Beach/Park Resiliency Plan

Town of Waterford

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Chapter 1: Introduction

1.1 Review of relevant documents/information from Waterford [POCD, Climate Change Risk Vulnerability Assessment and Adaptation Study 2017, past storm damage to beach and restoration measures]

As discussed in Waterford's Climate Change Risk Vulnerability, Risk Assessment and Adaptation Study from 2017, it is evident that the effects of climate change are already impacting and threatening both infrastructure and natural resources both in and along Waterford Town Beach. This document provided us with important information serving as both background to Waterford's history as well as a reference for the creation of our Beach/Park Resiliency Plan. We will provide a brief overview of the noteworthy information. First and foremost, the Town of Waterford has addressed their recognition to future changes in climate patterns that are expected to have significant ramifications towards infrastructure. Additionally, natural resources will also be impacted,based off of past impacts due to extreme precipitation, sea level, and storm surge resulting in flooding.

This project had 5 primary goals to proactively identify risks associated with changes and develop prioritized strategies to address them. They are as follows:

(1) Develop appropriate rainfall, tidal, sea level rise and storm surge scenarios for the Town of Waterford for present, near-term and long-term time frames (we will go into more depth on these scenarios below).

(2) Produce maps and graphics showing the likelihood, extent, and magnitude of flooding impacts.

(3) Identify critical infrastructure, facilities, and natural resources in Waterford that are vulnerable to present/future flooding.

(4) Develop and prioritize potential short-term/long-term adaptation strategies with order-of-magnitude cost estimates, including regulatory and policy changes to help manage infrastructure and natural resources with future increasing flood risks.

(5) Engage the public & government officials to solicit feedback on proposed strategies so that the Town can make informed decisions that will help to avoid future costly impacts to public & private property.

While this study assessed town-wide impacts and implications, many pertained to the Town Beach, for example, recognition of vulnerable natural resources, vulnerable roadways, vulnerable buildings & facilities many of which were located at or near the Town Beach. Adaptation strategies listed consisted of: protection, accommodation, and retreat starting with short-term leading into long-term strategies. Recommendations specifically for the Town Beach are as follows: investigate potential for beach nourishment and dune enhancement to strengthen the barrier beach system & more sand on the beach greatly benefits recreational experience of the beach.

Past storms, specifically regarding the Town Beach, have already breached, as well as damaged, entire sections of the Waterford Town Beach directly impacting infrastructure, natural resources, and their economy. Superstorm Sandy (2012) resulted in a major disruption in daily life and municipal services starting with widespread power outages. Furthermore, this storm breached dunes at Waterford Town Beach as well as many other natural resource impacts. Irene (2011) and another storm in 2010 had similar impacts as well as damaged roads and drainage infrastructure from extreme rainfall and flooding. After Irene, the Town of Waterford installed snow fencing, staked holiday trees behind snow fencing, and replaced sand as restoration measures for the breached dunes.

Our research for this project involved assessing several beach/park management plans created by other coastal communities in and around Connecticut. These resources provided many useful examples of both short and long-term solutions to flooding, sea level rise, and marsh migration.

1.2 Outline of areas to be addressed & time horizon (2030 and 2070)

The major areas that will be addressed in this plan are as follows: the beach itself, the marsh, the park/parking lot, and the footpath. Each area, as previously mentioned, having significant issues regarding climate change and/or sea level rise (listed below). In order to determine which issues take priority according to climate change, we have set the time horizon through the years 2030 (short term) and 2070 (long term). Current climate conditions of this year, 2019, were also used to identify priority adaptation projects. These time horizons are critical for evaluation and assessment of how soon the community feels each adaptation should be implemented. We will be referencing all three time periods throughout the prepared beach/park resiliency plan for the Town of Waterford. With these time horizons, we are also able to see the expected acceleration and increased impacts over time due to climate change, which help guide parameters of severity.

Issues of concern at Alewife cove and tidal inlet beyond the scope of this study:

- Jetty suggestions

Issues to be addressed at the beach:

- Sea Level Rise
- Preventative methods
- Dune restoration
- Erosion
- Collection of past measures taken

Issues to be addressed involving the marshes

- Marsh migration
- Invasive species

Issues to be addressed in the park/parking lot:

- Stormwater management issues (flooding)
- Recreational use of land
- Flooding, drainage

Public Education

Marsh Migration

Kayak Launch

Mowing

Issues to be addressed with footpath

Flooding, drainage

Accessibility

Chapter 2: Sea Level Rise

2.1 Inventory of existing conditions, natural resources, recreational areas

Link to interactive map of existing conditions

http://mapmaker.nationalgeographic.org/hNocaHcFlIiFi0mcTgqGwe//?edit=gP9ph9ocDFDthWmt9VVggo

Source: National Geographic

Figure 1

Taken at Waterford Beach

Upon our initial visit to the Town Beach in February 2019, we were able to get a glimpse of the existing conditions, natural resources, and recreational areas of and around the beach and park.

The following facilities are present in Waterford Beach Park: Canoe launch, two restrooms, parking areas, three pavilions, three picnic areas, a playground, and a volleyball court.

2.2 Projections for sea level rise and impacts to existing conditions and facilities based on time horizons

Annual Mean Relative Sea Level Since 1960 and Regional Scenarios for New London, Connecticut

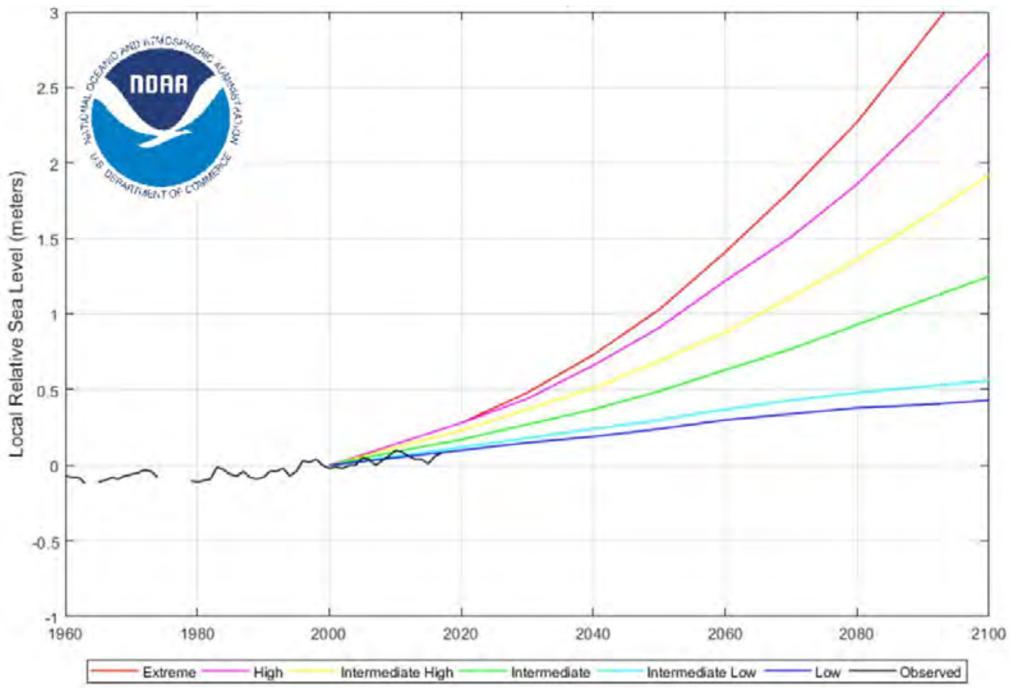


Figure 2

Source: NOAA

Figure 2 provides six possible scenarios for sea level rise until 2100. The black line represents observed data that has been taken at the New London station. Due to future uncertainty, there is a wide range of potential outcomes as represented in the scenarios. It is important to note a rise in local mean sea level will increase the occurrence of high tide flooding.

