Building Coastal Resiliency at Misquamicut Beach Report:

Design Solutions for a Changing Landscape

LAR 445 Spring 2017
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(Image from Google)

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INTRODUCTION

The main objective of the Misquamicut Beach Coastal Resilience Project was to generate creative design solutions for the community that mitigate damage to structures, caused by increased storm surge and inundation from sea level rise.

We aimed to protect existing houses from extreme damage in future storm events and ease the transition as water rises, while also maintaining the community's economic viability. Many of these design solutions include different forms of greeninfrastructure and stormwater management methods placed in key areas to divert flow away from structures. The master plan initiates a shift in the community, from beach tourism to eco-tourism. Improvements to the public realm stimulate the economy; temporary pavilions surrounded by scenic marshland allow for pop-up businesses to operate in Misquamicut despite massive storm events, and accessible kayak launches and extensive scenic trail systems create even more naturalized public space and activity throughout the town. Coupled with strengthened ecosystems and wide natural buffers, Misquamicut's community is prepared to transition with the inevitable changes of the landscape.

This project was a partnership with senior URI ocean engineering students and senior URI resource economic students. We collaborated with members from the University of Rhode Island Coastal Resources Center (CRC), as well as the Rhode Island Coastal Resource Management Council (CRMC). Misquamicut's Coastal Resiliency project was about using the alliance of many disciplines to create an integrated master plan that addresses resiliency concerns looking forward. By sharing the research and information each group collected throughout the semester the final design was able to meet the needs of the community in the most vulnerable areas, while also keeping economic feasibility in mind. The following report summarizes the work the landscape architecture students did in conjunction with the analysis and research of ocean engineering and resource economic students. The report will include an executive summary, an extensive site analysis, a master plan and design solutions, followed by conclusions and learnings gained from this multidisciplinary process.

(Image from Google)

EXECUTIVE SUMMARY

This project was a semester long endeavor for senior landscape architecture students, using our own site analysis as well as site information and research collected from the work of the resource economic and ocean engineering students we collaborated with.

We started the project with a site visit. As a class we walked through the history of the site by looking at how the community has responded to and recovered from past storm events. We looked at dune renourishment projects on Misquamicut Beach, and toured neighborhoods that had structures in the midst of being raised on concrete stilts above the flood zone. We met with Janet Freedman of CRMC and Theresa Crean and Chris Baxter of CRC during these site visits, and with their help identified general threats and opportunities of the site. Landscape students then researched precedent projects from around the world that had similar site components and issues. These precedents allowed us to see how other landscape firms around the world manage sites affected by storm surge and sea level rise; some solutions we found were relevant to Misquamicut and stimulated new ideas within the class. Some of these precedents included:

- Galveston Bay, TX
- The Big U, NY
- Sea Change, Boston

We then analyzed sea level rise projection maps, storm surge projections, marsh vulnerability maps, topography, and ArcGIS mapping for the study area. We assessed the existing vegetation of the area and looked further into Misquamicut's history of devastating storm events to determine more site constraints and opportunities.

We collaborated with senior ocean engineering to identify the most vulnerable areas in the town. Ocean engineering students developed a process (Coastal Environmental Risk Index) to assess the amount of damage to individual structures in the study area from a 100-year storm event, with and without 7' sea level rise. Their work not only found the most susceptible neighborhoods, but also showed how drastically the damage intensifies with the addition of sea level rise, and demonstrated the need for innovative landscape solutions to plan for the future.

The work of senior resource economics students also informed our design decisions. The students examined traditional mitigation methods and the cost-benefit analysis of possible strategies, which gave landscape students an idea of how realistic an idea was, and if its efficacy would outweigh the cost of construction. They made projections for how the housing market in the area would change as the landscape changes, and if one's perceptions of sea level rise affects the market. The students also conducted surveys throughout the study area to examine how residents perceive coastal risk and value open space, and then placed a dollar amount on that perception. They monetized green infrastructure alternatives which proved to be an essential part of building resiliency in a community. The work that all three groups did created a datum for intense design work by the landscape architecture students while informing the decision making of the final project. The result of this process was an integrated master plan for the community that addresses resilience concerns looking forward.

The master plan is a vision for Misquamicut that incorporates naturalized public space and green infrastructure; proposed temporary structures, trail systems, and layered landscapes work together to benefit the community by protecting its residents and promoting eco-tourism. At the center of this design is a flow diversion program, designed to reroute flow away from structures and direct it back into the ocean after a storm event. Using existing waterways, floodplains, topography, and proposed streams and swales, stormwater is able to flood, infiltrate, and move through the town with minimal damage. A proposed Wetland Park is part of this diversion network; it is a system of elevated natural trails and sunken basins that are designed to withstand flooding in a storm. The wetland basins in the park fill with stormwater, and overflow is directed into a connected system of swales and floodplains.

The park, along with a kayak launch and temporary dune pavilions, transition the town's economy to be centered around eco-tourism. The pavilions, made of modular framing and lightweight plastic, create spaces for pop-up businesses, public events, live music, and outdoor furniture. It creates a gathering space on the naturalized beach but can be easily deconstructed and stored away during a storm event.

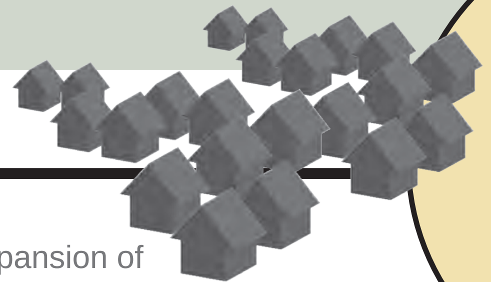
Layered landscapes and expanded native marsh buffers around vulnerable headlands and Winnapaug Pond naturally reduce surge, increase infiltration, and help to protect existing structures. The master plan includes 4 archetypal environments that will be implemented throughout Misquamicut – the beach, naturalized wetlands, the proposed Wetland Park, and the road. Layering native vegetation naturally shields homes from sea level rise and storm surge impacts.

The proposed design is both functional and attractive, integrating passive low-impact development with Misquamicut's unique identity.

