a broad range of approaches were carried forward into the site-specific assessment. While the assessment ensured inclusion of this broad range of approaches, it should be noted that the initial evaluation of various technologies also allowed for elimination of shore protection techniques that were deemed to have “fatal flaws” either due to excessive environmental impacts and/or being cost-prohibitive. Pros, cons and challenges of approaches were addressed.

Once the approaches were assessed relative to their applicability to shore protection, screening of these options was performed to determine the most appropriate approaches for each shoreline section. In general, discretionary criteria were utilized to assess the applicability of different options, considering aspects of each alternative including engineering, economics, long-term viability, and potential environmental impacts. Once the approach screening process was completed, a matrix of potential shore protection options was developed for each shoreline section based upon the assessment of vulnerability and “need” from the overall economic parameters. This scheme included both “hard” and “soft” shore protection measures, based on project need within each of the shoreline sections identified. In general, economic drivers were critical to this prioritization process; however, coastal resiliency also was addressed, as future shore protection expenditure planning required that a sustainable outcome will be achieved based upon a 50-year planning horizon. In some cases, the economics indicated that managed retreat is the most feasible alternative; however, other considerations and/or policy decisions by the Town might alter the selection of shoreline management approach. The outcome of the prioritization assessment of shore protection management strategies based on both “need” and economic drivers is aimed at providing guidance for future Town planning efforts.

The intent of providing recommended approaches to shore protection and/or shoreline management by study area was to indicate potential options that likely represent the most economically viable alternative, considering both environmental impacts and sustainability of the Scituate coastal development. Understanding the long history of “hard” shore protection along much of the developed coastline of Massachusetts, the analysis attempted to address many of the concerns about reduced littoral sediment supply. Where appropriate, combinations of “hard” and “soft” measures also were considered. The recommended approaches do not provide a detailed engineering-level analysis that is intended for design purposes, but rather provide conceptual-level information to assist with Town planning efforts. In this manner, the recommended approaches (as well as approaches that were not initially recommended) can be vetted by the Town as they move forward to address the town-wide coastal sustainability issues.

In the sections below, the shore protection approaches for each study area are listed and the conceptual design details are presented. A construction cost estimate was provided along with lifecycle costs for 50-years, if applicable. For non-structural coastal engineering measures (e.g. beach and/or dune nourishment), the design life generally is on the order of 5 to 15 years; therefore, designs could be readjusted as sea levels increase in the future. These design modifications would become part of the ongoing maintenance requirement for the project and there would be no need to incorporate sea-level rise directly into the design.

For all study areas, elevating homes and buildings in high hazard flood areas above base flood elevations is recommended, but has not been listed specifically. The cost to elevate a home is approximately $175,000. As of June 2016, 14 grant applications to elevate homes under the FEMA Hazard Mitigation Grant Program are underway and additional 7 applications are pending.

With all the approaches presented, there will be some impacts associated with construction. Beyond direct impacts to the coastal environment, these may include other concerns such as air quality impacts from construction equipment emissions, traffic impacts from material-carrying trucks, and noise impacts from heavy vehicles. Additional project-specific impacts would be identified during the permitting process and the appropriate mitigation measures would become part of the overall project. Potential permitting issues were identified for each approach. Difficult environmental permitting challenges are expected to arise in situations where coastal structures (i.e. seawalls and revetments) require expansion seaward and where the approach may adversely affect benthic flora and fauna.

In all the shore protection approaches, appropriate public access easements will need to be acquired from the involved property owners if the project is publically funded.

Below are each of the study areas shore protection approaches and their recommendations:

Minot Beach

Shore Protection Approach	**Cost**
Seawall North section - 330 feet	$2.7 million
Seawall South section - 1,200 feet	$9.5 million
Revetment Dike 1,200 feet	$5.0 million
Beach Nourishment Perched cobble beach - 1,200 feet	$600,000
Elevate Bailey's Causeway For emergency access - 900 feet	$675,000

Recommended Approach for Minot Beach

The recommended shoreline protection approach for Minot Beach consists of nourishment in the form of a perched cobble beach. The nourishment is estimated to cost $600,000 in initial construction costs and a total of $2.2 million over a 50-year lifecycle. In addition, the north portion of Minot Beach would need seawall improvements requiring a total of $6.7 million over a 50-year lifecycle. The need to raise Bailey's Causeway likely is dependent upon the shore protection developed along North Scituate Beach, as shore protection along Glades Road will allow emergency access to Minot Beach without utilizing Bailey's Causeway. Therefore, elevating the causeway has not been recommended at this time. Comparatively, the cost to maintain the status quo along Minot Beach over 50 years is estimated to be $31.3 million.