The figure shows the New London station's annual mean relative sea level with data from 1960-2019. The data from 1991-2009 serves as the baseline period, with the year 2000 being zero. The six regionalized sea level rise scenarios are based on the report on Global and Regional Sea Level Rise Scenarios for the United States (NOAA, 2019). In our report, we used the intermediate sea level rise scenario (green line) with projections of ~.25m by 2030 and ~.75m by 2070. For comparison, the Kleinfelder Risk Assessment Study had a **maximum** prediction of ~.18m in 2030 and ~.98m in 2070. In viewing both predictions of sea level rise for the Waterford Town Beach, from NOAA and the Kleinfelder Risk Assessment Study, both portray a general trend of increased sea level rise. While the predicted measurements may not match up by the year, both predictions discuss a gradual increase in sea level.

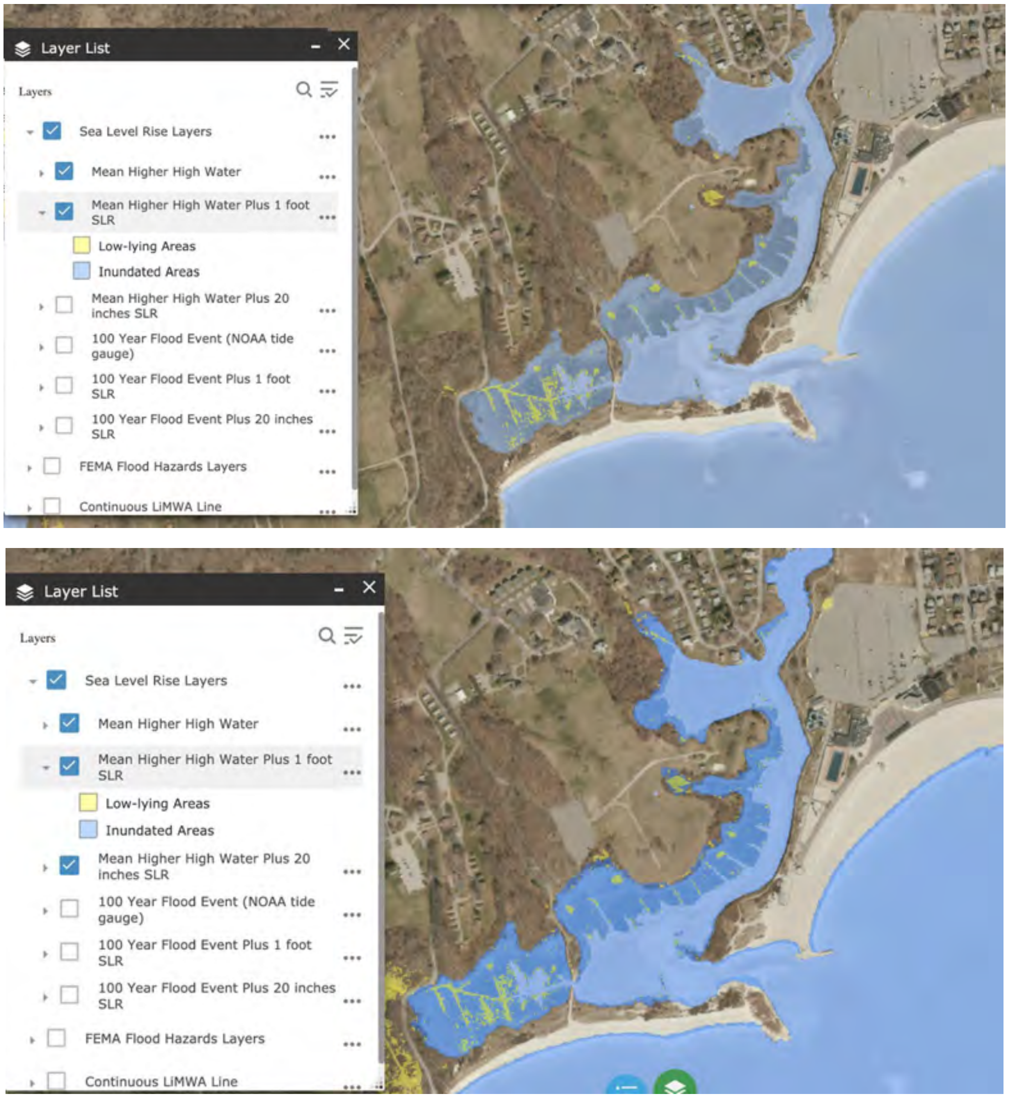


Figure 3

Source: Long Island Sound Integrated Coastal Observing System (LISICOS)

With the Long Island Sound Integrated Coastal Observing System, or LISICOS, Connecticut Shoreline Sea Level Rise Viewer, the projected high tide with 1 ft of SLR (similar to projected patterns from the predictions of 2030 SLR in Figure 2) and the projected high tide with 20 inches of SLR (about 10 inches less than projected 2070 SLR) follow patterns of increased land coverage of sea level rise. There is a shift inland in land affected by high tides with sea level rise from 2030 to 2070, indicating a trend of increased land affected. In Figure 3, the projections for sea level rise are shown for this change in land coverage for the different parts of Waterford Town Beach and depict how they may affect areas listed below:

Alewife Cove:

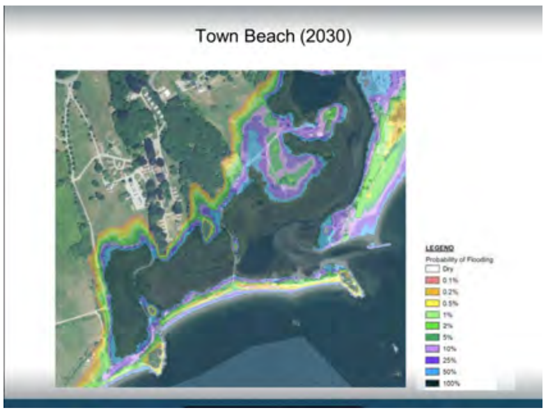
Looking at the projected maps for SLR, we can see that the current tidal inlet from Long Island Sound to Alewife Cove will cover a larger area with increased amount of inundated areas after inland after just 1 foot of sea level rise (a little over the projected sea level rise for intermediate SLR in 2030 from Figure 2).