HISTORICAL ANALYSIS

1662
Misquamicut is founded by 18 settlers (including John Babcock)

1894
Group of Westerly men purchase land to begin building cottages along the shore



Expansion of neighborhoods continues along the coast, density increases

1938 1944 1954 1991
Hurricanes hit Misquamicut

2012
Superstorm Sandy hits; Misquamicut is the most damaged town in all of Rhode Island

DEMOGRAPHICS

The population density is 12% higher than RI avg.
The median age is 9% higher than RI avg.

Approx. 21,000 residents
93.5% white
.92% black

Median household income - $59,279
Median home sale price - $260,000

Note: Homes are mostly small summer cottages in close proximity to each other

The Hurricane of 1938
Storm surge 14-18’
Killed approx. 100 people in RI

1944 - The Great Atlantic Hurricane
Category 3
Killed 46 people in New England

1954 - Hurricane Carol
200 homes washed away
Damage totaled $200 million
Killed 17 in RI

1991 - Hurricane Bob
Storm surge 5-8’
Caused extensive beach erosion
60% of all RI residents lost power

(Images from Google)

Atlantic Ave.

Shape of RI’s beaches changed dramatically, evacuation routes flooded and filled with sand

Misquamicut State Beach

Sand dunes were destroyed (84,000 cubic yards of sand were needed to restore the beach)

Two Little Fish Restaurant

500+ houses and businesses along the Misquamicut coast had significant water and/or structural damage

POST-SANDY

A process of:
Removing 3-6’ of sand from Atlantic Avenue
Cleaning sand before returning it to beach
Rebuilding Misquamicut’s protective dunes
Replanting dune grasses to stabilize replaced sand
Repairing structures damaged in the storm
Raising homes above base elevation (paid by FEMA grant)
Encouraging families to move further away from the water

Misquamicut is a community at risk;

It has developed as a densely populated area with structures built directly on the coast and along the inlet. The area has a history of large storm events that have had devastating effects on homes and businesses in the area, and yet the rebuilding process has not evolved to accomodate these events. More storms are to be expected in the near future and they are likely going to cause the same, if not more intense, destruction as in the past.

STORM SURGE ANALYSIS

HIGH DENSITY LAND USE

(Map by Cam Frecker)

(Source: StormTools)

LAND USE MAP

- Commercial
- Med/High Density Residential
- Developed Recreation
- Wetland

WATER CLASSES

- Low Intensity Use
  High scenic value
- Multi-Purpose Water
  Recreation
  Commercial
  Industrial
- Conservation
  Severe wave action
  Flooding and erosion
  Unsuitable for structures

CIRCULATION

- Experiences high volume of traffic in the summer months, especially on Atlantic Ave.
- Major roads sit in low lying coastal plain
- Homes on Western Headland only accessible by major roads

7’

5’

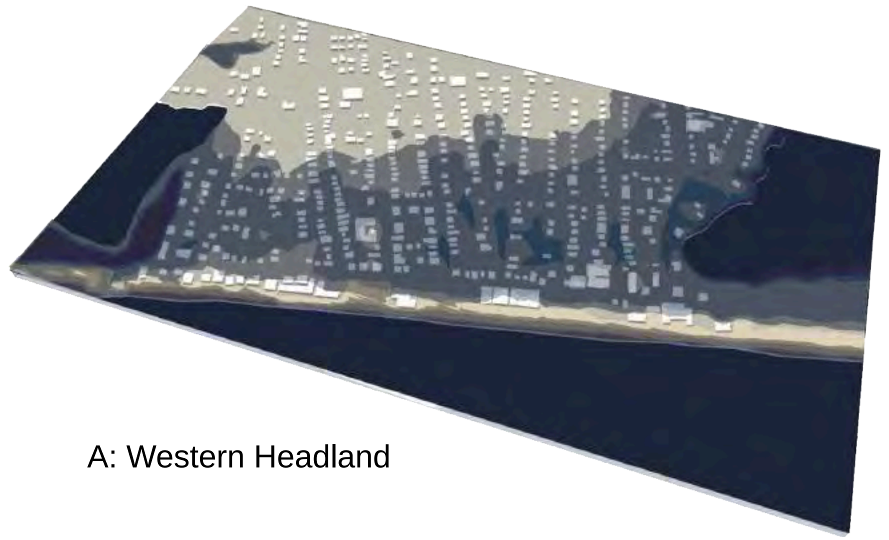
3’

2’

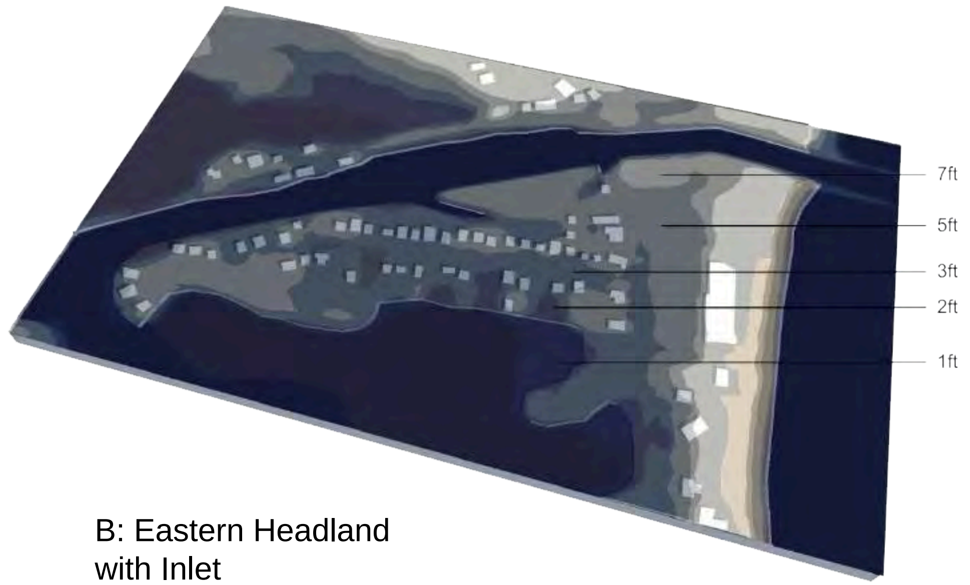
1’

