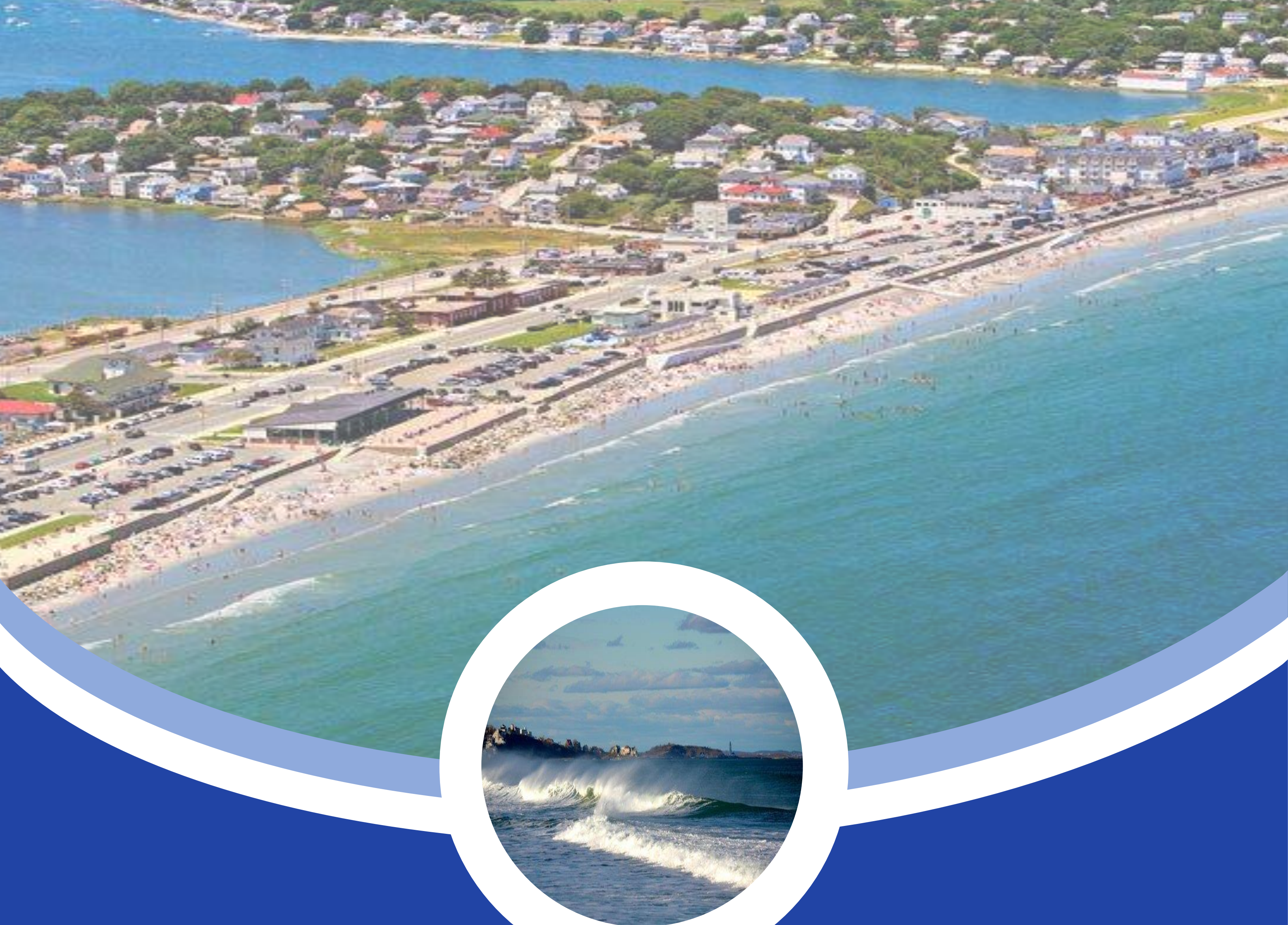

North Nantasket Beach Large-Scale Beach and Dune Nourishment Planning

Financial assistance provided by the Executive Office of Energy & Environmental Affairs (EEA), through the Massachusetts Office of Coastal Zone Management (CZM), under the FY19 Coastal Community Resilience Grant Program. This program provides financial and technical resources to advance new and innovative local efforts to increase awareness of climate impacts, identify vulnerabilities, and implement measures to increase community resilience.

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1 Introduction

Nantasket Beach is located in the Town of Hull, Plymouth County, Massachusetts. It lies approximately 4 miles southeast of the main entrance to Boston Harbor and approximately 12 miles east-southeast of Boston on the southeast shoreline of Massachusetts. Nantasket Beach is a crescent beach approximately 3-1/2 miles long which extends from two natural headlands, Allerton Hill to the northwest and Atlantic Hill to the southeast. The beach is oriented in a northwest-to-southeast direction and is exposed to the open waters of Massachusetts Bay and the Atlantic Ocean. The southern portion of the beach comprises the Massachusetts Department of Conservation and Recreation (DCR) Nantasket Beach Reservation, which spans 1.3 miles of coastline and is a heavily used public beach. The northerly portion of Nantasket Beach is primarily residential with private home and cottages paralleling the shoreline. Natural coastal dunes provide the primary form of coastal protection along this section, although there are some intermittent forms of other shoreline protection measures (stone revetments and jersey barriers).

Nantasket Beach in Hull, Massachusetts. North Nantasket Beach is located between the arrows.

Nantasket Beach is a valuable resource from both a commercial and recreational standpoint. The beach and the associated waterfront amenities serve as the defining feature for the Town of Hull and represent a significant draw for visitors and summer residents. Through time, Nantasket Beach has become one of the region's most valued recreational and natural resources, and is currently one of the busiest beaches in Greater Boston. However, the barrier beach has been eroding for over 150 years (Chapter 2). Although the rate of erosion has been relatively slow, the beach width has been significantly reduced compared to historical widths and the protective dunes have dwindled. The dunes now provide limited protection against flooding and minimal supply of sediment to the beach.

This report is part of a greater project, funded by the MA Office of Coastal Zone Management (CZM) Coastal Resiliency Grant Program that explores the use of nature-based approaches (strategies) to improve the community's resilience to impacts from global climate change. Project goals were developed to identify strategies for implementation for both the near-term and long-term. In the near-term, design plans were developed focused on repairing degraded and discontinuous sand dunes on North Nantasket Beach. In the long-term, large-scale beach and dune nourishment designs were developed based on an improved understanding of coastal processes along North Nantasket Beach.

These near-term and long-term resilience building approaches are aimed at providing increased flood protection for large areas of the community that contain critical transportation, public safety, wastewater, and recreational infrastructure along with half of the Town's private building stock. These strategies and the critical infrastructure they will protect were identified through the Town's sea level rise and storm surge vulnerability assessment[1] and adaptation planning study funded by the CZM FY15 Coastal Resilience Grants program.

This report describes the large-scale beach and dune restoration planning component of the project. This task provided a detailed level of understanding of the coastal processes acting on North Nantasket Beach that was utilized to develop a conceptual beach and dune restoration template. A range of conceptual nourishment configurations were considered, but all potential configurations could be constructed within the large-scale template designed as part of this scope of work. This allows the Town to pursue a variety of potential options and strategies.

This report includes main sections that describe the existing coastal processes at North Nantasket Beach, explain the development of the conceptual design, and summarize the permit requirements and costs associated with the next steps to further advance the large-scale beach and dune restoration.

[1] http://www.town.hull.ma.us/Public_Documents/HullMA_conservation/HULLCL~1.PDF)

2

Existing Conditions

2.1 Geology and History

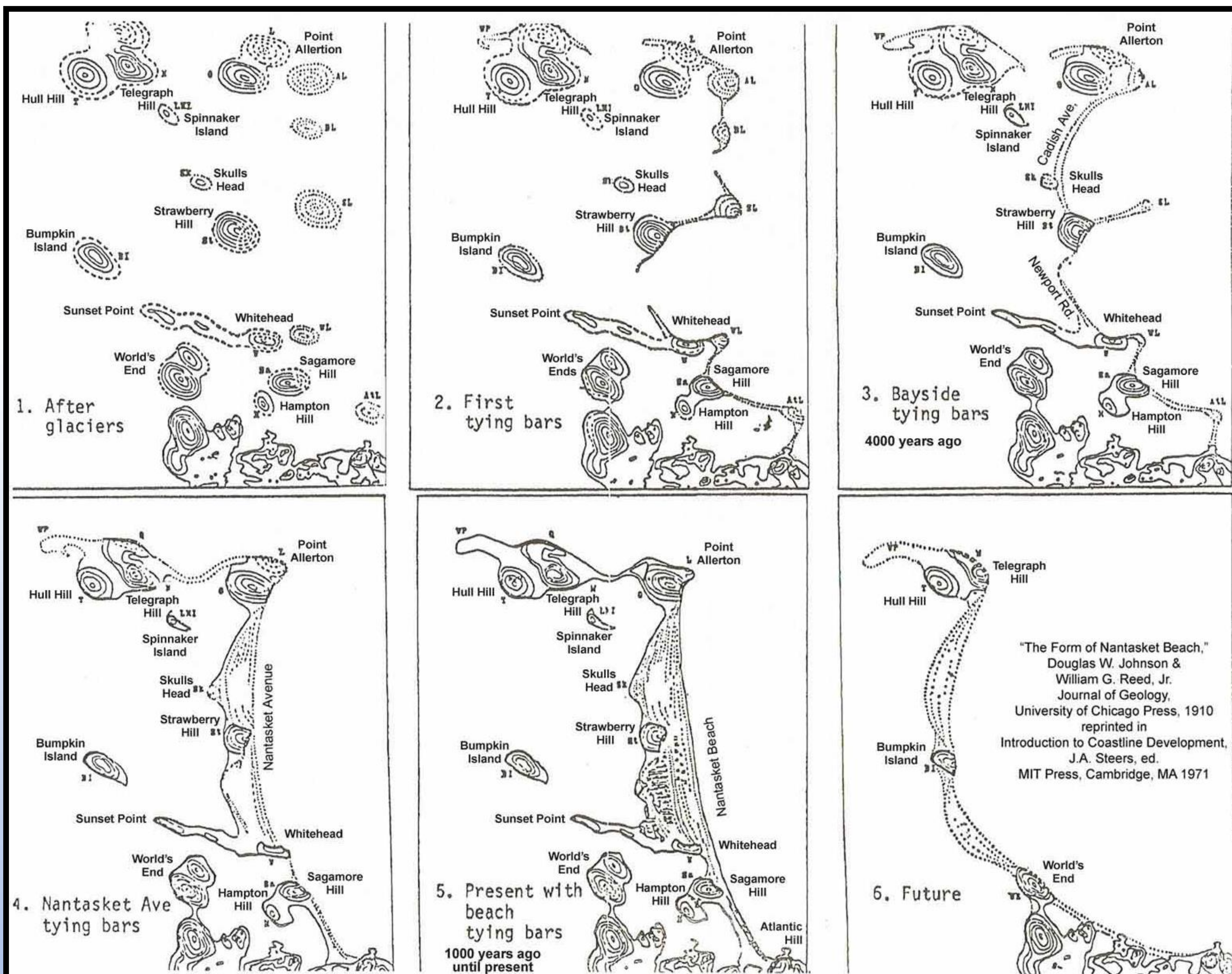
The present configuration of Nantasket Beach can be attributed to a series of shoreline processes and several former drumlin (elongate-shaped glacial hill) islands. In geological terms, Nantasket Beach is known as a complex tombolo, which is a coastal feature that forms when several islands and the mainland are interconnected by a complex series of land bridges. In this case, Nantasket Beach unites several former drumlin islands and the mainland (Johnson and Reed, 1910). The existing spit of land consists of several drumlins, including Hampton Hill, Sagamore Hill, White Head, Strawberry Hill, Allerton Hill, and Telegraph Hill. In addition to glaciation and coastal processes, human interaction and development has had a significant influence on the existing formation and topography of the area. The New England region is largely composed of moderate to thick surficial deposits of glacial origin overlying bedrock. New England has been glaciated several times and the coast experienced as many as four major periods of glaciation, ranging from Nebraskan to Wisconsinan in age (FitzGerald et al., 1994). The best geological record exists for the deposits left behind by the most recent glaciation, called the Wisconsinan Stage, which ended about 8,000 years ago. Retreat of the glaciers in southeastern New England began around 18,000 to 14,000 years ago.

Most of the surficial sediments in the Nantasket area are composed of glacial deposits of ice-contact till and stratified drift (sand and gravel outwash, with minor silt, clay, and till), swamp deposits, and beach deposits. As previously discussed, Allerton Hill, Strawberry Hill, Sagamore Hill, and Hampton Hill are all examples of drumlins, which are composed of variable materials, sometimes mantled over bedrock, or composed wholly of either rock or glacial drift deposits.

Allerton Hill at the northern end of North Nantasket Beach.

Glacial till is the poorly-sorted, non-homogeneous material deposited at the base of the glacier (lodgment till), or alternatively, deposited as material within the ice sheet which melted out as it was let down on the existing landscape (ablation till). The term "stratified drift" encompasses the generally well-sorted sand and gravel deposited by glacial melt water either on an outwash plain in front of an ice sheet, or in glacio-fluvial environments under, within, on top of, or adjacent to an ice sheet.