Marshes:

With SLR, we expect the current marsh to become more regularly flooded and the area surrounding the marsh to become transitional salt marsh (SLAMM) by 2055 with .74 m of SLR. This will be further discussed in the marsh migration chapter.

Walkway & Restrooms:

The path from the parking lot to the beach will be affected by sea level rise and high tide flooding in the coming years. The path is surrounded by marsh, making relocation difficult.



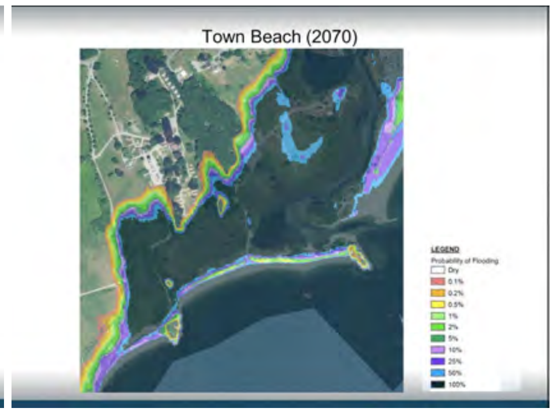


Figure 4 *Figure 5*

Source: Kleinfelder for “Climate Change Risk Vulnerability, Risk Assessment and Adaptation Study, Waterford, CT”

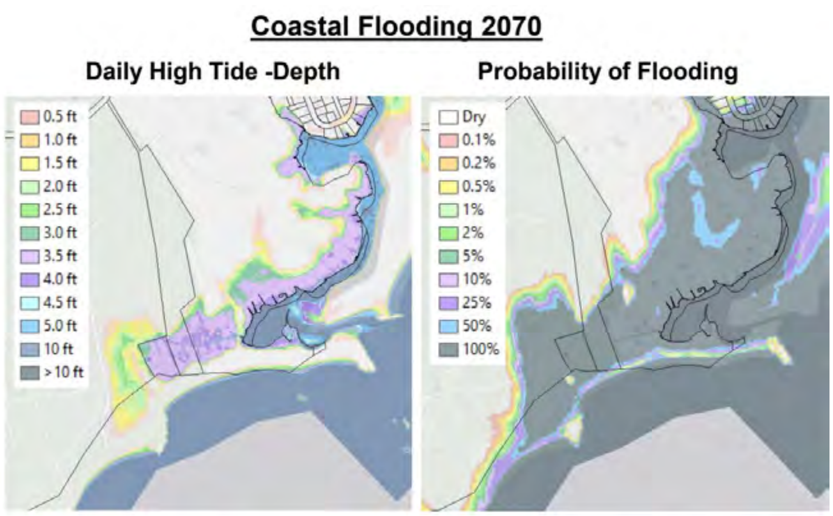


Figure 6

Source: Kleinfelder for “Climate Change Risk Assessment Study” Presentation”

Figures 4-6 depict coastal flooding predictions for Waterford Town Beach at both 2030 and 2070, showing a general trend for increased vulnerability in highlighted areas over time.

2.3 Strategies for mitigation of long-term impacts of rising sea levels and recommendations addressing sea level rise issues

Barriers or seawalls

Many beach communities have already implemented seawalls or levees as a method of protecting coastal development, as they have been used for centuries to protect homes, facilities, and other infrastructure. Even the slightest increasing sea level rise poses a risk to costing high amounts of money and ruining property, so a rather immediate and quick solution such as a seawall could solve the issue. While seawalls and other types of coastal armoring structures are effective in temporarily protecting spaces humans use and water supplies, there are many potentially harmful different effects of sea walls that must be considered. With sea walls, the potential effects include but are not limited to placement loss (where the beach area under the structure is lost); major physical changes to sand accretion and natural beach migration from sea level rise; limited public beach access; less aesthetic appeal and beach habitat for shoreline birds and coastal flora and fauna; and different economic impacts (Melius 8, 9). While seawalls and other forms of armoring are an option, there can be detrimental effects long-term for beach ecology, habitats, wetlands, beach recreation, and more (Melius 3-41).

Sand accretion measures

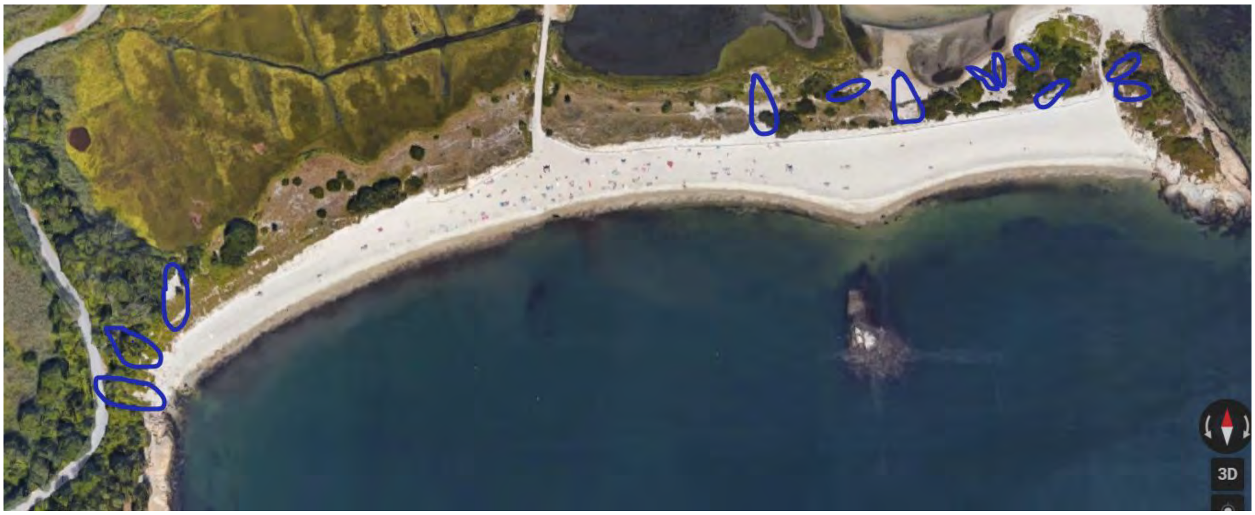
There are several options for promoting sand accretion to stabilize dunes and combat sea level rise. Our recommendations include: beach nourishment, sand fencing, and planting of vegetation.