PROJECTED SEA LEVEL RISE

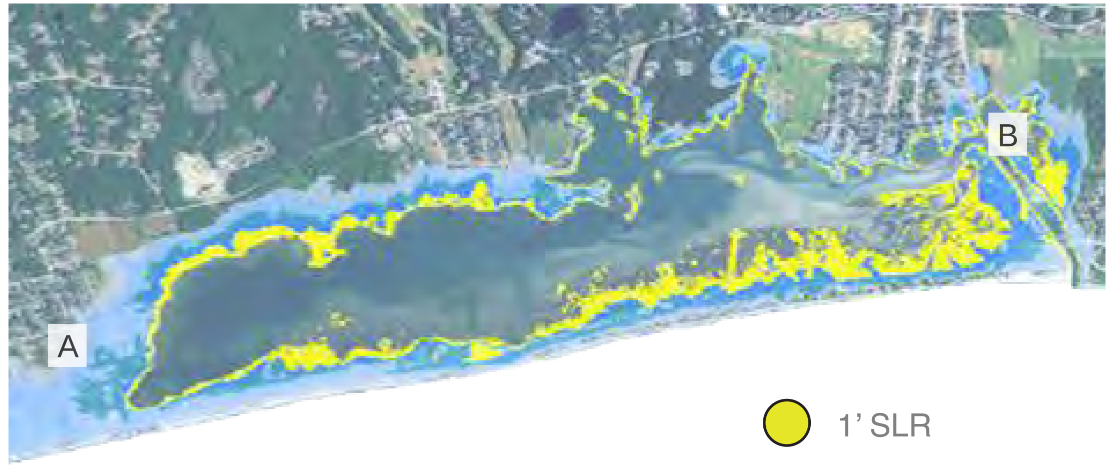
(Diagrams by Zack Driver)



A: Western Headland



B: Eastern Headland with Inlet



- 1’ SLR
- 2’ SLR
- 3’ SLR
- 5’ SLR
- 7’ SLR

PROJECTED SEA LEVEL RISE MAP

- Global sea level for the next 100 years is expected to rise at a greater rate than during the past 50 years (EPA)
- Studies predict that global sea level will rise between 6-10’ by 2100 (EPA)

These diagrams show the footprints of existing structures as well as existing topography on each of the major headlands (east and west). They are overlayed with colors that show how sea level rise is going to affect the town as water creeps inland – illustrating how drastically the landscape changes when confronted with only a few feet of rise. Misquamicut is located on a particularly flat and low-lying coastal plain. There are no hills or valleys to protect/divert water away from the community, and so it is extremely vulnerable to inundation from sea level rise (as shown here).

STORM SURGE ANALYSIS

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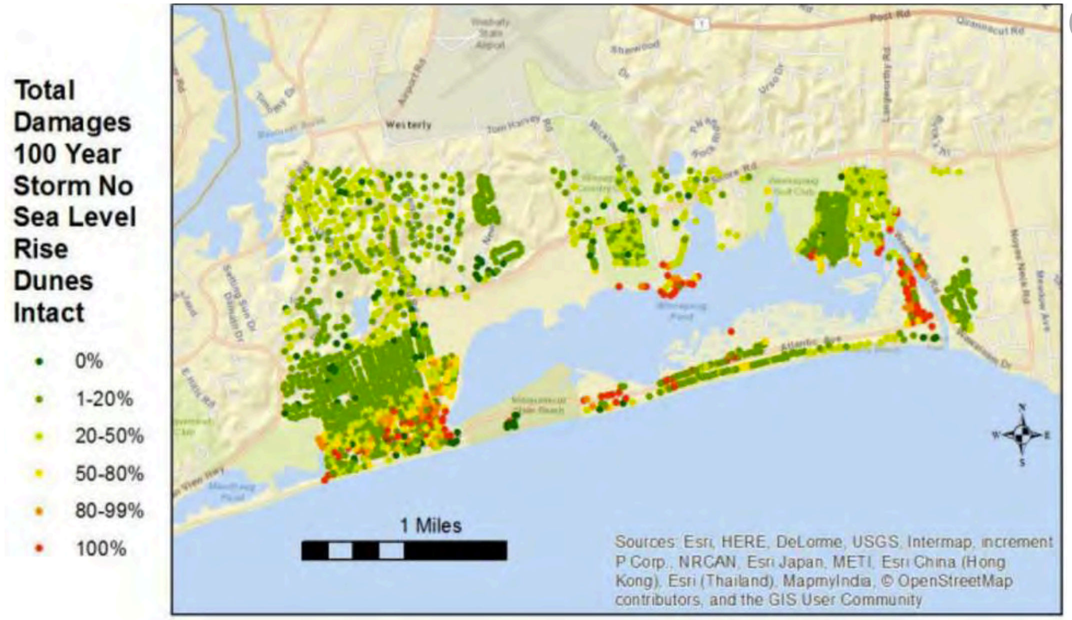
100 YEAR STORM (0 FT SEA LEVEL RISE)

(CERI, 2017)