The work of Johnson and Reed conducted in 1910 preserved much of the historical geologic record of Nantasket Beach as they were able to map abandoned marine cliffs and beach ridges prior to further development of the area. Based on an examination of the ancient beach ridges at Nantasket Beach, the size and alignment of the marine cliffs cut into the drumlins, and offshore profiles, Johnson and Reed (1910) concluded that five drumlins were once located east of Nantasket Beach (north of Atlantic Hill). Through erosional forces exerted by tidal fluctuations and wave action together with a slowly varying sea level these drumlins eroded and the sediments were transported and deposited among the other drumlin islands to form the complex tombolo system that makes up Nantasket Beach today. As such, the Nantasket barrier form evolved around a series of drumlins that served as anchor points. Johnson and Reed (1910) also suggested that historically, Nantasket Beach has been largely an accretionary (an area that deposits sediments and grows) feature.



The formation of Nantasket Beach as presented in Johnson and Reed (1910).

FitzGerald et al. (1994) presented observations that the amount of sand that would have been available from the drumlins is insufficient to account for the volume of the spit of land which makes up Nantasket Beach. They noted that the sediment of the drumlins is also quite different from the fine, well-sorted sand that comprises much of the material at Nantasket Beach. In addition, Nantasket Beach is adjacent to a major offshore sand deposit (FitzGerald et al., 1990). This led to their suggestion that the sediments of Nantasket Beach were derived from several intercepted drumlins and other glacial deposits located offshore that were then reworked onshore late during the Holocene transgression. The existence of Nantasket Beach can then be attributed to the erosion and redistribution of sediment from the existing drumlins as well as the drumlin remnants offshore.

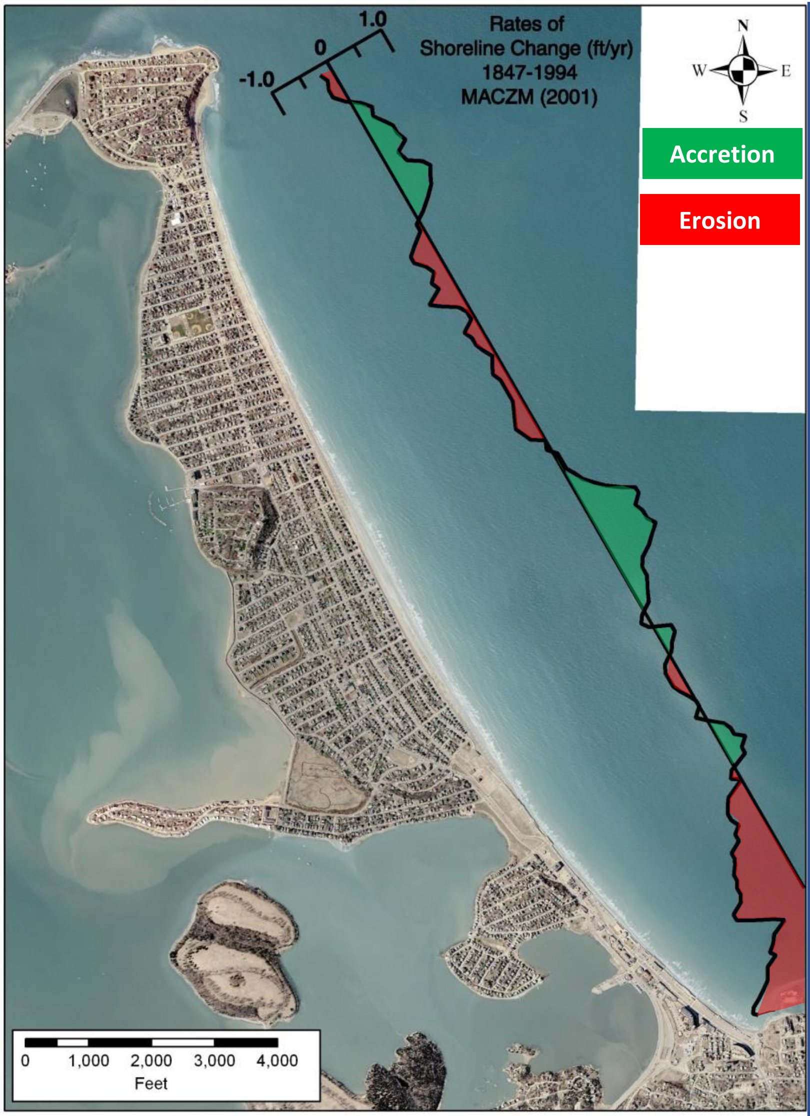
More recently; however, these historic sources of sediment have been consumed and there now exists a dwindling sediment supply available for Nantasket Beach to maintain its current shape and location, especially in the face of increasing storm events and sea level rise. This lack of sediment supply has resulted in a shift in the peninsula and barrier beach from a historically accretionary system to a contemporary erosional system.

Nantasket Beach has also been significantly influenced by anthropogenic (human) activities throughout the years. Anthropogenic impacts and infrastructure development have been significant contributors to the current configuration of Nantasket Beach. The first public house was constructed in 1826 and subsequently, numerous recreational structures were constructed during the 1800s. These structures were typically wood buildings constructed on wood pilings combined with wood bulkheads to restrict tidal flow under the structures (USACE, 1949). In 1880, a railroad was constructed which ran along the barrier spit and prior to 1900, riprap (3-4 cubic foot stone) was added along the seaward edge of the railroad to provide protection from coastal storms.

This riprap is still in place north of and within the DCR Reservation, most of which has been buried by the fill placed behind the existing seawall (USACE, 1949). During the 1900s, concrete seawalls were constructed to protect portions of the Nantasket Beach shoreline within the DCR Reservation, and additional structures built in the 1940s along the shoreline exist in essentially the same locations as they do today. Through all this, the shoreline of North Nantasket Beach has remained relative natural. However, there has been significant development of the areas landward of the beach, such that homes are densely situated along the entire peninsula. The reduction in dune and beach volume and health now creates a threat to hundreds of homes that are prone to flooding during coastal storm events.

2.2 Historical Shoreline Change

Waves, winds, currents, tides, and rising seas all work together to shape the coastline of Nantasket Beach. Overtime, changes to the barrier beach have occurred. In a physical system like that of Nantasket Beach, the geological and historical perspective is an important piece of understanding the past history of the region, determining the effects of the physical processes that have acted on the coastline throughout the years, and providing insight into the future. Regional geomorphic change is the evolution of depositional environments and topographic features over extended periods of time. Aerial photographs, topographic surveys, and hydrographic surveys of coastal and nearshore morphology provide data for quantifying regional geomorphology and change. Coastal shoreline change and digital bathymetric data for the same region observed at different time periods, produce a method for determining the physical changes of a region and providing valuable information on potential sediment movement within a region. Existing shoreline change information for Nantasket Beach was used to provide a historical perspective and to examine geomorphic variations in the coastal zone. In addition, this shoreline change information was used in ground-truthing the numerical sediment transport model. The shoreline change analysis presented here used a computer-based shoreline mapping methodology to compile and analyze changes in historical shoreline position and to quantify distances between historical shoreline positions from different time periods after they are placed on the same scale and geographic reference.



Rates of historic shoreline change between 1847 and 1994 throughout the Nantasket Beach region as determined by Thieler et al. (2001). The black line shows the rate of shoreline change for the entire time frame (1847 to 1994) where a negative rate of shoreline change represents shoreline retreat (erosion; shown as red) in terms of ft/yr, while a positive rate of shoreline change represents shoreline advance (accretion; shown as green) in terms of ft/yr. A significant portion of the Nantasket shoreline has been relatively stable with small rates of erosion or accretion, there are some distinctive areas of erosion and accretion along the shoreline. The area along the DCR portion of Nantasket Beach is clearly erosional as historical rates of erosion range between approximately 0.5 feet to 1.0 feet per year (ft/yr). The area directly north of the DCR portion of the Beach, between Sagamore Hill and Malta Street, is relatively stable with minor changes. The most significant area of accretion occurs between Malta Street and Coburn Street, with an accretion rate of up to approximately 0.5 ft/yr). Farther north, from Coburn Street to P Street, the beach is slightly erosional. Finally, the northern portion of Nantasket Beach, just south of Allerton Hill is primarily accretional. Most of the long-term historic rates are relatively small (less than 1.0 ft/yr), and in general indicate that the shoreline has been relatively stable, and in some cases (for rates less than 0.5 ft/yr) within the error bounds of the analysis.

The relative stable nature of the beach indicates that centuries of waves, currents, and tides have shaped the orientation of Nantasket Beach to be almost perfectly aligned with incoming energy on a net basis. While day-to-day conditions can certainly change the way sediment moves daily along the beach (i.e., waves more from the north will move more sediment to the south and waves more from the south will move more sediment to the north), overall Nantasket Beach appears to have minimal net alongshore sediment transport based on the shoreline change history and centuries of shaping the shoreline that created its current alignment. Ultimately, this means that storm events, which mobilize larger volumes of sediment movement, drive the more significant changes that occur at North Nantasket Beach. Subsequently, cross-shore movement of sediment is likely a key component of the current morphology at Nantasket Beach. The movement of sediment at Nantasket Beach is further explored in Section 2.6. While the beach has been historically stable, the ongoing development over the last 150 years has also limited the available sediment supply to the system. Therefore, Nantasket Beach now faces a dwindling sediment supply that results in increasing erosion and less capability of recovery after storm events.

2.3 Sediments

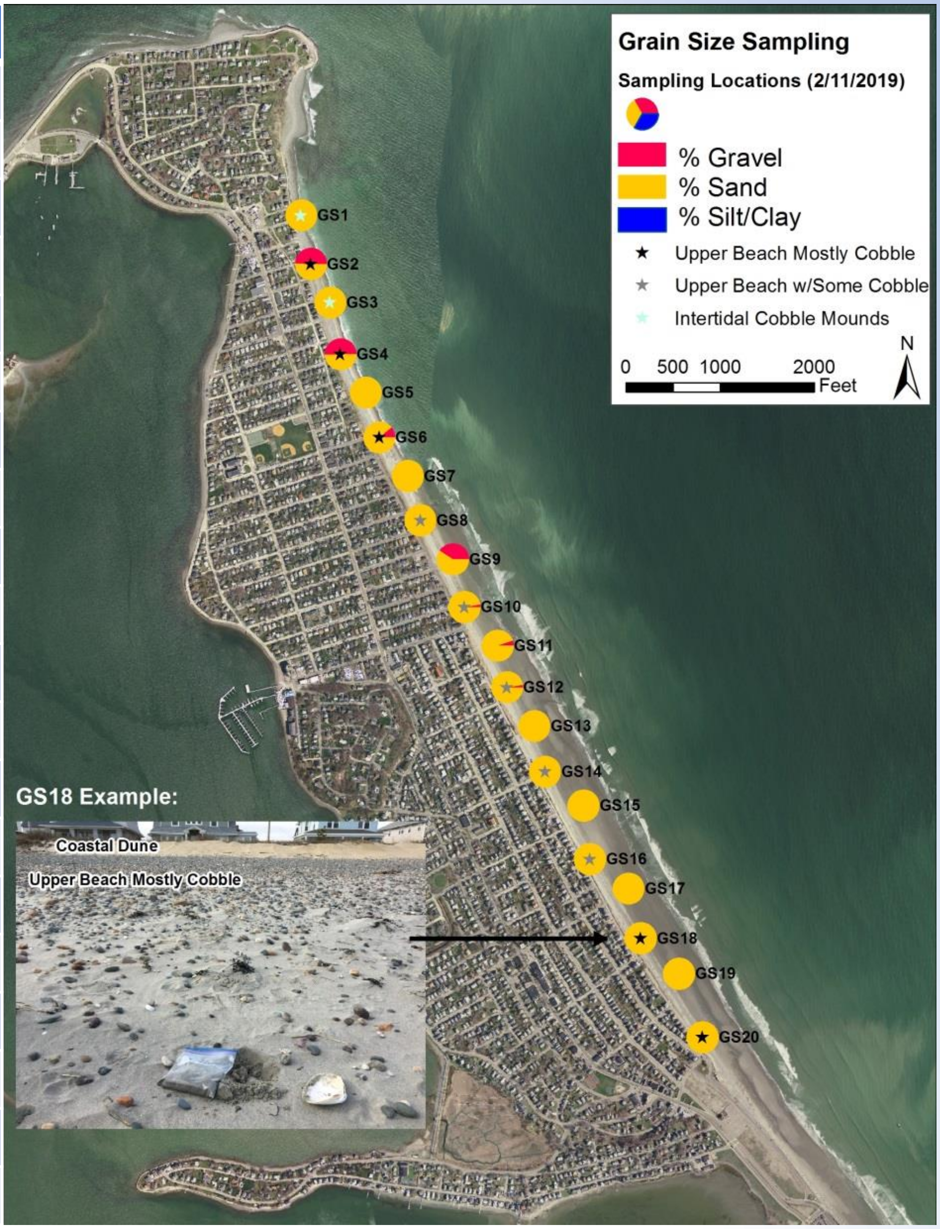
The characterization of natural sediments at Nantasket Beach is an important first step in evaluating littoral processes and the movement of sediments along the shoreline. In addition, knowledge of the grain size of the beach sediments help to define the compatible grain size sediment for any shore protection alternative involving dune or beach nourishment.