Beach nourishment

Beach nourishment involves importing sand from another location to help reduce the effects of erosion on both the beach and dunes. As coastal storms increase in both intensity and frequency, shoreline erosion may occur at a much faster rate depending on the track of the storm. Waves with high energy that move farther onto the shore pull loose sand back into the water where it deposits further offshore in deep water. Adding sand back to the shore is a potential short term solution that will require renourishment based on erosion patterns (UCSB, 2019). Sand can be obtained from the lower berm of the beach through a process called beach scraping or by importing sand from an outside source. Beach scraping moves sand from the intertidal zone to the dunes or upper beach. Moving this sand can change the offshore bathymetry and increase wave energy and is therefore not a recommended strategy. Importing sand will require an analysis of current sand to ensure the grain size is consistent.

Figure 7 (left) and Figure 8 (right)

Basemap: Google Maps



Basemap: Google Maps

This image above is a diagram of where footpaths have been observed during our site visit.

Sand fencing

In past beach management, Waterford has repeatedly installed and restored sand fencing. We recommend extending and restoring the sand fencing along the entire beach. The existing fencing has proven successful for trapping sand and restoring frontal dunes. With the dunes building in front of the fencing, there is risk of damage by foot traffic. During our site visit, we say many footprints through the frontal dunes where beach grass is beginning to grow. Increasing signage and adding string fencing in front of the current fencing may help reduce future damage.

In Figure 8, we identified important sections to consider adding sand fencing (shown in red) and string fencing (shown in blue). A lot of the sand fencing on the Alewife Cove side was damaged and there were several footpaths crossing over the dunes.

Beach grass planting

We also recommend the **annual planting** of *Ammophila breviligulata* (American Beachgrass) (See Figure 9). Beach grass has many favorable qualities in terms of dune restoration and protecting against erosion. It has a deep root system to anchor the plant, a quick establishment rate, and traps wind-blown sand with its leaves (Mass.gov). As sand accumulates, beach grass will continue to grow and spread, continuing the stabilization process.

To encourage plant growth, beach grass should be planted in early spring in areas along the dune system that are currently bare. (North Nantasket Beach Management Plan, 2012). The Cape May Plant Materials Center (NJPMC) provides native beach grass specific to the Northeast region as well as local/regional nurseries. The vegetation has the highest chance of success when it is not disturbed. Signage and public outreach can help reduce human foot traffic through the dune area.

Rosa rugosa (Beach rose) is an invasive species that is prominent in beach dunes. As shown in Figure 10, the plant has branches covered in sharp thorns. While beach rose can help stabilize sand and prevent foot traffic through sensitive areas, we would not recommend further planting of this species. As an invasive plant along the coast (CT Invasive Plant website: https://cipwg.uconn.edu/wp-content/uploads/sites/244/2018/12/CT-Invasive-Plant-List-2018Scientific-Name.pdf) it presents a risk of outcompeting native vegetation.

Figure 9

Figure 10

Living shorelines

Living shorelines both restore and create a layer of natural habitat to reduce erosion. A living shoreline works to reduce erosion, absorb runoff, and maintain a balanced ecosystem for organisms on land and in water.

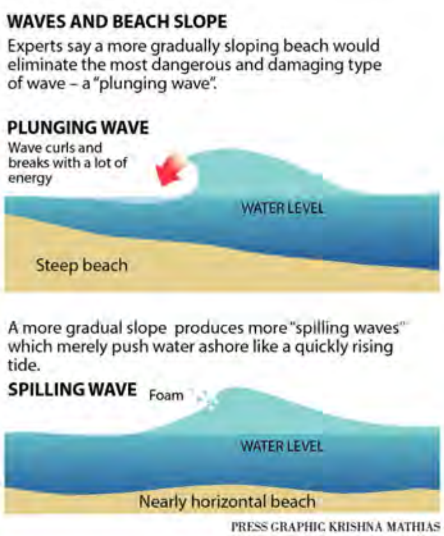
These shorelines are made up of vegetation and biodegradable material and can be tailored to the specific needs of each beach. Living shorelines provide a nice alternative to ‘hard’ shoreline stabilization methods such as seawalls or bulkheads, and provide numerous benefits such as nutrient pollution remediation, fish habitat provision, and buffering the shoreline from waves and storms. Living shorelines are also known to store carbon (or carbon sequestration), essentially keeping carbon out of the atmosphere.

Some examples of living shoreline techniques that are permitted in New England are sand fencing, slope flattening, coir logs, and reef balls.

Figure 11 (top), Figure 12 (bottom)

Reef balls: mimic the function of a coral reef by providing habitat for aquatic species (oysters, barnacles, etc.), decreasing wave energy, and reducing erosion. (Lambeck, 2016)

Implemented at Stratford Point, CT



Slope Flattening/Grading: using sand to create a more gradual slope.

Figure 13 (left), Figure 14 (right)

Coir logs:

2013

2016

A UConn graduate student, Jason Zylberman, created a Living Shorelines Site Suitability Tool to determine site potential for living shorelines along the Connecticut coast. The tool examines fetch, bathymetry, erosion history, and marsh data. Fetch is the distance wind travels uninterrupted over water in one direction. Bathymetry measures the depth of water near the shoreline. An ideal site for a living shoreline will have a low fetch (low wave energy) and shallow waters with a gradual slope (Zylberman 2015).

The parts of Waterford beach included in the study were found to be suitable for beach and marsh enhancement (Figure 15). Beach enhancement includes beach nourishment and dune restoration to protect the shore. Marsh enhancement focuses on adding new marsh vegetation and creating room for marsh to expand.

Figure 15

(Zylberman 2015)

Improved Methods of Beach Maintenance

Beach raking

If the practice of beach raking is used as maintenance of dunes, as grooming, raking, sieving, or cleaning sand, we suggest specific measures to be taken. Beach raking may be necessary for the economic, safety, and sanitary benefits of a beach but there must be a balance made between properly maintaining the beach and preserving ecological stability as well as dune effectiveness. Mechanical beach raking usually is deadly for beach plants. It is suggested that marine debris in the form of waste left behind by beach guests or man-made waste washed up on the beach from the ocean be taken care of and removed. Since marine debris has no value to the beach, it is suggested that the beach staff or small groups of volunteers can be properly trained in how to remove marine debris by hand without disturbing natural plants. However, removing other forms of possible beach material like larger rocks and seaweed (wrack), should be avoided as much as possible. Wrack can be necessary for many ecological reasons as well as beach preservation/building while larger rocks help slow down the process of eroding beaches and add to volume of beaches. If removal of these two types of beach material must happen for aesthetic and safety reasons, it must be performed with minimal negative impact (Berman 1-3).

Avoiding Off-Road Vehicles (ORVs)

The use of any vehicles on beaches can have negative effects. The weight and movement of these vehicles can crush roots of plants as well as burrowing crustaceans to a depth of 8 inches. It is recommended that ORV driving is at least 10 inches away from where there is a distinct increase in slope of a dune (otherwise known as the toe of a dune, or where the Spring High Tide Line usually is). The crushing of root systems for beach vegetation may be fatal for dune shaping/preservation, as mentioned before (Berman 1).