North Scituate Beach

Shore Protection Approach	**Cost**
Seawall and Revetment 1,800 feet	$14.8 million
Beach Nourishment Phase 1 - 2,900 feet	$8.2 million
Elevate Bailey's Causeway For emergency access - 900 feet	$675,000

Recommended Approach for North Scituate Beach

A beach nourishment project is currently in the environmental permitting stage for North Scituate Beach. In the initial phase, the nourishment would be placed along the northern 2,900 feet of the beach. The project would require approximately 240,000 cubic yards of material to construct a nourished beach with a renourishment interval of approximately 9 years.

Surfside Road

Shore Protection Approach	**Cost**
Seawall and Revetment 2,700 feet	$21.8 million
Beach Nourishment Phase II - 2,000 feet	$4.9 million

Recommended Approach for Surfside Road

Overall, the recommended shore protection approach for North Scituate Beach and Surfside Road is large-scale beach nourishment. Compared to the cost to reconstruct and maintain the seawalls and revetments along the two study areas over 50 years ($94.1 million), the 50-year lifecycle cost of nourishment is not significantly higher at $95.6 million, but the nourishment has the benefit of providing improved storm protection, providing a sediment source for the adjacent shorelines (i.e. likely improvement in shore protection to areas further south including Mann Hill and Egypt Beaches), and creating a recreational resource.

Mann Hill Beach

Shore Protection Approach	**Cost**
Constructed Dunes	$2.0 million

Stand-alone - 730 feet	
Managed Retreat Move landward, all homes	>$1.5 million
Managed Retreat Buyout, all homes	>$2.3 million

Recommended Approach for Mann Hill Beach

The recommended shore protection approach for Mann Hill Beach is managed retreat either in the form of moving the homes landward or buy-outs (>$1.5 million). If beach nourishment is constructed along North Scituate Beach and Surfside Road, the longevity of development along Mann Hill Beach could be improved; however, continued erosion of the cobble dune landform will be difficult and/or cost-prohibitive to maintain in the long-term, especially if 2 feet of potential sea level rise is realized over the next 50 years. The cost of maintaining the status quo over the next 50 years is $4.2 million which includes the cost of FEMA repetitive loss claims and assuming the complete loss of property values due to continued erosion and increasing water levels.

Egypt Beach

Shore Protection Approach	Cost
Constructed Dunes Stand-alone - 1,100 feet	$782,000
Protection Improvements for Pump Station Egypt Beach Pump Station	$560,000
Boulder Dike 2,300 feet	$1.4 million

Recommended Approach for Egypt Beach

The recommended shore protection approach for Egypt Beach is to construct a boulder dike ($1.4 million) and to implement protection improvements for the Egypt Beach pump station ($560,000). The cost of maintaining the status quo along the study area is $7.5 million, which accounts for the projected FEMA repetitive loss claims over 50 years. It should be noted that the boulder dike alone does not provide protection from severe storm events; however, it is anticipated that a rejuvenated sediment supply via nourishment provided further to the north will allow long-term accretion along the landward side of the dike. In this case, the overall effect will be improved coastal resiliency over existing conditions.

Oceanside Drive

Shore Protection Approach	Cost

Seawall and Revetment 10,000 feet	$80.2 million
Beach Nourishment (50 foot berm) 7th Avenue to Scituate Avenue - 3,800 feet	$7.2 million
Beach Nourishment (100 foot berm) 7th Avenue to Scituate Avenue - 3,800 feet	$10.3 million
Drainage Improvements for the Basins	$4.0 million
Protection Improvements for Pumping Stations Sand Hills Pump Station	$560,000

Recommended Approach for Oceanside Drive

The recommended shore protection approaches for Oceanside Drive are to rehabilitate the seawall and revetments, improve drainage of the basins, and to improve the protection to the Sand Hills pump station. The greatest cost is the seawall and revetment; the initial construction cost is $80.2 million with a total 50-year lifecycle cost of $199.6 million, which is lower than the cost of maintaining the status quo over 50 years ($246.8 million). While beach nourishment can be implemented along Oceanside Drive at a lower cost, there are obstacles in providing lasting protection for the northern portions of study area and the possibility of inhibiting and/or blocking navigational pathways into Scituate Harbor and outfalls from the basins. If beach nourishment is revisited as a potential alternative for this area, additional analyses of groins to reduce down-drift losses of sediment, as well as a thorough analysis of possible harbor shoaling concerns, should be performed.