Sediment samples were taken along the entire length of North Nantasket Beach from both intertidal and high tide locations on February 11, 2019. At total of 20 samples were taken at approximate intervals of every 375 feet alongshore. These samples were then analyzed for grain size distribution and classified based on the median grain size. Additionally, visual observations were recorded at each sampling location to identify the presence and amount of cobbles.

Since the sampling took place in February, the beach sampling results and observations represent a winter condition. As such, much of the upper beach (above the high tide line) consisted of at least some cobble mixed with sediment. In some areas, the upper portions of the beach were all cobble. The distribution of sediment sizes corresponds well to the historical shoreline change areas of erosion and accretion. For example, the shoreline between Malta Street and Coburn Street is the most sand rich areas along the shoreline. This area corresponds to the historic accretion area in the shoreline change. Similarly, the area between Coburn Street to P Street contains a higher quantity of cobbles indicating more sand has been eroded leaving a greater proportion of cobbles in the sediment composition.

The results of the grain size analysis (see figure) also provide insight on the local energy and/or sediment supply along the beach. For example, areas that have a higher percentage of coarser grain size material (gravel or cobble) are more likely to experience higher energy, represent an erosional area, and/or have a reduced sediment supply.

Sample Site	Median Grain Size (mm)
GS-1	0.19 -0.25 (fine sand)
GS-2	2.00-4.77 (fine gravel)
GS-3	0.19 -0.25 (fine sand)
GS-4	2.00-4.77 (fine gravel)
GS-5	0.19 -0.25 (fine sand)
GS-6	0.25-0.50 (medium sand)
GS-7	0.19 -0.25 (fine sand)
GS-8	0.50-1.00 (coarse sand)
GS-9	2.00-4.77 (fine gravel)
GS-10	0.50-1.00 (coarse sand)
GS-11	0.25-0.50 (medium sand)
GS-12	0.25-0.50 (medium sand)
GS-13	0.25-0.50 (medium sand)
GS-14	0.19 -0.25 (fine sand)
GS-15	0.19 -0.25 (fine sand)
GS-16	0.25-0.50 (medium sand)
GS-17	0.19 -0.25 (fine sand)
GS-18	0.19 -0.25 (fine sand)
GS-19	0.19 -0.25 (fine sand)
GS-20	0.19 -0.25 (fine sand)



2.4 Wave Transformations

In order to evaluate local sediment transport pathways, as well as assess and identify potential alternatives to mitigate erosion and build resiliency at Nantasket Beach, an understanding of the regional wave climate is required. Wave transformation modeling allows for simulation of refraction, diffraction, shoaling and breaking of waves at the regional and local level. Wave modeling allows for quantitative predictions of these processes.

Ocean wave energy is comprised of a large variety of waves moving in different directions and with different frequencies, phases, and heights. These waves undergo significant modifications as they advance into the coastal region, interact with the sea floor, and eventually reach land. The ocean climate also changes temporally with seasonal modulations. The variability in offshore wave climate, the transformations occurring as waves propagate landward, and the temporal modulations, all result in significant fluctuations in the quantity and direction of sediment transport in the coastal zone. Therefore, in many cases, using a single representative wave height, frequency, and/or direction is not the most accurate technique for assessment of wave climate, and subsequently, the sediment transport at the coastline. As such, a spectral wave model was used to propagate random waves from offshore to the nearshore region and investigate potential changes to the wave field.

This section presents results of the analysis of offshore wave climate east of Nantasket Beach and the transformations waves experience as they propagate towards the coastline. To quantify the wave impact along Nantasket Beach, site-specific wave conditions were determined using wind data, wave data, and a numerical wave transformation model. Wave transformation models provide predictive tools for evaluating various forces governing wave climate and sediment transport processes. Wave modeling results provide information on wave propagation across the continental shelf and to the shoreline, revealing areas of increased erosion ("hot spots of energy"). The refraction and diffraction mechanisms also result in changes in the offshore wave direction that may significantly influence the rate and direction of sand movement. Therefore, the quantitative information provided from the numerical model can be used to explain the physical processes that dominate a region and to furnish appropriate recommendations/solutions for each location along the coast.

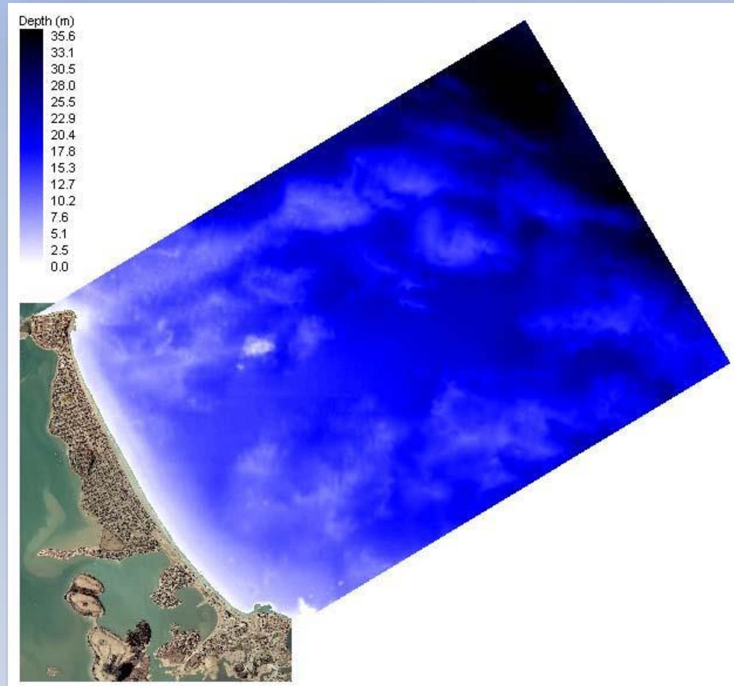
Model Grid Generation

The wave transformation model requires a grid consisting of a mesh of points. At each point within the domain, water depth, as well as ambient current data, is specified. Reference points are separated by spacing in the alongshore and cross-shore directions. The model domain encompasses the entire shoreline of Nantasket Beach. Due to the large region simulated, as well as the high level of detail required in the nearshore region, nested grids were specified as follows. The larger regional grid propagates the offshore waves from the ocean into the Nantasket Beach area, then the smaller, higher resolution grids provide greater detail on the wave processes directly along the shoreline. The grid nesting approach allows for accurate wave transformations from the offshore region to the nearshore region, and provides high-resolution wave information in the active zone of sediment transport. The color shading shown in the adjacent figures is representative of the depth in the model, assigned from the bathymetric source data. A series of three nested grids were utilized to determine the wave conditions, with specific focus on North Nantasket Beach.

Existing National Oceanographic and Atmospheric Administration (NOAA) hydrographic survey data were used to provide depth information for the wave model. These data were supplemented with site specific information that had higher resolution data in the nearshore region. These more local data sources included:

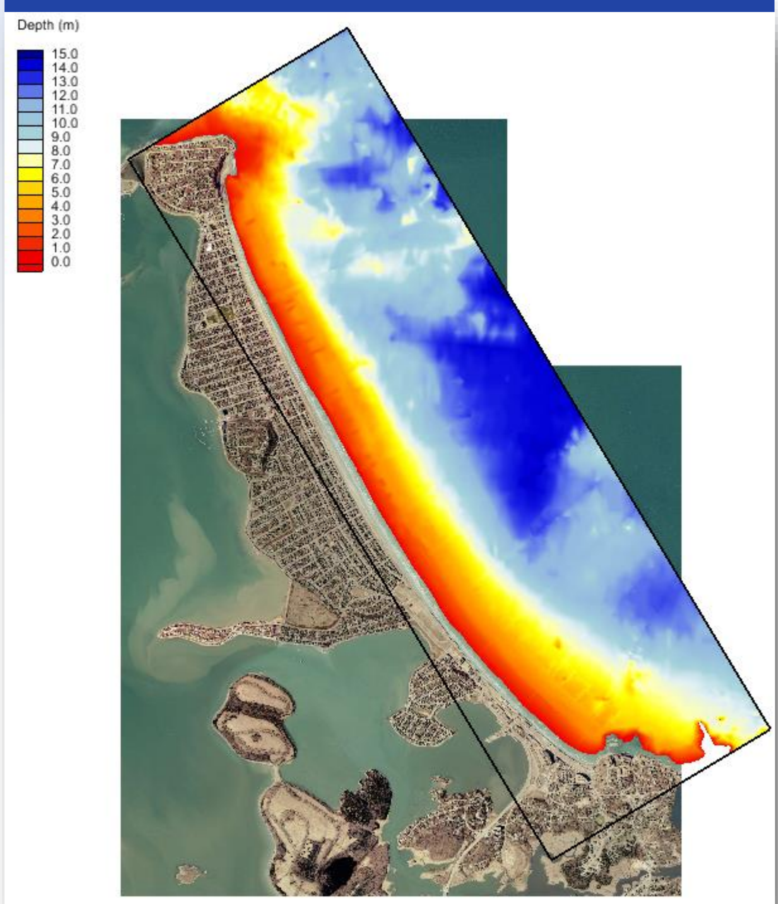
- *NOAA LiDAR (2000)*
- *USACE Beach Profiles (2006)*
- *DCR Beach Profiles (2006-Present)*
- *Town Beach Profiles (2003-Present)*

More recent data were always used instead of older data when available.



Intermediate grid used in the Nantasket Beach modeling. Darker blues represent deeper water, while lighter blues and whites represent shallower water.

Nearshore grid used in the Nantasket Beach modeling. Blues represent deeper water, while reds represent shallower water.



Wave Characteristics

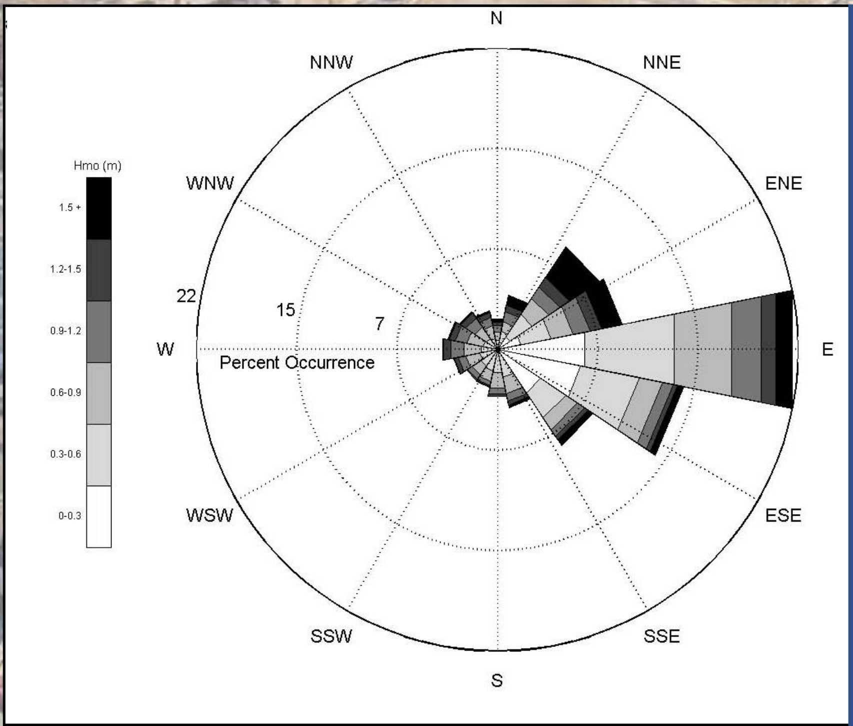
Transformation wave modeling can only be as accurate as the input data; therefore, a key component of accurate wave modeling is the analysis and selection of input wave data. The results derived from numerical wave transformation modeling, as well as the subsequent movement of sediment in the coastal zone, are controlled by the selected wave input conditions and the bathymetry that create the model grid. Assessment of the offshore wave climate and selection of input wave parameters requires determination of average annual and storm conditions.

Long-term time series of wave climate are not available for most shorelines because wave gages are expensive to install and maintain and are often temporarily out of service for maintenance or repair. For Nantasket Beach, two different types of time series wave data were used: National Data Buoy Center (NDBC) and US Army Corps of Engineers Wave Information Study (WIS) data.

Summary of relevant wave stations in the modeling domain.