Chapter 3: Marsh Migration

3.1 Anticipated marsh migration

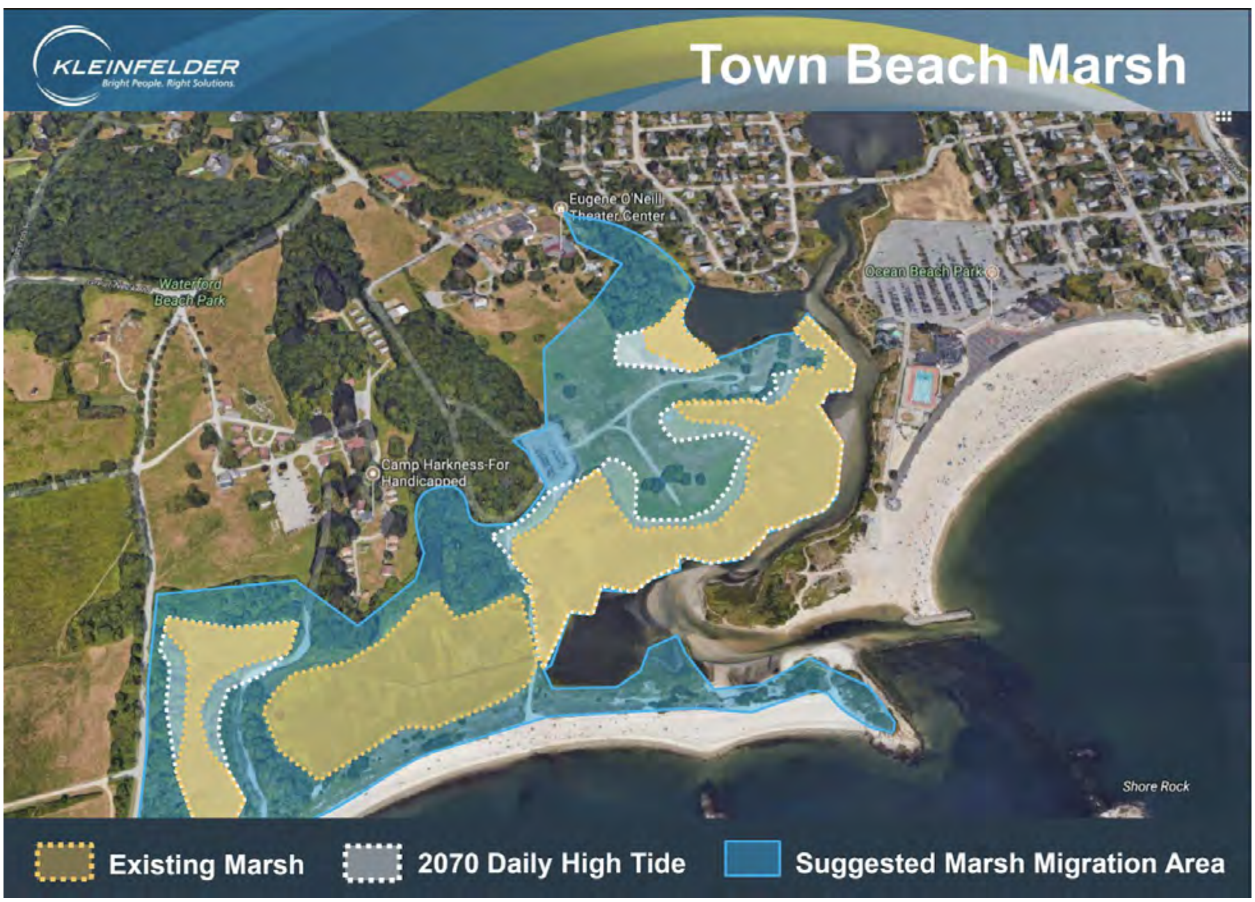
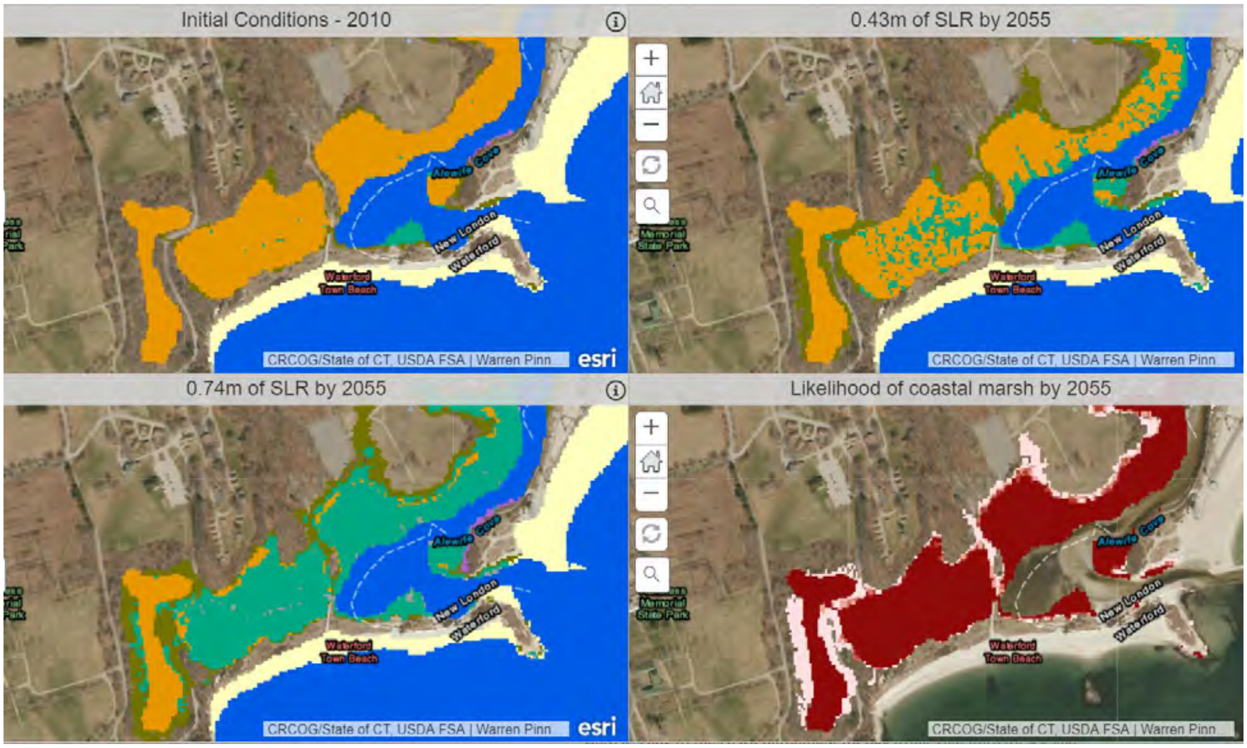