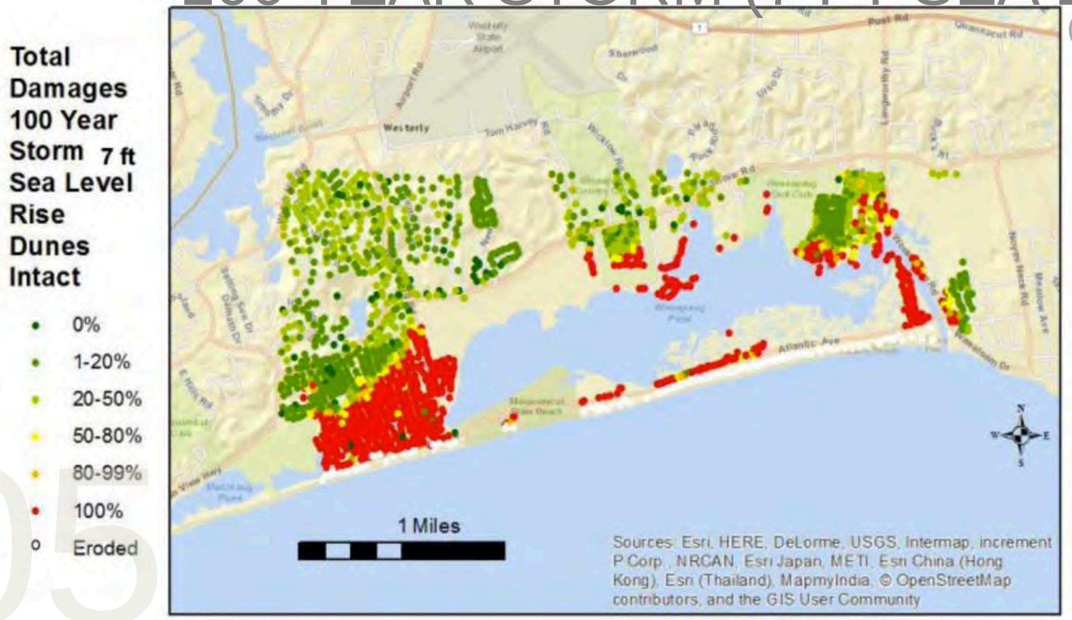


These maps were created by senior URI ocean engineering students using the Coastal Environmental Risk Index. They predict the amount of damage to individual buildings and structures in Misquamicut from a storm event, and demonstrate how much more the town will be affected when projected sea level rise is factored in.

These maps were crucial when making design decisions later on; we were able to identify the most susceptible areas based on the intensity of damage to buildings and then implement strategies that effectively protect them.

100 YEAR STORM (7 FT SEA LEVEL RISE)

(CERI, 2017)



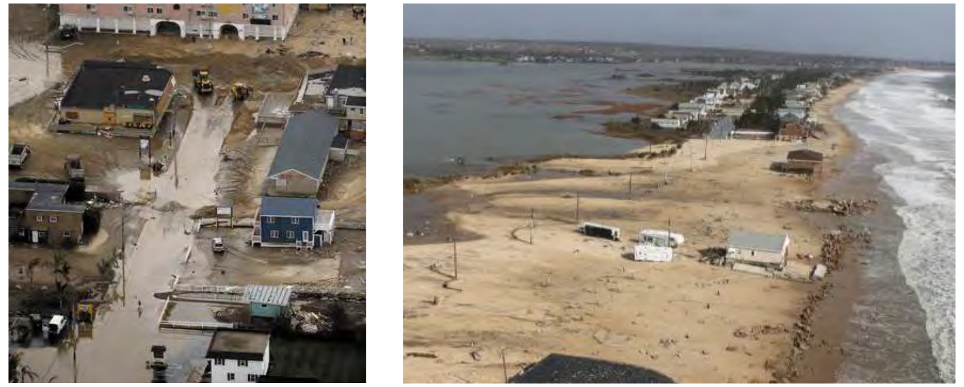
PERCENT DAMAGE

Structures > 50% Damaged	
Without SLR	14.5%
With SLR	47.8%

Note: > 50% damage **must** be rebuilt

EXTENSIVE DAMAGE

Sea level rise is going to greatly intensify damage done to structures in future storm events. There is a high volume of residents, businesses, and tourists that rely on low lying roadways. These roadways are surrounded by sensitive waterways and ecosystems and are prone to flooding, blocking important evacuation routes in the event of a disaster. Existing tidal marshlands and dunes do not currently provide significant relief from damage, and are susceptible to high erosion rates in a storm.

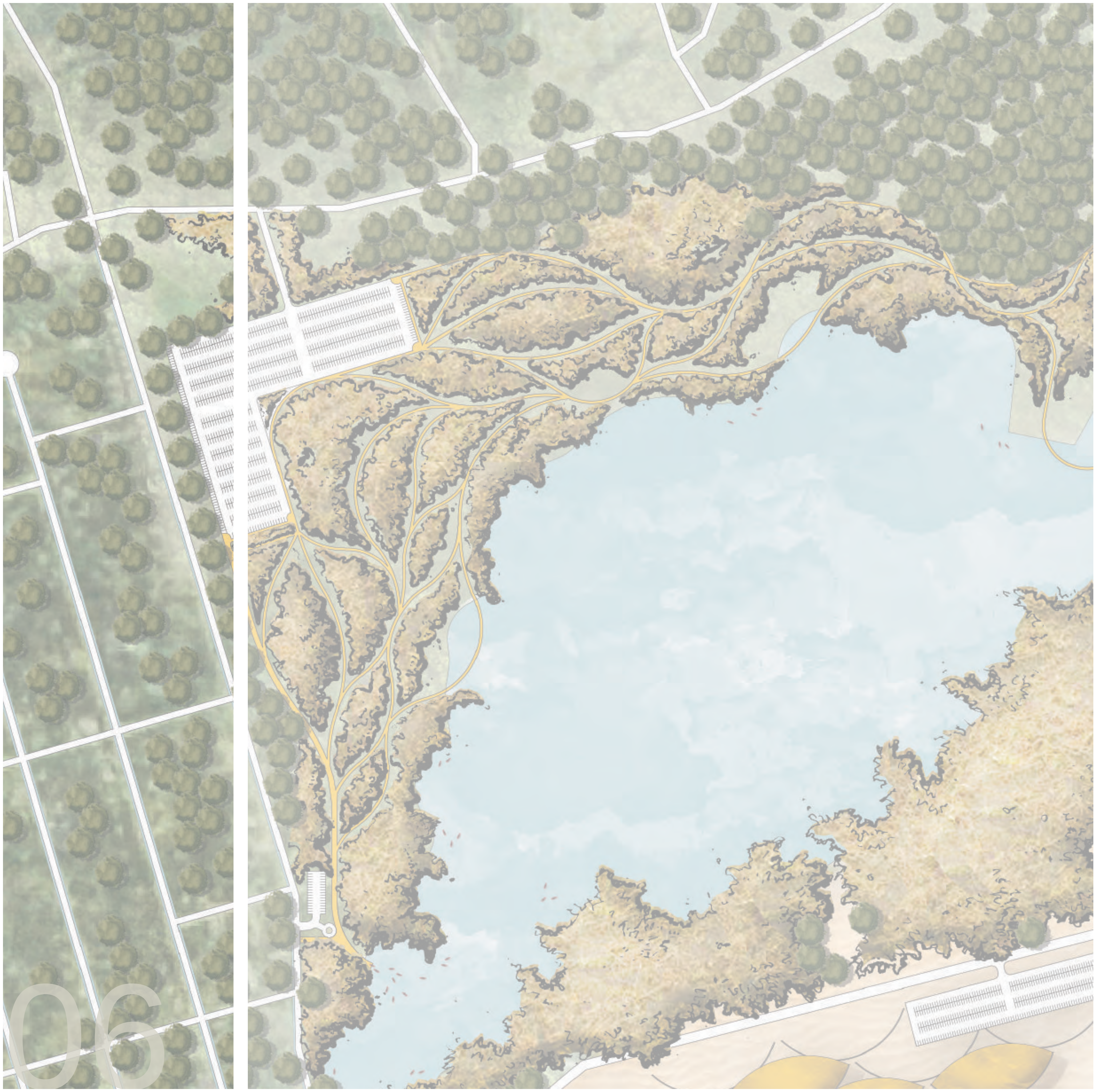


Damage in Misquamicut after Superstorm Sandy
(Images from Google)