Station	NDBC 44013	WIS 51	WIS 52	WIS 53
Latitude	42.35°N	42.42°N	42.42°N	42.33°N
Longitude	70.69°W	70.58°W	70.67°W	70.58°W
Depth (m)	55	40	63	56
Time Period (yrs)	1985-2005	1980-2014	1980-2014	1980-2014

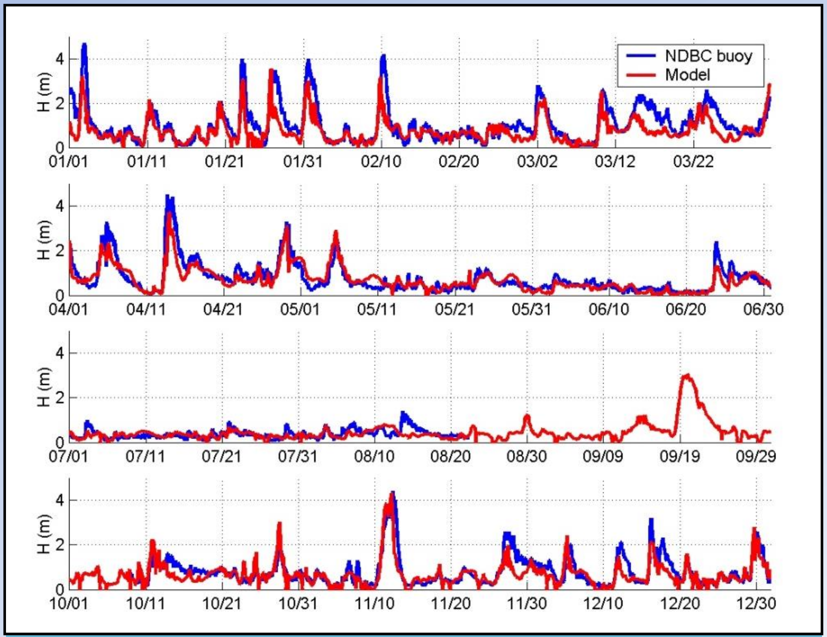
Both the NDBC and WIS stations provide long-record time series wave data. The NDBC buoy wave data were used to validate the model performance through comparison between observed wave data and model results. The WIS data sets offers a synopsis of the wave climate offshore of Nantasket Beach and were used to produce annual average wave conditions. As such, these data led to the development of appropriate input spectra and identify the variability in wave approach and the potential impacts on sediment movement. In order to develop the annual average wave conditions, a detailed analysis was conducted to summarize existing WIS data into detailed input spectra. Each spectral simulation contains distinct differences in energy or directional spectra, and consequently produces varying impacts in the wave transformation and sediment transport patterns.



The distribution of significant wave height (illustrated using a wave rose plot) for WIS station 52. The gray scale distribution indicate the magnitude of the wave height, the circular axis represents the direction of wave approach (coming from) relative to True North (0 degree), and the extending radial lines indicate percent occurrence within each magnitude and directional band. The primary clustering of wave directions tends to arriving from the east (90 degree), with higher energy events from the northeast.

Model Validation

Prior to using the model to transform long-term wave climate information into the Nantasket Beach region, the wave transformation model must be validated to ensure adequate performance. Model results were compared to the wave measurements from NDBC station 44013 for every hour of 1987. The directional distribution of energy for 1987 compares well to the overall 34-year energy distribution; therefore it was chosen as the validation time period. Visually, the modeled wave heights compare favorably to the observations, and specific wave and storm events were accurately simulated, as well as calm periods. Both average and storm conditions are well represented throughout the entire year. For example, the large event in the middle of November is accurately predicted, as is the entire month of July (smaller waves).



Comparison of the modeled (red) and measured (blue) wave heights (in meters) for 1987, with each panel presenting a quarter of a year of data. Portions of the time series without a blue line indicate time periods when the NDBC station was not recording.

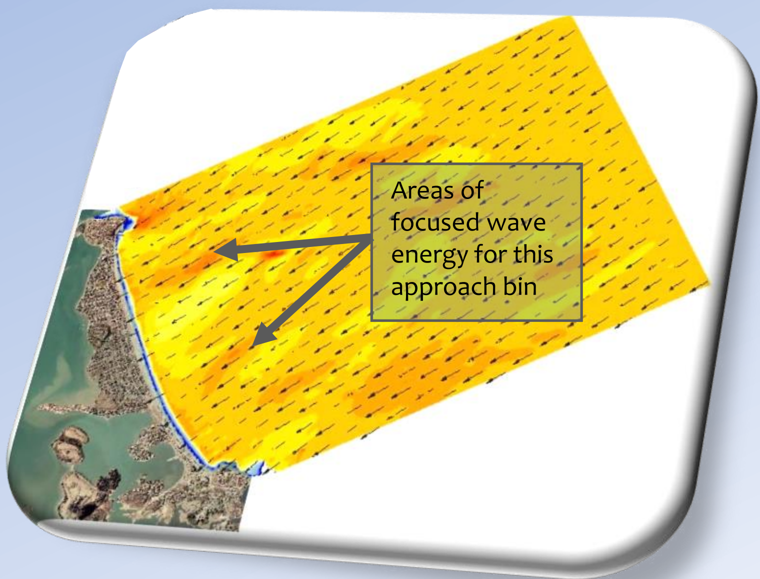
Once validated, the model can be extended to simulate a wide range of conditions, including longer time periods and storm events.

Model Simulations

In order to determine long-term wave conditions and wave statistics at the coastline, spectral data from WIS Station 52 were used to derive energy-conserving annual average directional spectra. Data were segregated by direction of approach, and an energy distribution, as a function of frequency, was generated from all the waves in each directional bin. The energy associated with each frequency was then summed to create an energy distribution for each approach direction. In essence, a representative two-dimensional spectrum was generated for each approach directional bin based on the sum of all the WIS spectra approaching from that mean direction. This can then be combined with the percentage of occurrence to create a long-term (34 year) evaluation of wave impacts at the shoreline. This energetic directional bin approach identifies all potential approach directions, including those that may occur only a small percentage of time during a typical year, but have potentially significant impacts on the shoreline and sediment transport (e.g., the higher wave energy approaches from the northeast).

Average Annual Conditions

All average annual condition directional approaches were simulated to produce a long-term basis of wave transformations at Nantasket Beach. These results were then used to provide input to the sediment transport modeling.



Example wave transformation results for a Northeast direction approach bin. Reds and oranges show areas of higher wave heights. Arrows indicated the wave direction.

CHANGING CLIMATE

Sea Level Rise considerations were utilized throughout the project assessments, specifically when evaluating wave transformations and beach nourishment performance. Projections utilized in this study were based on the Representative Concentration Pathways (RCP) greenhouse gas concentration trajectories developed as part of the Intergovernmental Panel on Climate Change (IPCC). These pathways describe a wide range of possible scenarios that may occur due to future anthropogenic greenhouse gas emissions. The RCP pathway utilized in this assessment (RCP 8.5) essentially assumes that the no changes are made to human based emissions. The sea level rise projections produced under this scenario (RCP8.5) were developed specifically for the Commonwealth of Massachusetts (Kopp et al., 2017) and are consistent with the projections being implemented for the statewide hazard mitigation assessments, presented by CZM, and utilized by MassDOT in the development of the Massachusetts Coast Flood Risk Model (MC-FRM). Therefore, this study aligns with the recommended projection values used for the coastlines in Massachusetts. Projections take into consideration the regional considerations of the Northeast (Kopp et al., 2017). Sea level rise conditions were used to evaluate wave conditions that may occur under a changing climate and the performance of the resiliency options.

Average annual cases were simulated to represent the complete wave climate offshore of Nantasket Beach. This consisted of directional bins with associated percent occurrence, significant wave height (mean wave height of the highest third of the waves), peak period (the period associated with the most energetic waves), and peak direction. Only waves propagating towards the coast were simulated. Waves headed offshore represent a calm period along the coastline.

Directional Bin (0°=N)	Approach Direction	% Occurrence	% Wave Energy	Sig. Wave Height (m)	Sig. Wave Height (ft)	Peak Period (sec)	Peak Direction (0°=N)
329 to 351.5	NNW	2.14	2.11	0.87	2.84	3.6	342.2
351.5 to 14	N	2.23	2.44	0.89	2.94	3.6	2.7
14 to 36.5	NNE	4.74	7.77	1.01	3.31	4.1	27.8
36.5 to 59	NE	9.10	25.88	1.21	3.98	5.1	47.7
59 to 81.5	ENE	9.74	14.72	0.89	2.92	6.1	70.7
81.5 to 104	E	22.58	14.67	0.60	1.97	7.0	92.4
104 to 126.5	ESE	13.57	5.77	0.45	1.48	5.6	115.0
126.5 to 149	SE	6.40	3.95	0.54	1.76	4.8	133.9
Calm	--	29.49	--	--	--	--	--

High Energy Events

Since high-energy events have a significant impact on many physical processes (and in most cases, dominate erosion), it is crucial to include storm simulations in wave modeling to assess the potential impact of a storm on the shoreline and the potential sediment transport along Nantasket Beach. High energy events were evaluated by reviewing the 33-year wave hindcast data from WIS station 52. A return period analysis was completed by the US Army Corps of Engineers. From this analysis, wave conditions for 10-year, 50-year, and 100-year return period storms were developed for Nantasket Beach. Since the wave direction of potential return period extreme events is unknown, a mean wave direction was calculated from all WIS data storm events. This direction was chosen to represent the wave direction for all return period synthetic storms.

In addition to the return period storm events, historical storm events were also simulated and included in the assessment. This included simulation of the Perfect Storm (1991), the Great Nor'easter of 1992, and the April Fools' Day Blizzard in 1997.

Storm surge values were also included in the wave modeling simulation to represent the increased water level experienced during the passage of a large storm event. Elevated water levels, even with moderate wave heights, can result in significant erosion along the shoreline. Storm spectra were developed from these storm parameters using standard parametric methods, since the observed spectra during these events are unknown. These input conditions were then used to simulate return period storms in the wave transformation model.

Wave parameters used to develop high energy wave event conditions.

Storm Event	Significant Wave Height (m)	Significant Wave Height (ft)	Peak Wave Period (sec)	Avg. Wave Direction (degrees)	Storm Surge (m above MTL)
10-year	7.0	23.0	10.2	45	2.71
50-year	8.6	28.2	11.3	45	2.96
100-year	9.3	30.5	11.8	45	3.05
Perfect Storm (10/31/1991)	5.6	18.4	10.0	49	2.80
Nor'easter (Dec. 11-14, 1992)	7.6	24.9	12.5	62	2.75
April Fools' Day Blizzard (April 1, 1997)	6.4	21.0	11.1	42	2.14

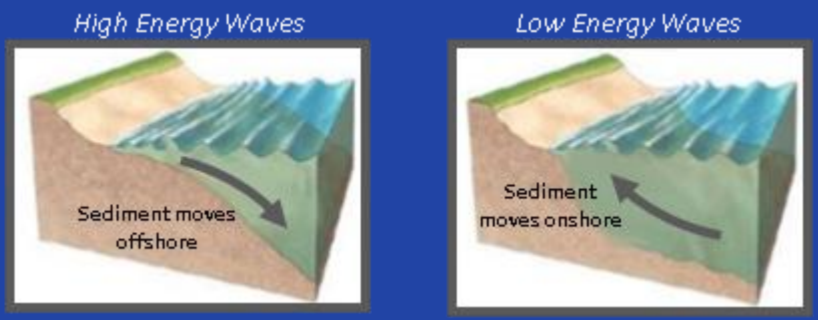
2.5 Sediment Transport

Understanding the wave transformations is a critical step in the determination of shoreline processes and changes, and this wave information is required in order to provide an estimate on how sediment moves in the nearshore region. The wave modeling results were the key input into the sediment transport modeling and beach nourishment performance evaluation. The goal of the numerical sediment transport models is to provide a physically-based representation of alongshore currents and sediment transport driven by breaking waves in the surf zone. Sediment transport at Nantasket Beach is evaluated in both the alongshore and cross-shore directions.

Sediment movement in the coastal zone can be estimated by using various types of sediment transport models and/or equations. These models may differ in their detail, in their degree of representation of the physics, in their complexity, and in other manners. Process-based sediment transport models (those that directly address the fundamental physics of waves, currents, and sediment transport) focus on the essential physics that capture the variable wave and current fields. The sediment transport modeling used to describe the movement at Nantasket Beach is founded in the physics of water and sediment movement. These process-based models provide information on the regional sediment transport trends in the presence of time-variable (in direction and height) waves.

Both alongshore and cross-shore models used herein are process-based models, which provide a more robust assessment than models or estimates based solely on empirical equations.

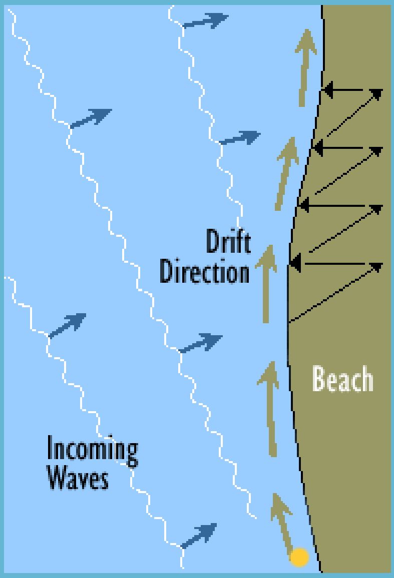
Cross-shore Sediment Movement



The cross-shore (or onshore and offshore) movement of sediment at a beach is most significantly influenced by the level of wave energy acting on the shoreline. During lower energy wave periods (e.g., summer conditions), net cross-shore sediment movement is directed onshore. However, when the beach experiences high energy waves (e.g., storms, winter conditions), the net cross-shore sediment movement is directed offshore. Additionally, for barrier beaches, such as Nantasket Beach, storm events can overtop the barrier beach and drive large volumes of sediment landward in overwash plains.