Figure 16



Legend

Figure 17 *Source: SLAMM Viewer, 2010*

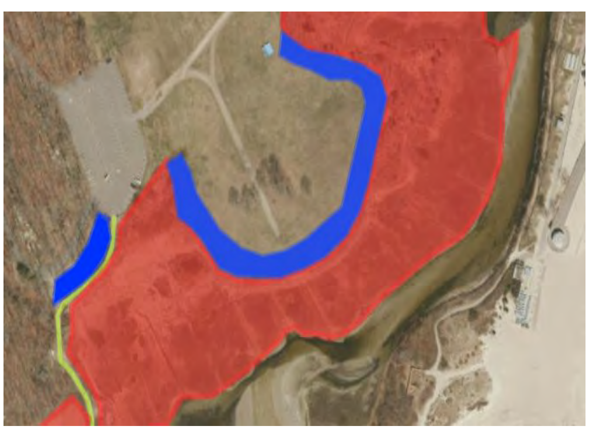
3.2 Recommendations for protection of existing marsh from erosion and impacts, hydrologic impacts of SLR

The slightest increase in sea level rise can have huge changes and potential complications for the marsh ecosystem. When the sea rises, the frequency and duration of tidal flooding will increase throughout the marsh causing low-lying areas of salt marsh to potentially become inundated. Areas of low marsh may transition to intertidal flats causing the boundary of low marsh and high marsh to shift. Similar changes will occur in the upland margin. Figure 17 is an image taken from the Sea Level Affecting Marshes Model or SLAMM Viewer. This model is used to predict potential changes in marsh habitat as sea level rise increases. The top-left photo shows the initial conditions as of 2010, outlining the area in orange where the marsh is irregularly-flooded. The second two images, top-right and bottom-left, show the same outline of irregularly-flooded marsh in 2055 with two possible sea level rise predictions: 0.43m and 0.74m. With this change we first see an increase in regularly-flooded marsh as well as areas that are predicted to be transitional salt marsh. With the second sea level rise prediction, we see a more widespread increase in regularly-flooded marsh. The last image outlines the likelihood of existing coastal marsh in 2055 in red, as well as the predicted marsh migration with regard to the potential conditions at that time in light pink.

Increased tidal flooding at higher elevations will cause tidal marsh vegetation to grow farther inland where elevation allows, replacing the upland plants, as a result causing marsh migration. There are only two ways in which the marshes can survive the impending sea level rise: an increase in marsh surface elevation and migration to higher ground. This of course, all depends on the rate at which the sea level rises. If the sea level rises faster than sediment and plant material can accumulate in the marsh, the marsh surface will become flooded more often, eventually causing the plants to die off, resulting in complete loss of marsh area. This would cause a range of ecological and economic impacts. Before this happens, there are a number of ways in which we can maximize the potential for marsh migration in the area.

When features such as rocky cliffs, pavement, and seawalls or barriers are in place lying adjacent to a tidal marsh, they actually prevent the tidal marshes from migrating inland as the sea rises. Permanent features reduce potential to persist in the face of sea level rise, so if in place, structures could be modified or removed to accomodate for marsh migration (if elevations allow for it). Restoration of land areas that are currently developed could help accommodate marsh migration. Restoration of tidal flows for marsh systems that are currently tidally restricted because of bridges or culverts is also extremely beneficial.

The most direct way to protect and promote the existing marsh, as well as marsh migration, is to let the marsh migrate inland. We recommend setting aside area based on future migration patterns. One way that has proven effective is reducing the area in which mowing occurs around the existing marsh. Changing the current mowing practices to allow room for the marsh to migrate can help protect the current and future marsh. We propose that approximately 15 feet inland (see Figure 18 below) be set aside for future marsh migration efforts therefore current mowing practices should begin to exclude this area.



Recommended Changes to Mowing Practices
Red: Existing Marsh
Blue: Suggested Area to Cease Mowing

Source: National Geographic

Figure 18

For more specific recommendations regarding protection of existing marsh migration we suggest implementing a marsh and wetland monitoring program. This data could be collected with assistance from volunteers or students from local schools. Example of tasks could include setting up permanent transects through the marshes to measure changes and creating an inventory of species supported by marsh habitat. This will not only serve as a way to increase public awareness of wetland values and protection efforts but also help the community support this as well. More broadly, it is important to support research into marsh migration and facilitate interaction among all parties involved in marsh-migration efforts along the Northeast coast. Another approach, with the appropriate resources, could be developing specific web-based resource about marsh migration in this particular region for the public, agencies, and organizations to learn and share information.

3.3 Evaluation of accretion rates required to keep pace with SLR projections and strategies to enhance existing marsh

The current existing marsh is expected to experience regular flooding by 2055. With current sea level rise predictions, the marsh will naturally migrate inland where elevations allow. A case study in New London, CT predicts the marsh will migrate between .59 to 1.57 ft by 2030 and 1.4 to 5.97 ft by 2070 with no accretion (NOAA, 2019). This range varies based on predictions about sea level rise, flooding, and erosion.

Thin layer deposition is a short-term solution that adds a layer of soil to a marsh surface to raise the elevation. It is important to determine where marsh is being lost and the desired thickness of the marsh to compete with sea level rise. Narragansett, Rhode Island supported several marsh enhancement projects which included a combination of thin layer deposition, placing clam shell bags along the marsh edge, and replanting vegetation (Northeast Ocean Council). The clam/oyster shell bags help to defend against erosion and hold the sediment in place, while replanting accounts for any vegetation lost under the added soil. These projects are expected to successfully slow erosion rates and marsh loss. For the marsh closest to the shore, the dunes and beach are the first line of defense against sea level rise. Restoration of the dunes and planting beach grass can help protect and enhance the marshes behind them.

3.4 Monitor protocol and database to track marsh community

With the transition of marshland naturally migrating inland, it is important to evaluate and track who and what these geographical changes affect. With that, it is recommended that a monitoring protocol/database is established in order to track different facilities and infrastructure that this marsh migration will impact as well as the users of those facilities.

Suggestions for this:

- Setting annual dates for testing
- Create potential list of different marsh migration scenarios with list of who each scenario affects
- Warn residents/owners beforehand, work on outreach and information accessibility for nearby residents
    - Flyers, TV announcement, phone calls, door-to-door, town meeting
- Brainstorm and communicate potential options for residents/owners
- Establish plan/create options of resistance or alternative accommodations for them

3.5 Recommendations for invasive species control

The current marsh is expected to experience regular flooding by 2055 (see Figure 17). The change in flood regime will affect the vegetation that will survive. When water levels rise, water ponding occurs on lower elevation marsh which kills vegetation. *Spartina alterniflora* (Smooth Cordgrass) is dominant in regularly flooded salt marsh while *Spartina patens* (Saltmeadow cordgrass) is dominant in higher elevation marsh with irregular flooding (Adapt CT, 2019).

