Appendix A

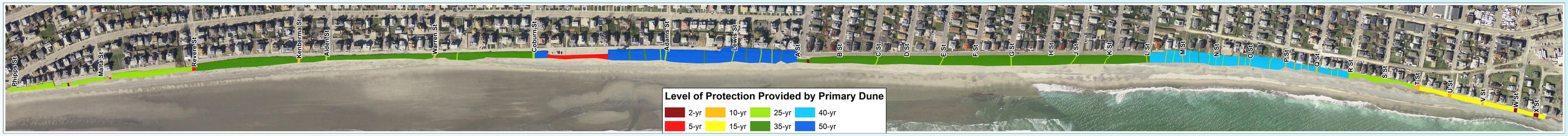
Dune Vulnerability Estimates

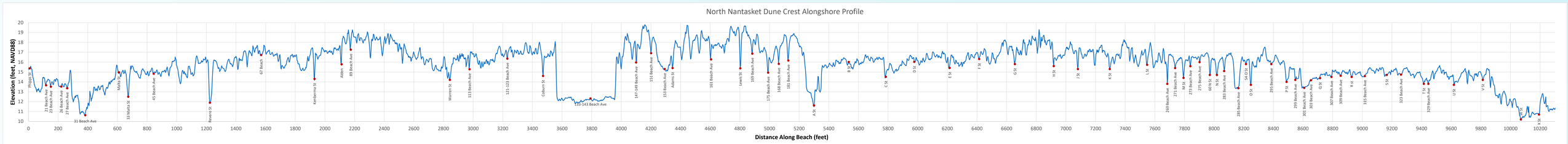
2019 MCZM Coastal Resilience Grant Program

NORTH NANTASKET DUNE RESILIENCY AND RESTORATION

Introduction

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 beach and dune system is critical to the ongoing maintenance of the natural system and if interrupted or suspended can have large negative impacts on the ability of the system to provide flooding and erosion control benefits. The beach and dunes size, shape, slopes, and volumes determine how well the system can protect an area 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. The figures below show the level of protection provided by the primary dune along North Nantasket Beach (upper panel), and the elevation of the dune crest along the beach (lower panel). The color distribution on the upper panel indicates lower (red) to higher (blue) protection ability with crossing locations clearly visible on both panels. The results can be used to prioritize restoration actions.



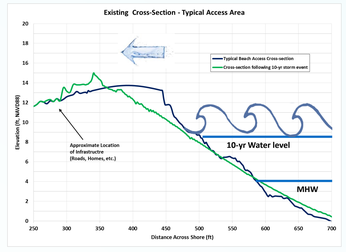


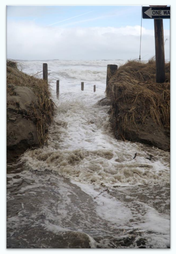
Level of Storm Protection – Volumetric Basis

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. 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 at the right provides a 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.

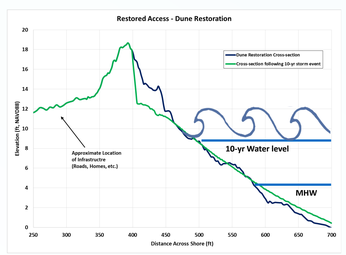
Approximate Volume in Dune (cubic yardage / linear foot)	Level of Storm Protection (Return Period)
5	< 5-yr
10	5- to 10-yr
15	10- to 20-yr
20	20- to 25-yr
25	25- to 30-yr
30	30- to 35-yr
35	35- to 40-yr
40	45- to 50-yr
45	> 50-yr

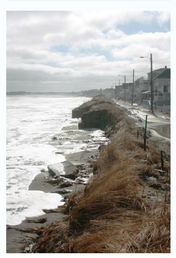
Low Elevation Crossover





Restored Crossover

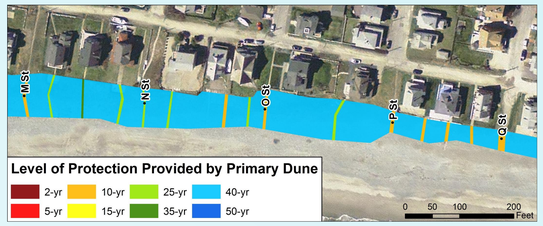




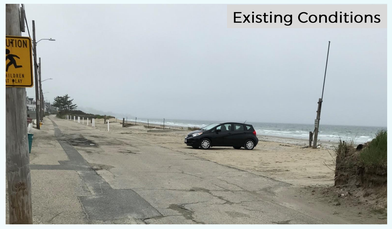
Existing dune crossings with minimal elevation, volume, and vegetation create weak spots in the overall dune system. Modeling of a 10-year return period storm event and the impact the storm has on the dune system is shown for an existing dune crossing (upper panels), and a restored dune crossing (lower panels). The model results in the center panel 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). The restored dune protects the landward area while sacrificing some volume.

Reduced Level of Storm Protection at Crossovers

While the health of the dune naturally varies to a certain extent, dune crossings further interrupt the dune and create vulnerabilities in the system. These weak points can result in upland flooding during lower level storm events that may impact larger upland areas. These lower elevation, unvegetated pathways form conduits for penetration of ocean based water during storm events and greatly minimize the overall protection of the dune system. Restoring dune continuity is critical for storm damage protection. The figure to the right shows the reduced level of protection that can be caused by crossovers that are not adequately maintained at desired elevations.



Coastal Dune Resiliency – Restore Dunes



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. An example dune restoration design is shown to the left (133-143 Beach Ave. restoration as existing and proposed conditions).

Coastal Dune Resiliency - Enhance Crossings

Walking over dunes and/or directly impacting the vegetation that helps create and hold the structure of a dune has significant impacts. If root systems are no longer providing structure, the dune integrity can be compromised. Wind and water driven erosion start to wear down the dune faster than it can rebuild itself. As such, dune crossings should be reduced as much as practicable and diligently maintained. There are number of potential options available to enhance dune crossings, including both structural and non-structural options. However, in all cases, the elevation and volume of the enhanced dune crossing are critical. In many cases, such as that shown to the left, this means minimal changes.

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