Alongshore Sediment Movement

The along shore movement of sediment at a beach is influenced by the energy and direction of the approaching waves, as well as a number of other factors (grain size, beach slope, wave steepness, etc.). Incoming waves induce nearshore currents and create wave swash on the beach. The creation of these nearshore currents and the intertidal swash zone produce sediment movement along the beach. The direction of waves and current movement changes throughout the year, resulting in changes in the direction and rate of transport; ultimately there is a dominant net direction that occurs due to the dominant wave transformations. This produces the net alongshore transport rate.



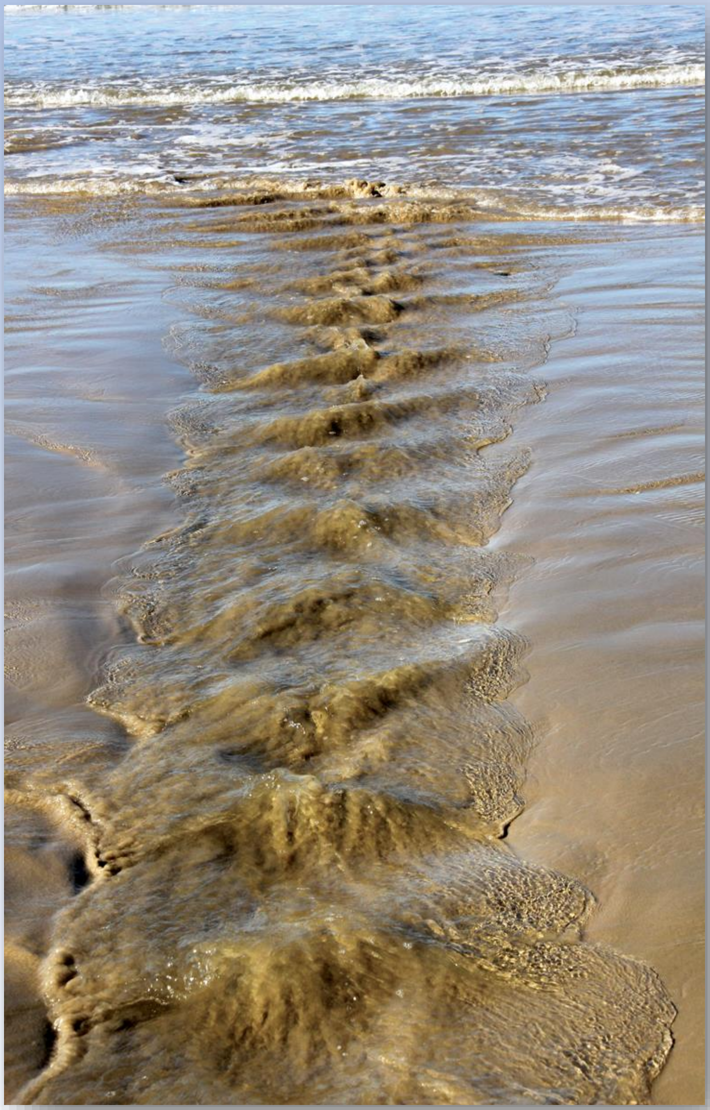
Alongshore Sediment Movement

Investigation of the alongshore movement of sediment should involve more than just determining the net rate of transport along a stretch of shoreline. The waves and currents driving the movement of sediment result in areas of convergence and divergence that lead to changes in the shape and response of the shoreline. For example, a reduction in the rate of transport along the shoreline results in an area more prone to accretion or reduced erosion. Likewise, an increase in the rate of transport will likely result in an area of increased erosion or reduced accretion. Similar to flow of traffic on an interstate, these changes in the "speed" of the sediment flux result in area of sediment congestion (potential increased deposition) or swifter travel (potential increased erosion).

The goal of the alongshore model is to provide a physically-based representation of alongshore currents and sediment transport driven by breaking waves in the surf zone. To achieve this physically-based representation, it is important to understand what alongshore sediment processes may cause erosion or accretion. Typically, a section of shoreline can be represented as a cell (in the case of Nantasket Beach, every 5 meters was utilized). A certain amount of sediment enters this cell from the updrift side (direction from which the waves advance), and a certain amount leaves the cell to the downdrift side. This sediment balance may vary depending on the wave conditions. There are three possibilities that may be observed for that wave condition:

a. The same amount of sediment enters a cell as leaves the cell.
b. More sediment enters a cell than leaves the cell.
c. More sediment leaves a cell than enters the cell.

The first possibility leads to a stable shoreline. The shoreline neither erodes nor accretes. The second possibility leads to an accumulation of sand in the cell, which is a situation causing accretion (building out of the shoreline) to occur. The final possibility leads to a net loss of sediment in the cell, which causes erosion.



Alongshore sediment transport flux was computed by using the wave transformation results to determine nearshore hydrodynamics, and subsequently, the sediment flux (representing the rate of sediment moving) along Nantasket Beach. All wave directional bins were combined to create an average annual sediment transport. When considering an average annual year (waves arriving from various directions), the littoral transport rate is a relatively constant value. These calculations assume that sediment is available on the beach for transport (e.g., potential transport). If the shoreline is armored (e.g., revetment), or has a reduced sediment supply, the sediment transport rates may differ from the values presented herein.

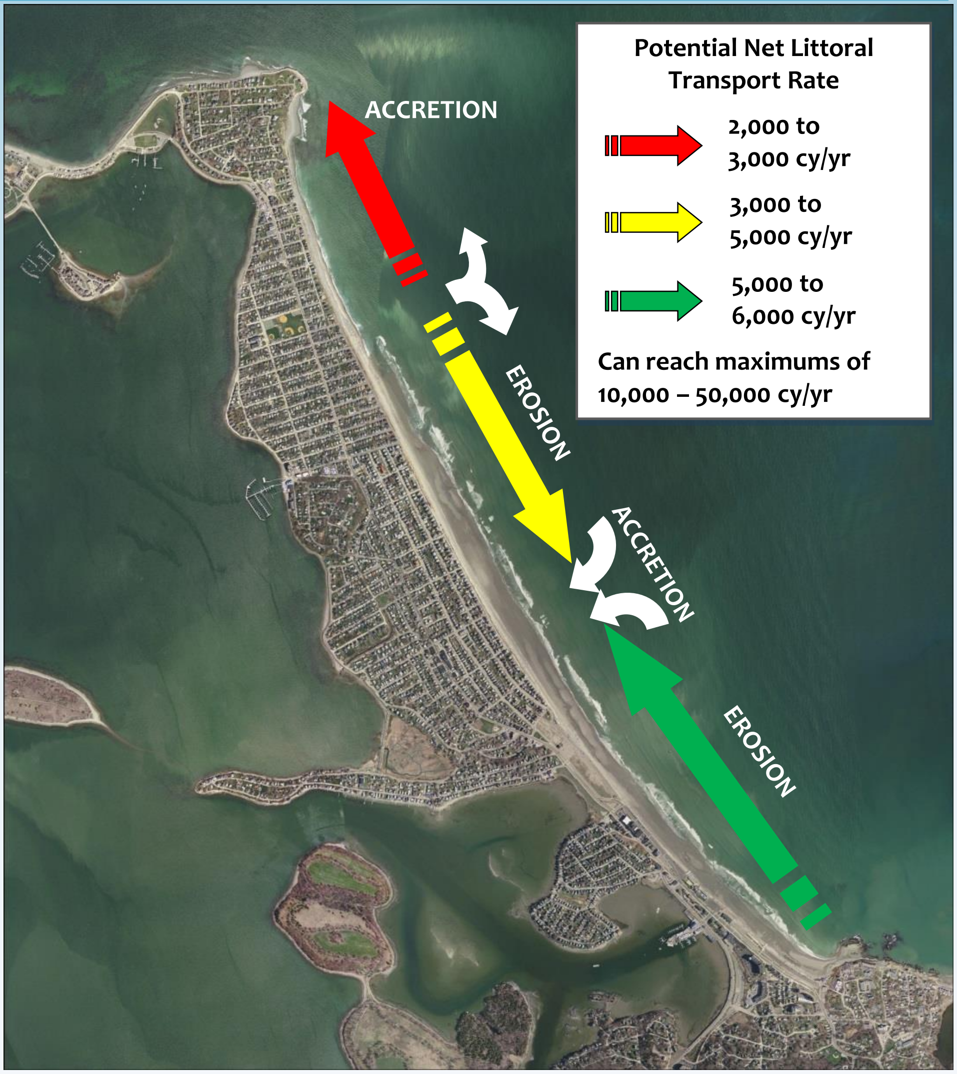
Alongshore Sediment Movement (cont.)

The alongshore sediment movement indicates that, on an average annual basis, the alongshore rates of movement are relatively small (average rates of approximately 5,000 cy/yr with maximums reaching up to 50,000 cy/yr). For example, many Atlantic Ocean facing shorelines have potential transport rates of 10 to 100's of thousand cubic yards per year. Nantasket Beach's smaller rates are consistent with the stable historic shoreline change rates and orientation of the shoreline. The southern portion of Nantasket Beach (DCR Reservation) has an average annual longshore transport directed to the northwest at an average rate of approximately 5,000 to 6,000 cy/yr, with maximum rates ranging from 10,000 cy/yr to 50,000 cy/yr (due to focused wave energy). The center portion of Nantasket Beach (between approximately K St. and Kenberma St.) experiences sediment transport to the southwest at an average annual rate of approximately 3,000 to 5,000 cy/yr. The convergence of these two net annual transport pathways results in an area of sediment accretion, which corresponds to the same accretion area observed in the historical shoreline change analysis and sand rich area in terms of sediment. Additionally, since these two areas (DCR Reservation and K St. to Kenberma St.) have sediment moving out of the area, without sediment moving in, these areas will tend to be erosional in nature. This is also consistent with the historical shoreline change analysis and sediment grain size (more cobbles in these areas).

The northernmost section of Nantasket Beach (north of N Street) has transport rates of 2.000 to 3,000 cy/yr directed towards the northwest. This creates an area of sediment divergence, and subsequently erosion in the area around M St.

These variations in rates and directions of transport along Nantasket Beach create areas of subtle transitions resulting in an acceleration or deceleration ("traffic jams") in the alongshore movement of sediment. In areas where there is a decreasing transport rate, the shoreline should respond with a reduced erosion rate; in areas where there is an increasing transport rate, the shoreline should respond with a higher erosion rate. This means that more (increasing rate) or less (decreasing rate) sediment is leaving the area towards the next cell or grouping of cells alongshore. The historical response in the shoreline is consistent with these transitions.

Results from the physics based alongshore sediment transport model for average annual conditions. Arrows indicate direction of transport while colors indicate magnitude.



Alongshore Sediment Movement (cont.)

These relatively small transport rates, and reversals in transport direction along the shoreline, also support the historically relatively stable nature of the Nantasket Beach shoreline. In general, the larger-sized cobble material is not mobilized during a majority of the average annual wave conditions. The more commonly occurring, but less energetic, wave approach directions arriving from the east and east-southeast are not capable of mobilizing the cobble material. During these conditions, only the sand portion of the beach is mobilized and transported to the north-northwest. The cobble component of the distribution is only mobilized during the more energetic wave conditions (e.g., northeast north-northeast). During these conditions, both the sand and cobble components are mobilized and transported to the southeast. In addition, during storm events, which also typically arrive from the northeast, both cobbles and sand are mobilized to the southeast. Therefore, in the alongshore direction at Nantasket Beach, cobbles are more consistently transported to the southeast, while the net movement of sand is more consistently to the northwest.

Storms result in increased magnitudes of sediment transport relative to non-stormy periods. For example, a 50-year return period storm produces alongshore transport rates up to 10 times greater than those for average annual conditions. However, these storms are also short-lived relative to an annual timeframe such that the influence on the alongshore rate is less pronounced. Storms; however, do have a major impact on the cross-shore sediment transport. In order to put in context the amount of material that may be temporarily moved during a significant storm event (i.e., a typical 10-year storm event), alongshore sediment transport rates average 60,000 cy/yr to the southeast, with maximum flux rates exceeding 200,000 cy/yr. This is significantly larger than the average annual conditions. Although these storms obviously don't last an entire year, and therefore move only a fraction of the annual amount, these high-energy storm events result in a significant amount of sediment movement at Nantasket Beach and play an important role in the overall consideration of alternatives for erosion mitigation. For example, a 1 day 50-year storm event could transport as much material as an entire average year (approximately 2,000 cy in the alongshore direction).