Phragmites australis (Common Reed) is an invasive species commonly found in wetlands (Figure 19). Phragmites can spread rapidly by growing new shoots from underground rhizomes and easily outcompete native species (Wolfe, 2018). Phragmites grows in higher elevation salt marsh and upland marsh borders as it cannot survive regular flooding of saltwater. Therefore, if no measures are taken to protect salt marsh and reduce flooding, the *phragmites australis* may naturally be eliminated. However, it also has the potential to migrate inland. Accretion measures such as thin layer deposition do put the marsh at risk of further *phragmites australis* invasion.

Current strategies being used to curb the species are herbicide, hand-pulling/cutting, and black plastic. Aquatic herbicides requires multiple years of spraying for maximum effectiveness. Typically the plants are sprayed in the late summer or fall and then mowed a month later to encourage decomposition (Wolfe, 2018). Hand-pulling or cutting also must be repeated annually (typically at the end of July) and can be more labor intensive. The rhizomes can grow deep into the ground, making hand-pulling ineffective as the plant can easily regrow. After the *phragmites australis* has been cut, putting large sheets of black plastic over the stand will help kill off the remaining plants. The plastic is held down by rocks and is most effective in areas with direct sunlight that can heat it (CIPWG, 2019).

Figure 19

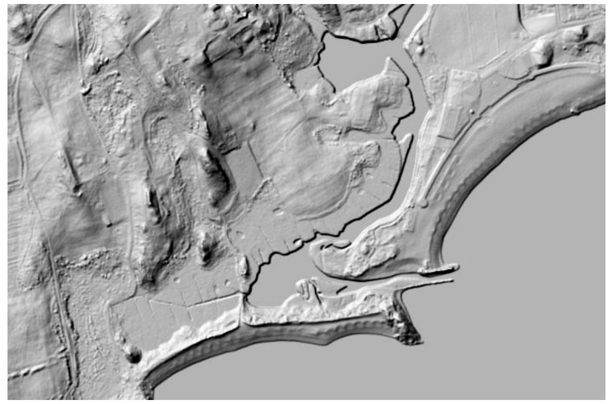
Chapter 4: Stormwater Management

4.1 Review of existing stormwater drainage patterns

Figure 20 (top left), Figure 21 (top right), Figure 22 (bottom)

CT ECO Contour Map

CT ECO Hillshade Map



Potential reasons for pooling of stormwater include: the water table is too high and soil is already saturated, the soil is compacted or impermeable, low elevations/improper grading, or thatch/plant type.

It is important to note that due to our lack of knowledge of the water table, this location makes it difficult to propose any subsurface stormwater management solutions with confidence. In Figure 22, we identified the sections of the park that currently experience pooling during and after storm events.

→ Contour maps use contour lines to connect points of the same elevation. They allow us to visualize topography of the landscape through a map using the contour intervals (distance between lines) to decipher difference in elevation. The closer the lines are together, the steeper the elevation.

→ Hillshade maps also depict a grayscale 3D representation of a surface using the sun's relative position to provide shading and depth to the image. This map is another way of visualizing the area being dealt with with regard to elevation, hills, and slopes, *4.2 Areas for stormwater collection*

After review and assessment of current existing stormwater drainage problems, we have come to the conclusion that nothing should be done until a more in-depth study is completed on the stormwater issues at hand. Further evaluation of the areas of concern, changes in slope, the water table, infiltration and evaporation rates would be extremely beneficial in deciding what solution will be most feasible and effective. Given our knowledge of this area as of now, we have preliminary suggestions for the time being until more is known.

First, regrading the area and adding more soil might assist in re-directing the water as well as absorbing the water. Again, because the land is so close to the water table, this solution alone will not solve the problem. Regrading in combination with shallow bioswales have the potential to increase chances of stormwater drainage. Shallow bioswales allow for the collection, conveyance, filtration, and infiltration of stormwater. These bioswales could be located either along the parking lot or on the sides of the hill could assist the redirection of water away from the center of the park (See Figures 23 and 24 for reference of possible aesthetic and park options for bioswales). We suspect minimal water coming from the parking lot, but with the amount of water present, it might benefit. Prior to constructing a bioswale, stormwater flow needs to be more closely evaluated in order to avoid ditching, damage to the plants, and erosion problems. Biowales also decrease the amount of available green space throughout the park.

Another possibility would be converting the mainly flooded areas of the park into a pocket wetland. Pocket wetlands are designed to be shallow marsh systems to control stormwater volume and facilitate pollutant removal. These constructed stormwater wetlands temporarily store runoff in shallow pools while supporting conditions suitable for the growth of wetland plants. Advantages to a pocket wetland include: relatively low maintenance costs, enhanced aesthetic & recreational benefits, wildlife habitat, and high pollutant removal. Disadvantages include: more land requirement than other possible management practices, higher construction costs, difficult to maintain during potential dry periods, potential breeding for mosquitoes, safety issues for pedestrians, and the potential to act as a decoy wetland (intercepting breeding amphibians moving towards vernal pools).

Lastly, we looked into the construction of a french drain. A french drain is a gravel filled trench with a perforated or slotted pipe attached used to direct surface or groundwater away from a specific area. In doing so, surface level water gets directed to the lowest point and seeps through the surface level gravel into the drain. This gravel also works to block passage of excess debris. French drains differ from typical surface drains because they collect water over the entire length of the drain as opposed to just one particular spot. Slope is essential when considering installation of a french drain, downhill course must be downhill enough to keep water running along to intended destination.

Figure 23 Source: Project Groundwork

Figure 24 Source: Community Planning & Development

Chapter 5: Facilities / Park Management

5.1 Facilities impacted by sea level rise and proposed adaptation strategies

From collected on-site data and observed sea level rise projections, we have identified facilities of the beach and park that may be impacted as well as researched potential adaptation strategies.

- Trail:
    - Relocate first section of path closest to parking lot further inland
    - Proposed Strategy: Boardwalk
    - Boardwalks are commonly used in wetlands as they are aesthetically pleasing and do not require heavy equipment. Boardwalks can be raised to accommodate flooding and sea level rise. If necessary, the material used to construct the boardwalk can be modified to allow for vehicle travel.

    - This link: https://www.aswm.org/pdf_lib/2_boardwalk_6_26_06.pdf , provides an outline of the boardwalk construction process and if a boardwalk is compatible with your landscape
- Bridge: In viewing 1 ft of sea level rise projections, the newly constructed bridge connecting the path from the parking lot to the path to the beach appears as it would be inundated.
    - Proposed Strategy: As there are limited options as to what can be done about the potential of the bridge being impacted by sea level rise, it is suggested that there should be expectations for this to occur in the future and periodic checking of the rock infrastructure around the bridge. With the newly built bridge put in place, concerns about this area being damaged by sea level rise, high tide flooding, and storm surges are significantly reduced.
- Current Beach space
    - Proposed Strategy: Continuous check-in of beach state including annual data collection of beach loss, if possible. Implement recommended dune enhancement and maintenance, incorporate other beach protection measures mentioned to maintain as much recreational and beach space as possible.