Cedar Point

Shore Protection Approach	**Cost**
Seawall and Revetment Rebecca Road - 1,300 feet	$10.4 million
Beach Nourishment Cobble berm - 1,200 feet	$4.6 million
Boulder Dike 1,200 feet	$720,000

Recommended Approach for Cedar Point

The recommended shore protection approach for Cedar Point is to rehabilitate the existing seawall and revetments, place cobble nourishment along the narrow section of Lighthouse Road, and install a boulder dike. The 50-year lifecycle cost of these approaches is approximately $43.7 million. While the cost is higher than the cost to maintain the status quo ($36.4 million), the benefits include increased storm protection, upgraded condition of the existing coastal engineering structures, and improved emergency egress. In the case of Cedar Point, a major portion of the existing dwellings are well below the 100-year still water elevation and any increase in sea level will have a marked effect on this highly vulnerable area.

First Cliff

Shore Protection Approach	**Cost**
Revetment 1,700 feet	Maintenance costs only
Elevate Edward Foster Road For emergency access - 800 feet	$600,000
Elevate Edward Foster Road (Causeway) For emergency access - 1,800 feet	$1.8 million

Recommended Approach for First Cliff

The recommended shore protection approach for First Cliff is to maintain the status quo ($10.3 million over 50 years). Plans for repair to First, Second, and Third Cliff are underway to address damages incurred from over the last several years from Hurricane Sandy, Winter Storm Nemo, and Winter Storm Juno.

Edward Foster Road

Shore Protection Approach	**Cost**
Seawall and Revetment 970 feet	$7.8 million
Elevate Edward Foster Road For emergency access - 800 feet	$600,000
Elevate Edward Foster Road (Causeway) For emergency access - 1,800 feet	$1.4 million

Recommended Approach for Edward Foster Road

The recommended shore protection approach for Edward Foster Road is to rehabilitate the seawall and revetment at a cost of $19.4 million over a 50-year lifecycle ($7.8 million initial cost). While the cost of maintaining the status quo is lower at $11.7 million over 50 years, the rehabilitated structure can protect against increased wave overtopping due to potential sea level rise and maintain the emergency egress between First and Second Cliff.

Second Cliff

Shore Protection Approach	**Cost**

Revetment 2,200 feet	$8.9 million
Elevate Edward Foster Road For emergency access - 800 feet	$600,000
Elevate Edward Foster Road (Causeway) For emergency access - 1,800 feet	$1.8 million

Recommended Approach for Second Cliff

The recommended shore protection approach for Second Cliff is to maintain the status quo ($13.3 million over 50 years). Plans for repair to First, Second, and Third Cliff are underway to address damages incurred from over the last several years from Hurricane Sandy, Winter Storm Nemo, and Winter Storm Juno.

Peggotty Beach

Shore Protection Approach	**Cost**
Beach Nourishment (50 foot berm) North Peggotty Beach only - 780 feet	$1.6 million
Beach Nourishment (100 foot berm) North Peggotty Beach only - 780 feet	$3.0 million
Beach Nourishment (50 foot berm) Entire beach - 1,800 feet	$2.9 million
Beach Nourishment (100 foot berm) Entire beach - 1,800 feet	$5.8 million
Constructed Dunes Stand-alone, north Peggotty Beach only 780 feet	$918,000
Constructed Dunes Stand-alone, south Peggotty Beach only 1,000 feet	$2.7 million
Managed Retreat Move landward, all homes	>$4.8 million
Managed Retreat Buy-out, all homes	>$8.7 million

Recommended Approach for Peggotty Beach

The recommended shore protection approach for Peggotty Beach is managed retreat either in the form of moving the homes landward or buy-outs from the town (>$4.8 million). The cost of maintaining the status quo over the next 50 years is $16.9 million which includes the cost of FEMA repetitive loss claims and assuming the complete loss of property values due to continued erosion and increasing water levels. Peggotty Beach represents one of the most highly erosional areas along the Scituate coast, where overwash of the low-lying barrier beach has caused readily observable landward migration of the barrier beach into the salt marsh system along its landward limit. While this effect may have an adverse impact on salt marsh resources, this overwash process is natural and existing environmental regulations acknowledge and accept this natural process. The overwash is also necessary for the barrier beach to adapt to sea level rise. While regulations encourage beach and dune stabilization through nourishment, it may prove difficult and/or cost-prohibitive to maintain the Peggotty Beach shoreline in its present position; therefore, it is likely that some type of managed retreat will be necessary over the next 50 years, even if proactive nourishment is performed along the beach.