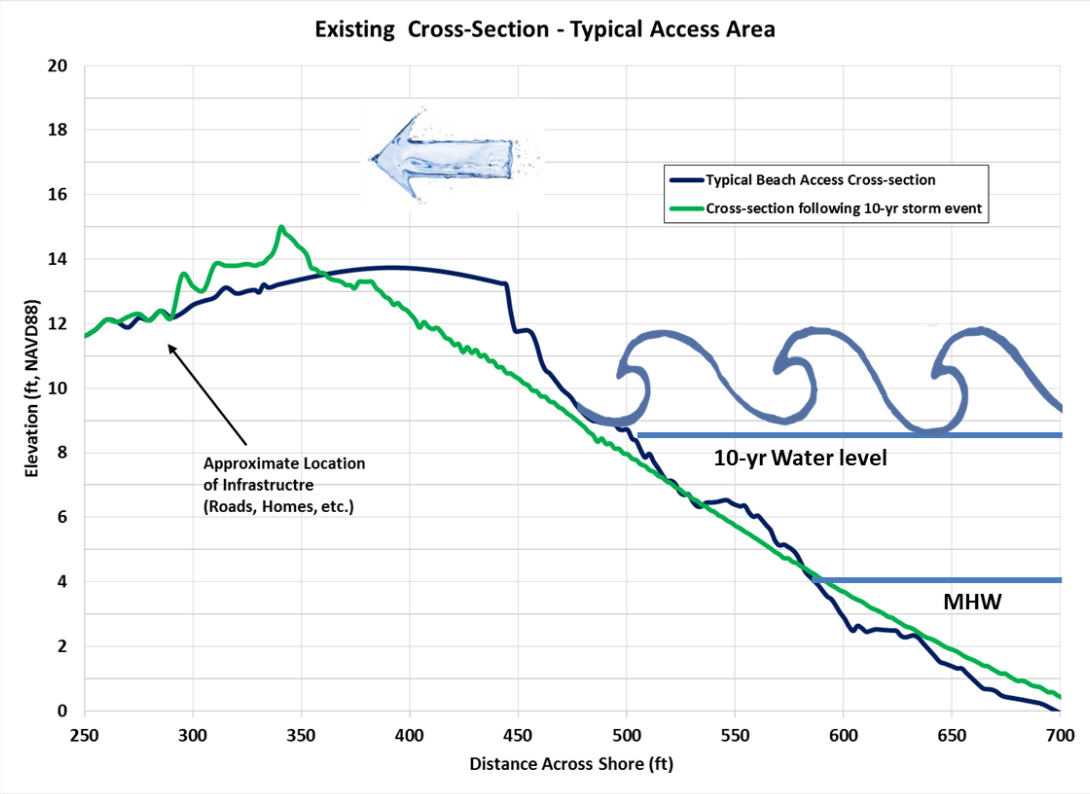
Cross-shore Sediment Movement

In addition to alongshore sediment transport, physical processes of cross-shore sediment transport were evaluated for key locations along North Nantasket Beach. Cross-shore simulations of sand movement were conducted for normal wave and tide conditions, and more importantly storm conditions (surge and storm waves). Additionally, sea level rise conditions were also considered.

The sediment transport model XBeach (Deltares, 2015), was utilized to simulate sediment transport in the cross-shore direction in the nearshore regions of Nantasket Beach. The model was used to evaluate volumetric estimates of cross-shore sediment transport, and to determine the performance of various alternatives at the various site-specific critical locations. As such, the performance of potential dune and beach restoration solutions could be evaluated.

The XBeach model (Deltares, 2015) includes the hydrodynamic processes of short-wave transformation (refraction, shoaling and breaking), long wave (infragravity wave) transformation (generation, propagation and dissipation), wave-induced setup and unsteady currents, as well as overwash and inundation. The morphodynamic processes include bed load and suspended sediment transport, dune face avalanching, bed update and breaching. Effects of vegetation and the presence of hard structures have also been included. The model has been validated with a series of analytical, laboratory and field test cases using a standard set of parameter settings.

More details on the cross-shore modeling can be found in Chapter 3, which includes simulations of existing conditions, as well as cases with the resiliency measures in place.

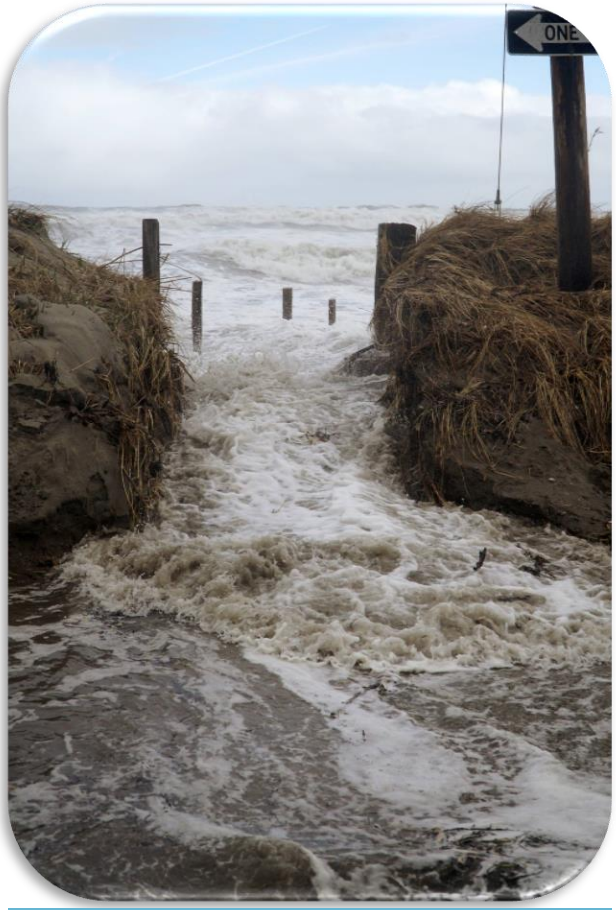


Modeling of a 10-year return period storm event and the impact the storm has on the dune system at a typical crossing location. The model results show the pre-storm profile (blue line) and the post-storm profile (green line). The existing dune crossing experiences flooding of water through the dune crossing and pushes sediment into the landward area (e.g., road).

3 Design Development

3.1 Importance of Beaches and Dunes

Beach and dune systems are the interface between the water and the land. They are naturally dynamic environments that fluctuate in size, shape, and form based on the effect of wind, waves, tides, and storm events. The state (or condition) of the beach and dune system is critical to the ongoing maintenance of the natural system. If this natural system is interrupted or suspended, it can have large negative impacts on the ability of the system to provide flooding and erosion control benefits. The beach and dune size, shape, slopes, and volumes determine how well the system can protect an area and absorb energy during a storm. The primary frontal dune along North Nantasket Beach varies significantly in its size, shape, volume, and makeup, and as such offers varying levels of protection along the North Nantasket Beach. Dune continuity is critical for functional storm damage protection. In areas where the existing dune is healthy, the overall resilience is significantly increased, where areas with gaps or weaknesses reduces flood control. In addition to storm protection, healthy dune systems can serve as a repository for sand to naturally replenish beaches that have experienced significant erosion from coastal storms. At Nantasket Beach, the importance of dunes is heightened due to the dwindling sediment supply and pressures of increasing sea levels.



Flooding through a beach access path along North Nantasket Beach. The reduced elevation and lack of vegetation creates a weak spot in the dune system.

The beach also has an important role in protecting the upland areas. The beach forms the first line of defense against the energy of the ocean and is the primary wave energy absorber. The beach acts as a mobile buffer that has a natural self-protection ability by adjusting its shape and bar formations to the incoming wave energy. This self-protection process is why the beach changes between a winter condition (sediment moves offshore to break higher waves further from the upland) and summer condition (sediment moves back onshore since the wave energy is smaller in the summer). The same process happens during a storm event, but drastically faster sometimes resulting in drastic erosion as the beach tries to protect the upland. The narrowing of the beach due to a lack of a sediment supply, which is occurring at Nantasket Beach, has a significant impact on the ability of the beach to function as intended. The beach, especially at Nantasket, provides a high level of ecological, recreational, and economic benefits. As such, restoration of the beach and dune system is principal to building long-term resilience for the Town of Hull.

3.2 Dune and Beach Design

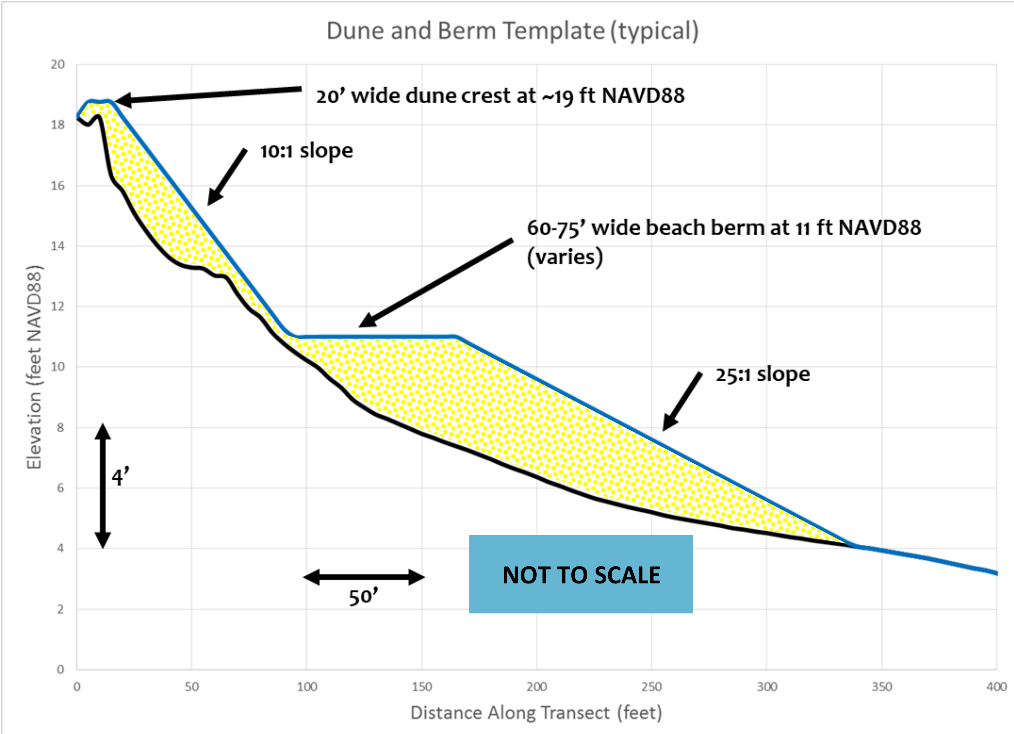
While Nantasket Beach has long served as a valuable recreational resource and critical ecological habitat, it also provides crucial storm protection to the developed mainland shores of Quincy, Hingham, and Hull, as well as the vibrant resources of Hingham and Quincy Bay. Now, the potential acceleration of climate change, with sea level rise and increasing frequency and intensity of erosion inducing events, adds expanded pressure to the durability of the system. With these mounting pressures, increased resiliency of the beach and dune system is paramount. Armed with an improved understanding of the coastal processes that influence and shape the Nantasket Beach, the approach for restoring the beach and dune system of Nantasket is described herein.

As discussed, one of the primary causes of coastal erosion is a deficit of sediment within the coastal littoral cell. To offset this deficit, nourishing the beach and dune with compatible sediment placement is a logical means for improving the resiliency of a shoreline where such a project is economically feasible. Beach nourishment does not stop erosion, but it does strengthen the system (beach and dune) by the addition of compatible material. The damage to landward areas are reduced by extending the shoreline toward the ocean and increasing dune volume.

The stable nature of the Nantasket Beach system and its orientation (formed over centuries of natural adjustment to the waves, currents, and tides) makes the system and ideal candidate for a large-scale beach restoration project. The relatively small alongshore transport rates will increase nourishment performance.

At a site like Nantasket Beach, the beach also provides a major recreational and ecological benefit. Beach nourishment is typically the most non-intrusive technique for coastal protection and involves placing sand, from an offshore or upland source, in a designed template on an eroding beach. Beach nourishment at Nantasket Beach would be intended to widen the beach and dune, as well as provide added storm protection, increased recreational space, and added habitat area. Although nourished sand is eventually displaced alongshore or transported offshore, the sediment that is eroded takes the place of areas that would normally have been lost or eroded during a storm event. Therefore, beach nourishment serves a significant role in storm protection and works with the dunes to provide overall resilience. The beach and dunes perform in a symbiotic relationship during a storm event, as the beach provides added protection to the dunes (breaking wave energy further offshore, while the dunes provide added sediment for the beach. In addition, nourishment is the only alternative that introduces additional sand into the system. For coastlines with a dwindling sediment supply and faced with rising seas, this is critical for long-term success. The many benefits of nourishment, and the ability to control negative environmental impacts with careful design and planning, make nourishment a viable resiliency option for Nantasket Beach.

A successful beach and dune nourishment project consists of more than simply placing sediment on a beach. Ideally, beach and dune restoration projects are engineered. A beach nourishment template, which consists of numerous design parameters, is based on the characteristics of the site and the needs of a project.



Representative cross-section showing key parameters and dimensions for the restored dune and beach system at North Nantasket. Please note that horizontal and vertical scales are not the same. The black line shows an observed, representative profile and the blue line shows the proposed restoration template.

Every nourishment design is unique, since different beaches in different areas have different physical, geologic, environmental, and economic characteristics, as well as different levels of required protection. The design must consider climatology, the shape of the beach, type of native sand, sediment volume and rates of sediment transport, erosion patterns and causes, waves and water levels, historical data and previous storms, probability of certain beach behaviors at the site, existing structures and infrastructure, and past engineering activities in the area.