TIDAL MARSH VULNERABILITY ANALYSIS (5’ SLR)

- Potential Marsh Loss
- Persistent Marsh Zone
- Potential Marsh Zone

Misquamicut’s landscape is expected to change in response to rising sea levels and storm surge, creating a need for resilient marshland that can protect the community from damage.



DESIGN SOLUTIONS

– Preserve community's character and retain its identity in the presence of a changing environmnent

– Transitional public spaces (designed to withstand flooding in a storm event without damage and eventually be fully inundated from sea level rise)

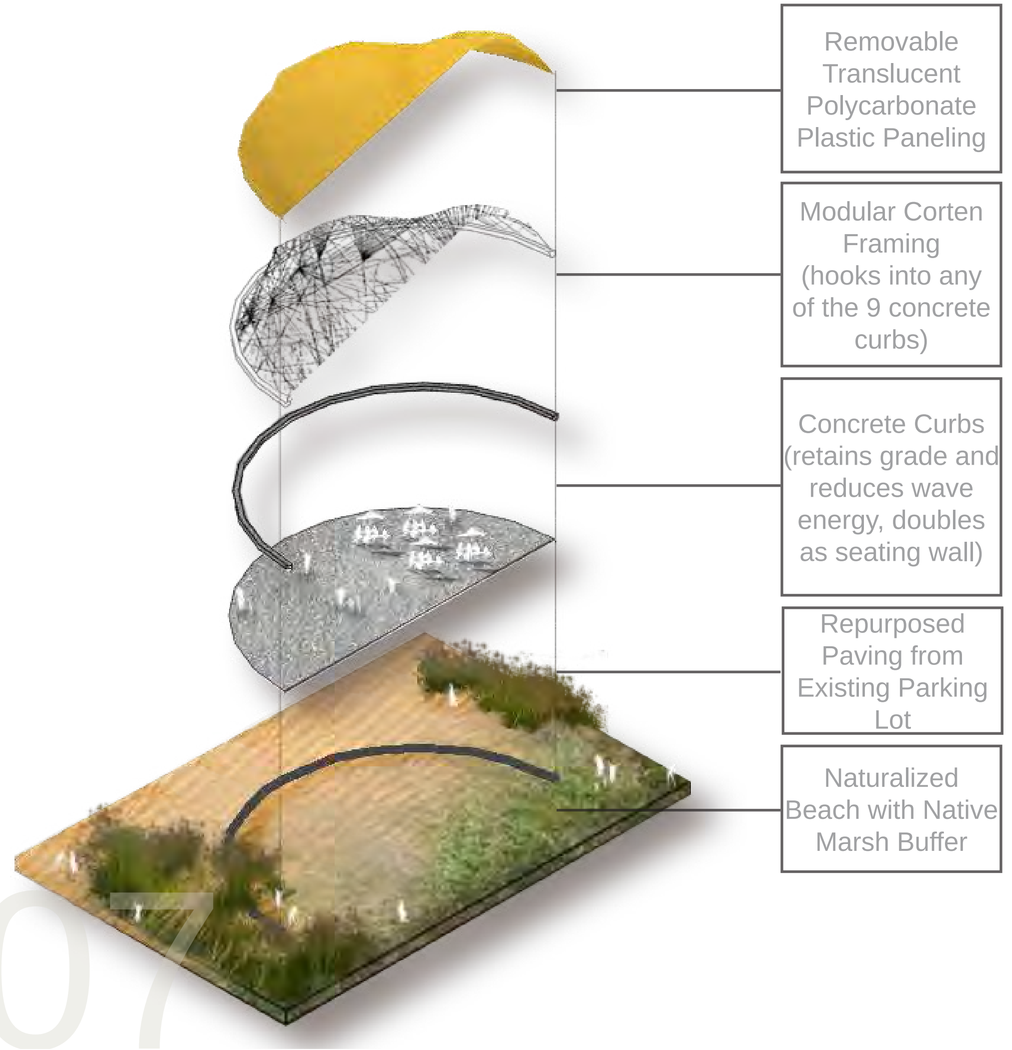
– Flow Diversion Program (directing water away from structures and back to ocean, increasing infiltration capacity with green infrastructure)