The following facilities on the beach and park are not directly impacted by sea level rise but may be affected by projected high probability of flooding due to future sea level rise (see Figures 4, 5, 6).

- Volleyball court
    - Proposed Strategy: Leave as is, continue to maintain.
- Picnic areas
    - Proposed Strategy: Leave as is, continue to maintain.
- Parking lot
    - Proposed Strategy: If plans for repaving the parking lot exist in the near future, it could be crucial to encourage well thought-out parking lot design and material types in order to do so.
- Restrooms
    - Proposed Strategy: Coastal groundwater tables are expected to rise which will decrease the available volume of soil below the drainfield of a septic system. This can reduce the drainfield's ability to treat wastewater. Potential monitoring techniques include: measuring changes to the groundwater table and conducting ground-penetrating radar (GPR) surveys for drainfields (Cox, 2019).
- Electricity outlet near open park
    - Proposed Strategy: With limited data gathered about this electricity box, no specific strategies can be proposed, but it is suggested that more research in how this electricity box will be affected should be done.

5.2 Small craft launch to cove to eliminate unwanted footpaths through marsh and dune systems

There is currently only one sign for the kayak launch and a partial gravel path to Alewife Cove. Unwanted paths are being created through the marsh and dune systems due to foot traffic. Blocking off dunes with snow fencing and adding clear signage can help eliminate future destruction. It is also recommended to add signage for the kayak launch at the parking lot, where kayakers will be directed immediately. If there is substantial interest from kayakers, we recommend adding amenities such as a public storage unit and offering kayak rentals. A fee can be charged for residents to store their personal kayak or rent one.

The current location of the canoe launch is of low concern for flooding and sea level rise and provides a direct gravel path from the parking lot. There is open space available near this launch for a potential storage unit for kayaks and canoes. We observed some erosion occurring along the edges of the cove including near the launch. Coir logs, both inexpensive and biodegradable (Figure 13 and 14), can be added to prevent further erosion.

5.3 Signage and public education

→ Dune signs - goal is to stop walking on the dunes

We suggest more signage for advancement of public knowledge regarding protection of the dunes to be displayed along the entire beach, especially surrounding areas where the dune footpaths and sand fencing are located. These signs could provide pedestrians, as well as beach users frequent and adequate information regarding why the dunes are there and more importantly why it is crucial they must stay there. These signs should continue to alert the public as they are now, while also educating by doing so. Waterford has one of the best examples of an intact dune system in the state.

→ Marsh signs - goal to educate people on marsh migration

Signage near or around areas of marsh could also benefit the public, especially in regards to the advancement of marsh migration. Given mowing practices are pushed away from the current marsh, signage regarding why this has been done would be beneficial for the public to realize they too should refrain from interaction with the marsh. Signs could include benefits of the marsh and how the beach and park would be effected without the marsh.

→ Stormwater management

Areas where stormwater management is implemented would also be good opportunity for educating the public on ways in which stormwater runoff is actually very important and impactful. Signs could include before and after pictures of the area. This sign has potential for adding in ways in which the public can help reduce effects of stormwater runoff in relation to themselves.

→ Living classroom - goal to educate the youth

Designating certain areas of both the beach and park for a “living classroom”. A living classroom is designed to inspire young people to achieve their potential through hands-on education utilizing natural sites like such. These education purposes could also help further the implementation and development of signage and advancement of public knowledge. Living classrooms could also be a great way for the youth, residents, and all who participate to learn about all the unique features Waterford Town Beach and Park have to offer and to pass along that information for years to come.

→ With all signs, we recommend the inclusion of all residents that might visit the beach, such as multilingual residents to ensure all-inclusive advancement of public knowledge. Inclusive signage could be as simple as use of pictures (such as before and after), as well as diagrams, to help implement this.

5.4 Preservation of natural resources functions balanced with public recreational use and enjoyment

As Waterford beach is a town park and beach, the approximately 80% of residents and 20% non-residents using the beach during the season have a stake in the access to these beach and park resources. With fishing, supervised swimming, picnic areas, restrooms, walkways, summer concerts, private parties, and beach access amongst other facilities, Waterford Town Beach is a highly valued visitor space for the public to enjoy.

Ways to maintain beach and park natural resources include addressing many of the potential issues with sea level rise and marsh migration affecting facilities, as suggested. Access to the beach itself (and therefore to recreational beach activities), through walkways and the bridge while maintaining minimal plant and species damage should be points of focus. Another main point of focus to address is the effect of stormwater pooling on availability and use of park space. Current lack of water drainage and pooling of stormwater in the park space should be a priority to address.

Continuation of beach resiliency practices such as dune restoration efforts will be an essential component to maintaining the conditions and protection of the beach and therefore public access to the beach.

Chapter 6: Conclusion

Summary of recommendations

- **Sea Level Rise Mitigation:** Consider beach nourishment, living shoreline techniques, and dune enhancement.
- **Walking Path Suggestion:** Consider elevating/filling low points of the path. Future consideration of boardwalk could be also be beneficial.
- **Dune Protection:** Support dune stability by adding signage, rope fencing, and educational pieces about dunes.
- **Dune Restoration:** Continue the build up and growth of dunes by adding sand fencing and planting beach grass.
- **Protection of existing of marsh & promotion of masrh migration:** Refrain from mowing 15 feet inland from the existing border of the marsh.
- **Stormwater Management:** Further evaluation of drainage patterns of stormwater and feasibility of management practices required. Preliminary suggestions include: land regrading, shallow bioswales, pocket wetlands, and French drains.
- **Kayak Launch**: Add more signage, use coir logs to reduce erosion, and create a more defined path.
- **Public Education**: Incorporate residents, especially students through volunteer projects and living classrooms with educational signage.

Future studies should include a coastal processes test that measures:

- Height of water table
- Tides & Currents
- Erosion patterns
- Soil analysis
- Impacts of Jetty & Groin
- Geological history

Throughout this report, all recommendations share the same goal; the preservation and continued public enjoyment of Waterford Town Beach and Park. This beach and park draws the attention and care of people with its natural beauty and impressive expanse of dunes, tidal marsh, and open park space/facilities. With the current and future concerns confronting this area, changes to current care practices should be considered, as well as the introduction of new recommended beach and park resiliency strategies. As a place the community shares, these steps should be created for and by the stakeholders regarding the quality and conditions of Waterford Town Beach and Park. Mitigation and adaptation are most effective when community members stay informed, get involved, and share ideas. We hope that the town will continue discussion of how to protect and improve the existing natural resources of the beach and promote future studies drawing advice from experts in engineering, science, and planning. Regional collaboration with other vulnerable coastal communities is an efficient way to try different resiliency strategies, exchange ideas, and implement the best possible practices. We hope Waterford Beach will continue to be preserved and enjoyed for many years to come.

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