The structure of a nourishment template is designed to yield a protective barrier that also provides material to the beach and dune. A higher and wider beach berm is designed to absorb wave energy. Dunes are needed to reduce damage from storms. Nourishment length, berm height and width, dune height, volume, and offshore slope are critical elements of a beach nourishment design. The proposed North Nantasket Beach regional adaptation strategy (or plan) consists of a beach nourishment project spanning approximately 2.0 miles along the northern portion of the barrier beach. Appropriate permits should be obtained to meet a comprehensive beach nourishment project. However, actual implementation can be tailored based on sediment volume available, cost, and need. Site-specific designs can be modified to consist of overfill (additional sediment) in certain areas to bolster the protection at critical shoreline stretches or in areas with increased wave energy. While the large-scale nourishment was engineered, it is also understood that in some cases smaller nourishments of opportunity may arise based on sediment becoming available.

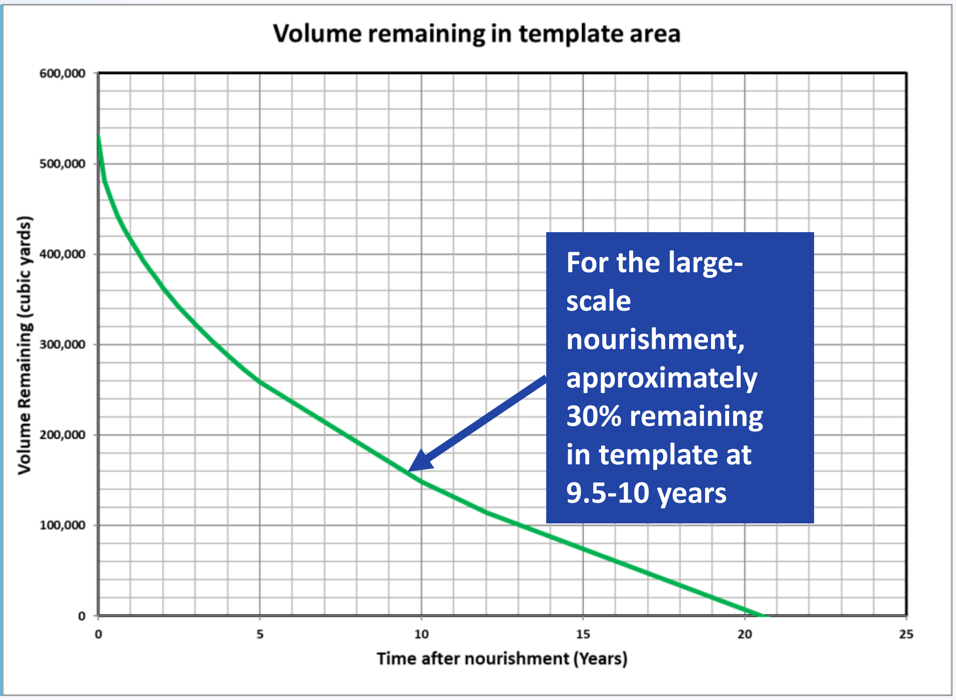
GOALS OF LARGE-SCALE TEMPLATE APPROACH

Through design and permitting of a large-scale nourishment for North Nantasket Beach:

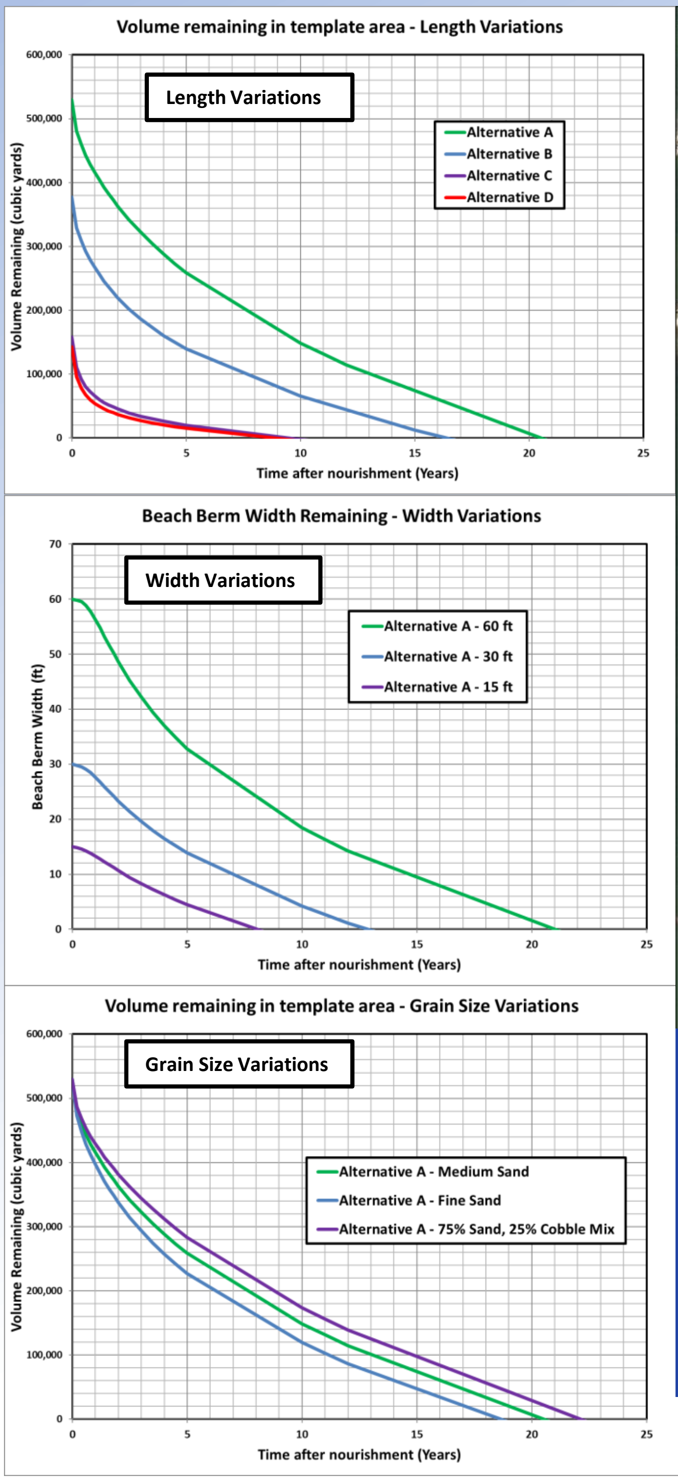
1. The Town of Hull can be prepared to respond quickly if needed. For example, if beach compatible sediment becomes available from a navigational dredging project, the Town of Hull will have a nourishment location available.
2. The Town of Hull creates flexibility and a range of options that would be available based on needs, sediment availability, and funding. For example, the Town could pursue various widths, lengths, volumes, and combinations of dune and beach restoration approaches that fall within the permitted template area. This allows the Town flexibility to nourish when funds or sediment become available and/or in response to emergency restoration needs.
3. The Town of Hull can consider various sediment sources in the future. The Town can be selective in ensuring that the sediment source adequately meets their needs and is beach compatible for Nantasket.

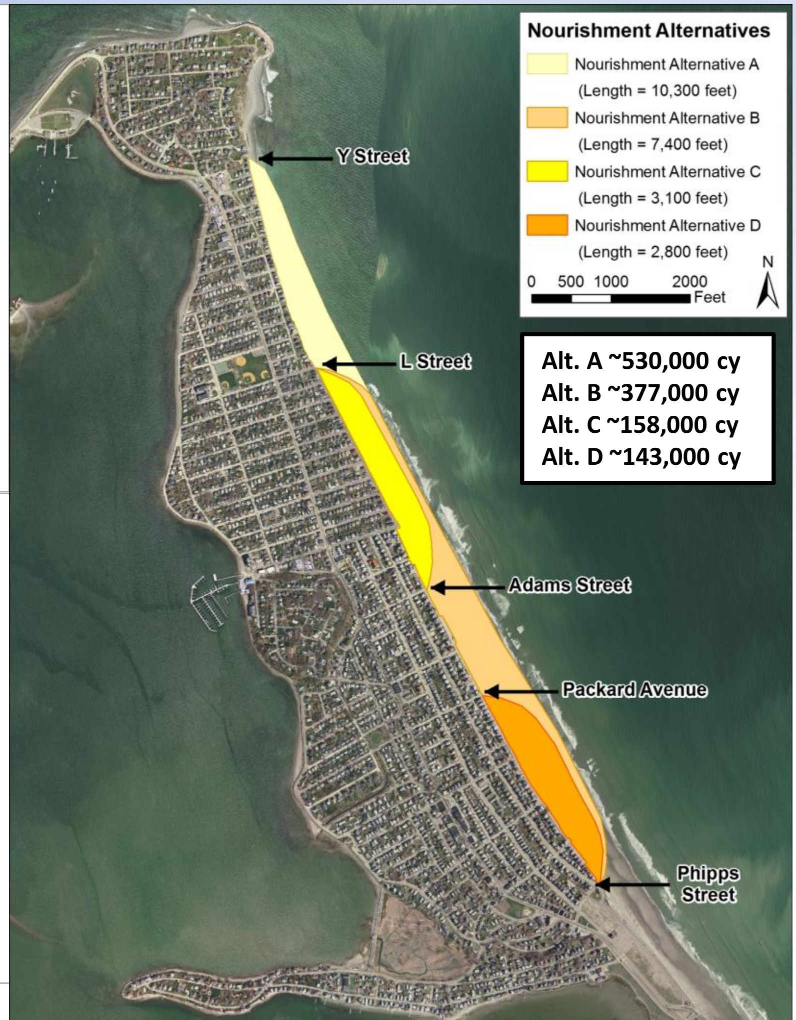
3.3 Performance

Since the nourishment material diffuses (spreads) over time, it is possible to evaluate the longevity of the nourishment by looking at the amount of material left in the project area. The lifetime of the beach nourishment is based upon the volume of the initial beach fill left within the boundary of the initial fill template. The percentage remaining will decrease with time, but that material is not necessarily lost from the system, it has just spread to regions outside of the original nourishment template. For example, sediment will likely be transported to other portions of the Nantasket Beach shoreline. Therefore, although the sediment no longer falls within the initial nourishment template, it has not disappeared from the system as a whole.



It is recommended that the Town strive to complete the full nourishment project since it offers improved performance and longevity, and thus over the long-term is the most cost-effective. It is understandable that a variety of other factors (e.g., other projects, available budget, sediment source, etc.) may come into consideration when prioritizing resilience options. As such, a number of potential nourishment options were considered that varied the volume, length, beach width, and grain size to determine fluctuations in performance. A final set of prioritized strategies, similar to that presented for the access path restoration (Task 2 of this grant), can be further defined in the final design and permitting stage.

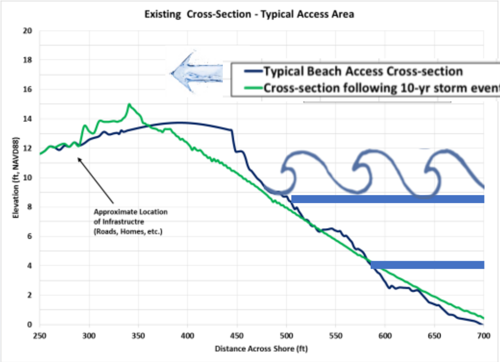




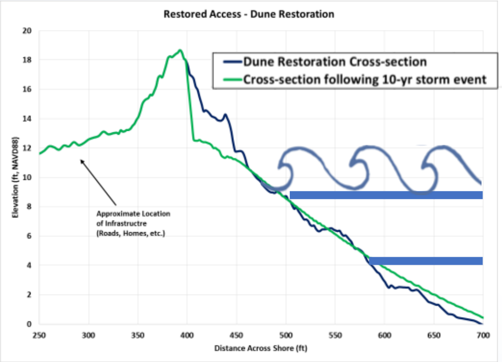
The performance of beach and dune restoration varies based on the design parameters. The figures to the left present a variety of service life assessments when varying some of these key parameters. The upper panel presents variation in performance relative to length of the nourishment, the middle panel presents variation in performance relative to width of the nourishment, and the bottom panel presents variation in the performance of the nourishment relative to grain size.

Dunes serve as a barrier between the waters edge and inland areas, taking the brunt of storm surges and wave attack. Dunes are especially important in areas where the beach may be narrow or in areas with dwindling sediment supplies. Dune performance is evaluated by determining the response of the dune system to a storm event, since day to day conditions generally do not impact the dune.