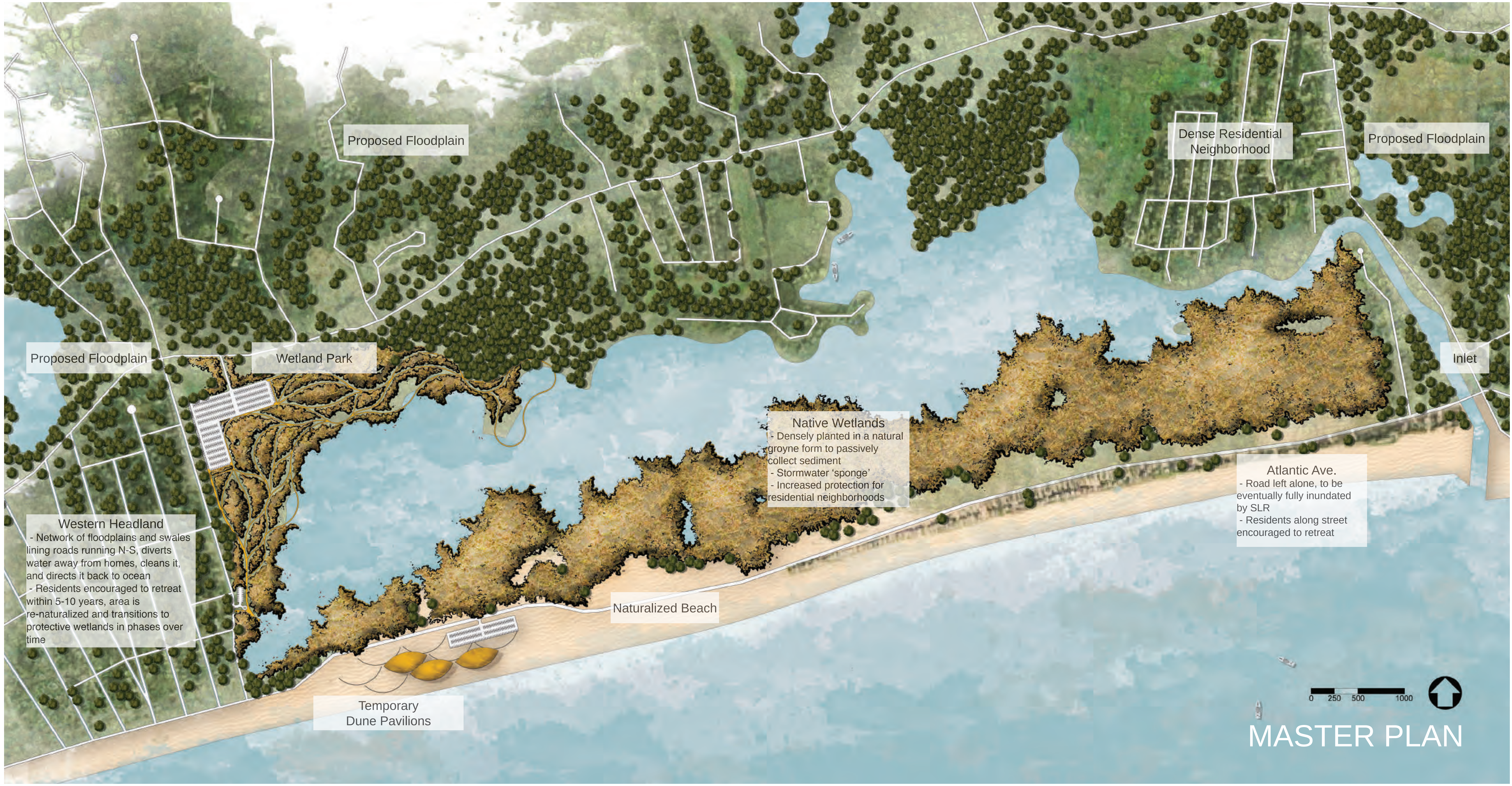
– Shift economic driver of the area to be centered around eco-tourism (multifunctional event spaces, trail system, kayak launch)

– Layered landscapes (enhancing protective wetland buffer around barrier beach and headlands)

TEMPORARY DUNE PAVILIONS

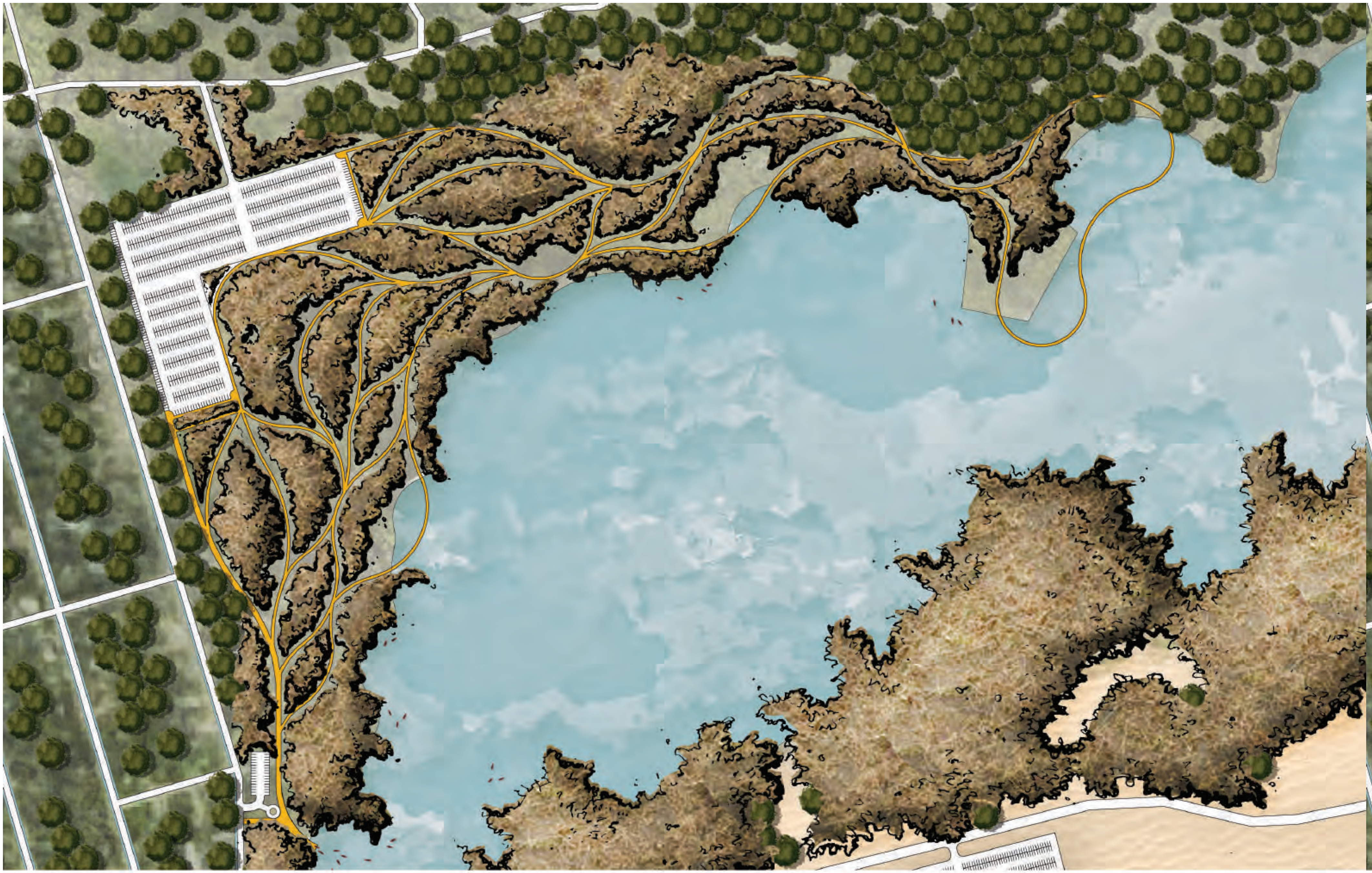
These temporary pavilions emerge from the sand and create public space on the naturalized beach, referencing the curvilinear shape of a protective sand dune. A series of C-shaped concrete curbs and repurposed asphalt paving create the base for the pavilions where the modular framework attaches. The steel skeleton and plastic paneling that create the structure, inspired by agricultural hoop houses, can be easily moved around and deconstructed in a storm event. The structures are relatively low-cost and create opportunities for temporary businesses, public events, and movable outdoor furniture to bring this space to life, attracting both tourists and residents to the area.