Third Cliff

Shore Protection Approach	Cost
Revetment 4,800 feet	$19.2 million
Elevate Gilson Road For emergency access	$750,000

Recommended Approach for Third Cliff

The recommended shore protection approach for Third Cliff is to maintain the status quo ($26.8 million over 50 years). Plans for repair to First, Second, and Third Cliff are underway to address damages incurred from over the last several years from Hurricane Sandy, Winter Storm Nemo, and Winter Storm Juno.

Fourth Cliff

Shore Protection Approach	Cost
Revetment 720 feet	$2.9 million
Elevate Central Avenue For emergency access	$3.6 million

Recommended Approach for Fourth Cliff

The recommended shore protection approach for Fourth Cliff is to maintain the status quo ($4.3 million over 50 years).

Humarock North

Shore Protection Approach	Cost
Seawall and Revetment 4,800 feet	$38.0 million
Beach Nourishment (50 foot berm) Humarock North only - 3,500 feet	$4.1 million
Beach Nourishment (100 foot berm) Humarock North only - 3,500 feet	$6.3 million
Beach Nourishment (50 foot berm) Humarock North and South - 10,500 feet	$12.3 million
Beach Nourishment (100 foot berm) Humarock North and South - 10,500 feet	$26.4 million
Constructed Dunes Stand-alone - 4,800 feet	$9.6 million
Elevate Central Avenue 4,800 feet	$3.6 million
Managed Retreat Buy-out, all homes along Humarock North	>$57.0 million

Recommended Approach for Humarock North

The recommended shore protection approach for Humarock North is to elevate Central Avenue, construct dunes along the Humarock North, and nourish the beach along the entire Humarock North and South. The total cost for both North and South Humarock would be approximately $152.6 million over a 50-year lifecycle ($25.5 million initial cost). Compared to the cost of maintaining the status quo for both Humarock North and South over 50 years ($103.6 million), the recommended approaches have the benefits of increasing storm protection, eliminating the need for post-storm roadway clearing along Central Avenue, providing an increased littoral sediment supply to protect down-drift beaches, providing a greater recreational resource, and preventing a breach between Humarock and Fourth Cliff. Again, similar to other areas with extensive historical storm damage, the estimates utilized to project potential storm damage for the 50-year projections related to the status quo scenario are conservative and likely underestimate future damage costs, especially if sea level rise accelerates as projected.

Humarock South

Shore Protection Approach	Cost
Seawall	$66.4 million

8,300 feet	
Beach Nourishment (50 foot berm) Humarock North and South - 10,500 feet	$12.3 million
Beach Nourishment (100 foot berm) Humarock North and South - 10,500 feet	$26.4 million
Constructed Dunes Stand-alone - 8,300 feet	$10.7 million

Recommended Approach for Humarock South

The recommended shore protection approach for Humarock South is to nourish the beach along the entire Humarock North and South, as the contiguous nourishment provides a design life that is substantially greater than nourishing either Humarock North or Humarock South as stand-alone projects. This would be performed in conjunction with raising Central Avenue and reconstructing the dune along Humarock North. The total cost for both North and South Humarock would be approximately $152.6 million over a 50-year lifecycle ($25.5 million initial cost). Compared to the cost of maintaining the status quo for both Humarock North and South over 50 years ($103.6 million), the recommended approaches have the benefits of increasing storm protection, eliminating the need for post-storm roadway clearing along Central Avenue, providing an increased littoral sediment supply to protect down-drift beaches, providing a greater recreational resource, and preventing a breach between Humarock and Fourth Cliff. Again, similar to other areas with extensive historical storm damage, the estimates utilized to project potential storm damage for the 50-year projections related to the status quo scenario are conservative and likely underestimate future damage costs, especially if sea level rise accelerates as projected.