Low Elevation Crossover



Restored Crossover

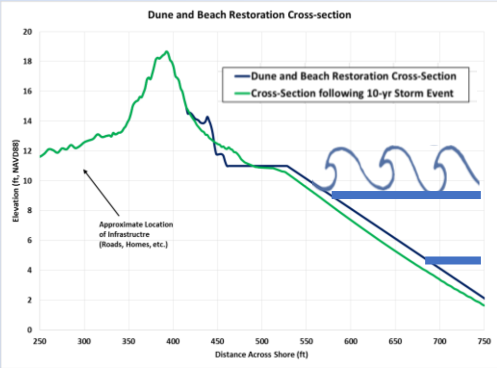


Approximate Volume in Dune (cubic yardage / linear foot)	Level of Storm Protection (Return Period)
5	< 5-yr
10	5- to 10-yr
15	10- to 20-yr
20	20- to 25-yr
25	25- to 30-yr
30	30- to 35-yr
35	35- to 40-yr
40	45- to 50-yr
45	> 50-yr

In general, the more volume, width, and height in a dune, the more effective and efficient the system will be at reducing the impacts of coastal hazards. The overall volume of sediment in a dune is an important indicator of the level of protection that a dune can provide. The effectiveness of the North Nantasket dune system was evaluated based on the volume of the existing dunes and use of site-specific physical processes modeling of various return period storms. The results of the analysis provide a general guide for targeting the volumetric health of a dune to offer a level of protection. The table provides an indication of the required volume needed in a North Nantasket dune to reach a specific level of protection. These values can be used a guideline for determining the design of healthy dune systems.

While restoring the dune alone provides valuable protective ability (as shown above), the addition of a beach restoration with a dune provides even greater benefits as the two work together as a complete system. The response to a 10-yr storm shown demonstrate the effective of the overall system.

Restored Dune and Beach



4 Permit Requirements and Costs

One of the next steps towards building resilience for the North Nantasket Beach area is to finalize the engineering design, recommend prioritized options within the large-scale template, and obtain permits for the proposed dune and beach restoration. While important short-term measures are focused on optimizing and enhancing dune crossovers and ensuring dune health to reduce storm induced flooding, being prepared with a permitted large-scale beach nourishment template provides flexibility to the Town of Hull for building long-term resilience. For example, having a permitted beach and dune template allows the Town to be nimble in accepting beach compatible material that becomes available, respond to emergency restoration needs, and ultimately be more cost-effective in managing the beach system. Obtaining the required permits for the large-scale nourishment includes: field investigations, permitting tasks, developing engineering plans, and continued public education and outreach.

Field Investigations

Prior to filing for permits, a number of field investigations will be required, including:

- A more detailed coastal resource delineation assessing the distribution of cobble throughout the project site will be necessary to characterize grain size for compatible nourishment.
- Desktop assessments including changes in shoreline position and Essential Fish Habitat (EFH). Changes in shoreline position will be mapped and updated with data from recent years. The review of EFH will require assessing the presence of species within project site and any potential impacts to these species.

Field Investigations (cont.)

- Two separate field investigations conducted by boat are recommended to access the state/condition of benthic and shellfish habitats.. A benthic survey investigation will inspect for indicators of Rocky Intertidal Shoreline and Complex Bottom Type. Both types of seafloor offer potential habitat to species and the nourishment design would seek to avoid or minimize impacts to these resources. The shellfish survey would require hiring a fishing boat to conduct trawling along the coastline to determine the presence and distribution of shellfish along the seafloor within the project site.

Permitting

Environmental permits for the proposed large-scale beach nourishment will be required from local, state, and federal agencies. The regulatory process within the Commonwealth of Massachusetts for obtaining permits can be quite lengthy and complex. The permit applications that will likely be required for the project, include:

- MEPA Certificate (State)
- WPA permit, Order of Conditions (Local)
- Chapter 91 Permit (State)
- Federal Consistency (State)
- Individual Permit from the US Army Corps of Engineers (Federal)

Permitting (cont.)

The permitting process will involve a number of steps, which are shown in a graphical representation to the right. The proposed approach is geared to fit within a strict timeline consistent with the funding timeframe of CZM's Coastal Resiliency Grant Program. This specific approach is centered around filing an Expanded Environmental Notification Form (EENF) with the Massachusetts Environmental Protection Act (MEPA) Unit and requesting a waiver from the mandatory Environmental Impact Report (EIR) requirement. The specific steps include:

Pre-Application Meeting

Prior to starting the MEPA filing process a pre-application meeting is advised, with the purpose to strategize on MEPA permitting path, hear concerns from other regulatory agencies, and help avoid unnecessary MEPA review.

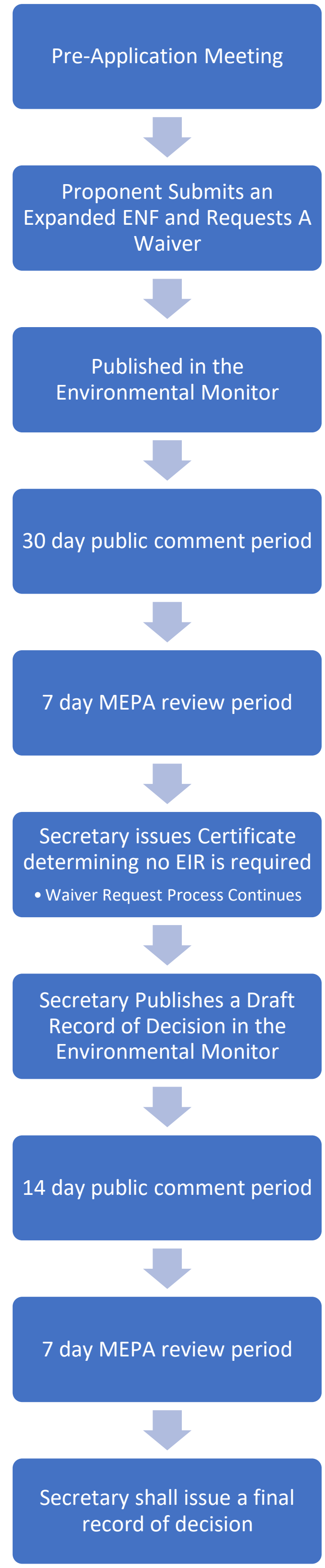
EENF Filing with Request for Waiver of Mandatory EIR and Single EIR

A review with MEPA will be required under 301 CMR 11.01 prior to the issuance of any other permits. To receive the Certificate, an EENF must first be filed with MEPA, and reviewed by numerous state environmental regulatory agencies (e.g., Division of Marine Fisheries, Natural Heritage and Endangered Species Program, DEP, CZM, etc.), and the public. The purpose of the EENF filing is for MEPA to rule on whether or not the project will have significant environmental impacts, and therefore requiring a filing of an EIR. An EIR is a comprehensive document that must characterize the existing environment, demonstrate the need for the proposed project, evaluate alternatives and environmental impacts, and make the case that the proposed project is the most acceptable alternative from an environmental standpoint. Depending on the size of the project, the MEPA regulations also include thresholds for mandatory EIRs. In these cases, the Secretary's Certificate on the EENF essentially provides the scope of work and issues to be addressed in the EIR. Based on the assumptions listed above and review of the regulations, we know the project will likely meet the following regulatory thresholds for an EENF and Mandatory EIR under 301 CMR 11.03 requiring the preparation of an EIR.

A possible avenue through MEPA, based on discussions at a pre-application meeting would be to file EENF and request a waiver from the mandatory EIR.

According to 310 CMR11.11 (1) the standards required to receive a Waiver are:

a. "result in an undue hardship for the Proponent"
b. "not serve to avoid or minimize Damage to the Environment"



Typical MEPA waiver request timeline.

Permitting (cont.)

Likely the proposed large-scale nourishment project would qualify for a Waiver as the requirement for preparation of an EIR would result in an undue hardship to the Town, as considerable financial resources are already being used to develop and implement plans for addressing long-term management of their coastal resources. Also, preparation of an EIR would not serve to avoid or minimize damage to the environment.

Once qualified, the Secretary can grant a Waiver if 310 CMR 11.11(3) a and b are met, as listed below.

a. "the Project is likely to cause no Damage to the Environment"
b. "ample and unconstrained infrastructure facilities and services exist to support the Project"

To meet the first standard, mitigation measures would be employed to ensure the impacts of the project would avoid or minimize Damage to the Environment. For the second standard, this project would not require any infrastructure or services to accomplish its overall goal of beach nourishment. In addition, the adjacent DCR beach nourishment project at Nantasket Beach successfully followed this same course of action though MEPA.

At the same time as requesting the Waiver, it is also advisable to request a Single EIR, in case the Waiver request is denied. For example, if the Waiver is denied at the end of the initial seven-day MEPA review period, the Secretary will either issue a written Certificate stating they require a Single EIR or possibly require a Draft and Final EIR. If the Waiver is denied but a Single EIR is granted, a Single EIR can expedited the MEPA process.

Notice of Intent

This application (a Notice of Intent) is filed with the Town of Hull Conservation Commission as per 310 CMR 10.02 (2)(a). All coastal resources will need to be documented, as well as project plans and potential impacts. Abutters within 100' to the project site would be identified and notified via certified mail. The NOI application is followed by a site inspection with the Commission, as well as public hearing(s). Public hearings with the Conservation Commission would involve presenting the project, answering questions, and receiving comments from the Commission and the public. Once the project is approved, the Commission will issue an Order of Conditions.

Chapter 91

This application is filed with the Massachusetts Department of Environmental Protection Waterways Division. The Chapter 91 Permit essentially provides permission to work in State-owned waters below the high-water mark. The application will include a project narrative, site maps illustrating areas of existing resources to be impacted and proposed areas of nourishment, and publishing a public notice. Signatures from the Town Zoning and Planning Boards will need to be acquired during the application process. In accordance with Chapter 91 protocol, waterfront abutters and certain regulatory agencies will be identified and notified of the project via certified mail.

Permitting (cont.)

Federal Consistency Review

This request is sent to the Massachusetts Coastal Zone Management (CZM) Agency. CZM's role is to ensure consistency with their marine environmental policies and an appropriate level of coordination between the state and federal agencies. A Consistency Statement will need to be prepared in compliance with CZM policies. After the Chapter 91 Permit is issued, a Consistency Determination can be issued by CZM.

Application for Department of the Army Permit Form (PCN)

An application is filed with the United States Army Corps of Engineers (USACE) detailing anticipated impacts to waters of the U.S. and mitigation measures to avoid and minimize impacts. Further details required include federal threatened or endangered species presence, photographs of waterway to be impacted (preferably at low tide), habitat presence, type of soil affected, historic information of project area (including previous permits with USACE), and project plans. Beach nourishment within waters of the U.S. requires submitting a Preconstruction Notification form to the USACE. Written determination from the USACE granting an Individual Permit must be received prior to the start of the project. Coordination with the USACE may be required to ensure the project complies with any applicable general conditions. The GP typically cannot be issued until CZM issues its Consistency Determination. The USACE process also requires input from the US Environmental Protection Agency (EPA), US Fish and Wildlife Service (USFWS), and the National Marine Fisheries Service (NMFS).

Meetings and Public Outreach

Part of the permitting process will involve meetings with the Town following critical steps in the permit tasks. This includes meetings after the completion of the field studies, a pre-application meeting with the Town and various regulatory agencies to discuss permit approach, and meetings to review progress and discus any further requirements.

Additionally, prior to filing of permits, it is recommended that public outreach meetings be held to inform the public on the merits of beach nourishment and to communicate with relevant homeowners that will require easements associated with the filing for a Chapter 91 Permit. Three educational meetings with the public on the merits of beach nourishment are encouraged in order to describe the project, the benefits of nourishment, and the results of no action that incorporate projected sea level rise and increased flooding resulting in damage to housing. Homeowners with land rights to the beach will need to be identified and met with to discuss the process of acquiring easements and the implications associated with receiving the easements. This process will require considerable amounts of coordination with the town council in order to prepare legal documents and to determine alternatives if easements are not signed.

Final Design and Engineering Plan Sets

While the technical work presented herein provides the basis for an engineering design, including appropriate dimensions and scale, the engineering design plans need to be created for permitting and construction. This will require an updated survey of North Nantasket Beach and generation of an engineering plan set that provides the details and specifications for construction and placement of beach compatible material.

The proposed design template presents a large-scale nourishment project for North Nantasket Beach; however, that doesn't mean that the large-scale project has to be completed all at once, or that plans need to be in place to fill the entire template. By permitting the entire beach restoration template areas, the Town would be prepared to accept beach compatible material as it becomes available, thereby completing smaller projects as needed or respond to emergency restoration needs. This also allows the Town to cost-effectively manage the beach system by taking advantage of opportunistic sediment sources (e.g., beneficial reuse of clean dredge material at lower cost).

Next steps also will include recommendations on prioritized areas for dune reconstruction and/or beach nourishment. These recommendations will span a range of nourishment volumes such that the Town can be prepared to provide targeted restoration projects as sediment becomes available or cost allows.

Next Steps

The recommended next steps for the Town of Hull's long-term protective measures would be to acquire the required permits for the proposed large-scale beach restoration project. Ideally, this would be accomplished through a CZM Coastal Resiliency Grant or Municipal Vulnerability Preparedness (MVP) Action Grant, both of which represent logical steps forward in the resiliency building process.

Estimated Costs for Next Step: Final Design and Permitting of Large-Scale Beach Restoration

TASK	Cost Estimate
Field Investigations	$25,244
Permitting	$98,056
Meetings	$6,862
Survey, Engineering and Prioritization	$22,450
Public Education and Outreach and Easements	$15,052
Total	**$167,664**

The estimated costs for this next step are outlined in the table. Due to the high variability in costs associated with various sediment sources, the cost of construction of part, or all, of the proposed beach restoration template is difficult to estimate. However, to complete the full project template (530,00 yd^3), costs are expected to range between $13 - $16 million.

5 References

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