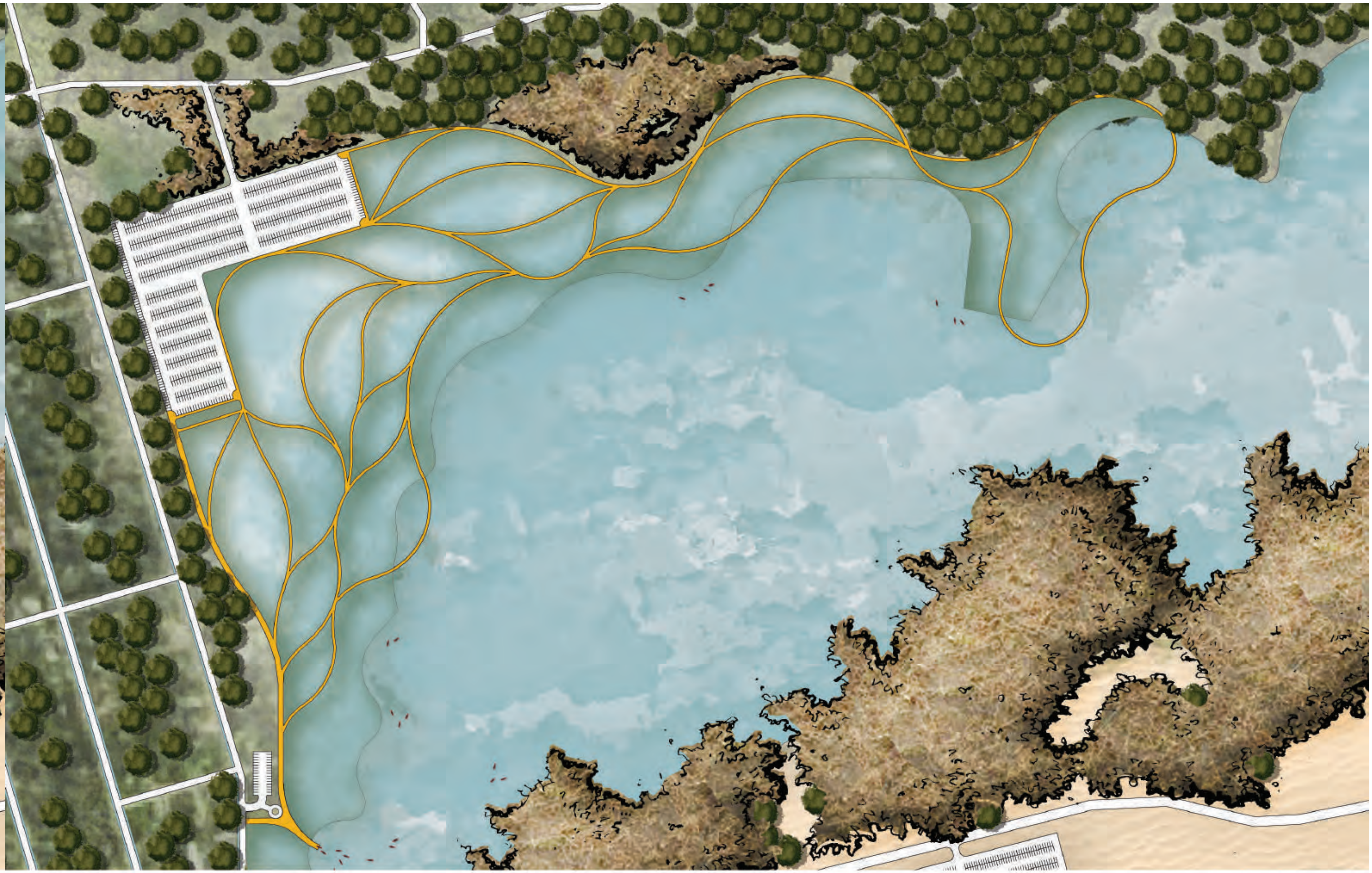


FLOW DIVERSION PROGRAM

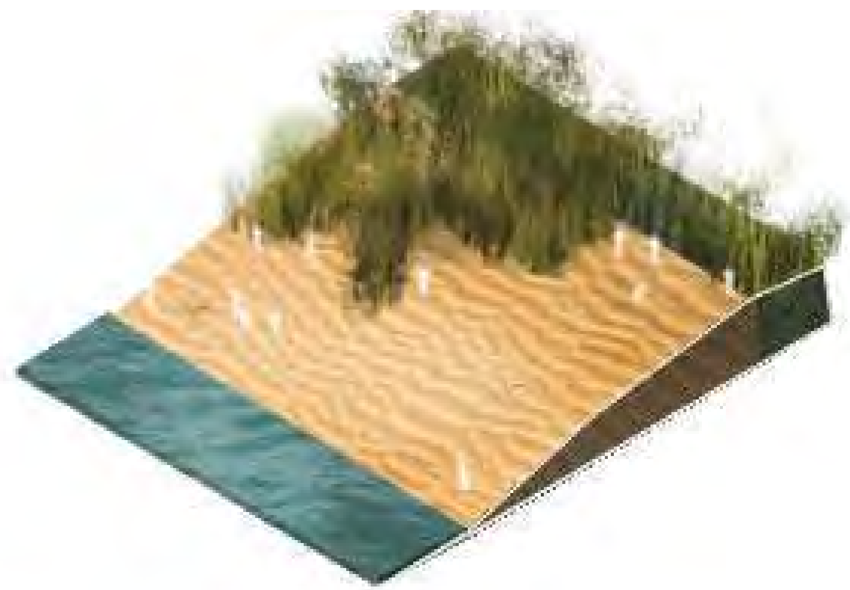
By connecting existing bodies of water to a network of proposed swales and floodplains, stormwater is able to move through the town and permeate drain at its own pace. The Wetland Park is designed as a system of natural trails and vegetative wet and dry basins that can fill up and flood during a storm. When the park overflows, water is directed into the sunken parking lot and then to designated floodplain areas and an existing pond. It is then rerouted down into the residential swale system where it can infiltrate or be sent back to the ocean. This green infrastructure progam protects vulnerable structures from damage due to inundation during a storm event and is both functional and attractive, integrating passive, low-impact development with Misquamicut's identity.



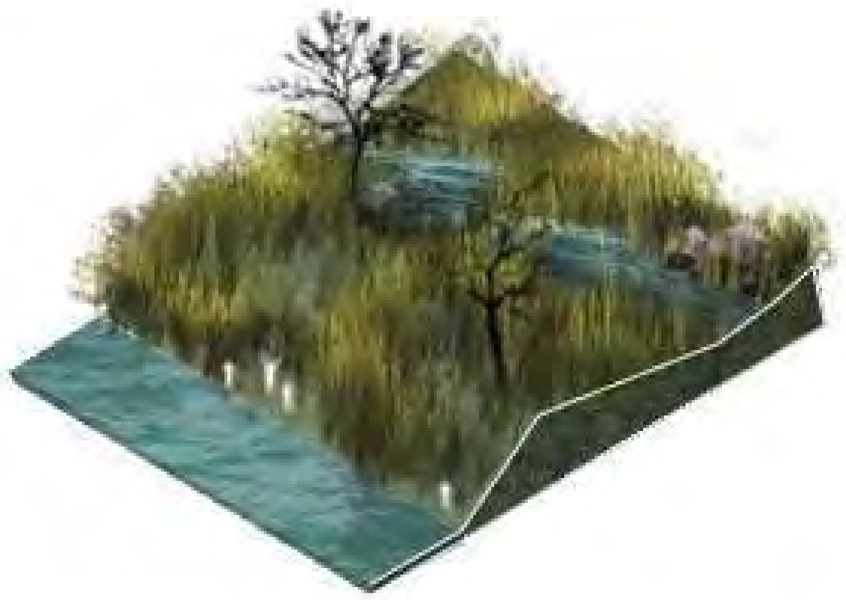
WETLAND PARK NO SURGE



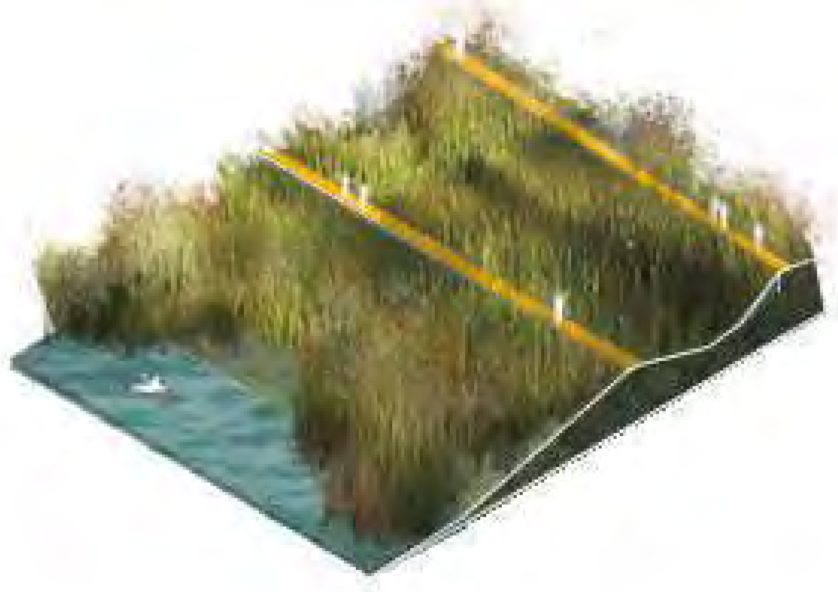
WETLAND PARK WITH SURGE



NATURALIZED BEACH
WITH MARSH BUFFER



PROTECTIVE WETLANDS
AND STREAM



WETLAND PARK WITH ELEVATED
TRAILS AND SUNKEN BASINS

MARSH BUFFER AND
ROADS WITH SWALES

LAYERED LANDSCAPES

Protecting and increasing wetland buffers around the community promotes flood resilience and naturally shields the town from sea level rise and storm surge impacts. Adding layers of native vegetation increases filtration and directs water away from vulnerable structures. These diagrams represent the 4 archetypal environments that will be used to increase protection throughout Misquamicut - the beach, naturalized wetlands, the proposed Wetland Park, and the road.

Naturalized Beach with Marsh Buffer

Adding a wider vegetative buffer on the barrier beach helps to hold down sand on existing dunes. The beach is expected to be fully inundated from sea level rise within the decade; native vegetation increases infiltration and reduces wave energy in a storm event for the short term with the intention of eventually going underwater.

Protective Wetlands and Stream

This landscape archetype will be implemented in naturalized areas around Winnapaug Pong. The stream captures water that runs inland and directs it away from vulnerable areas. Stormwater is able to infiltrate as it flows through the landscape. The vegetation also captures pollutants.

Wetland Park with Elevated Trails and Sunken Basins

This park is a collection of wet and dry basins filled with native vegetation. As stormwater floods the park the water collects in the basins, where it is stored until it either drains back into the pond or infiltrates.

Marsh Buffer and Roads with Swales

Lining roads that run N-S in the residential neighborhoods with swales further directs the water away from structures and back to the ocean. The swales create scenic and functional rain gardens to drive past.

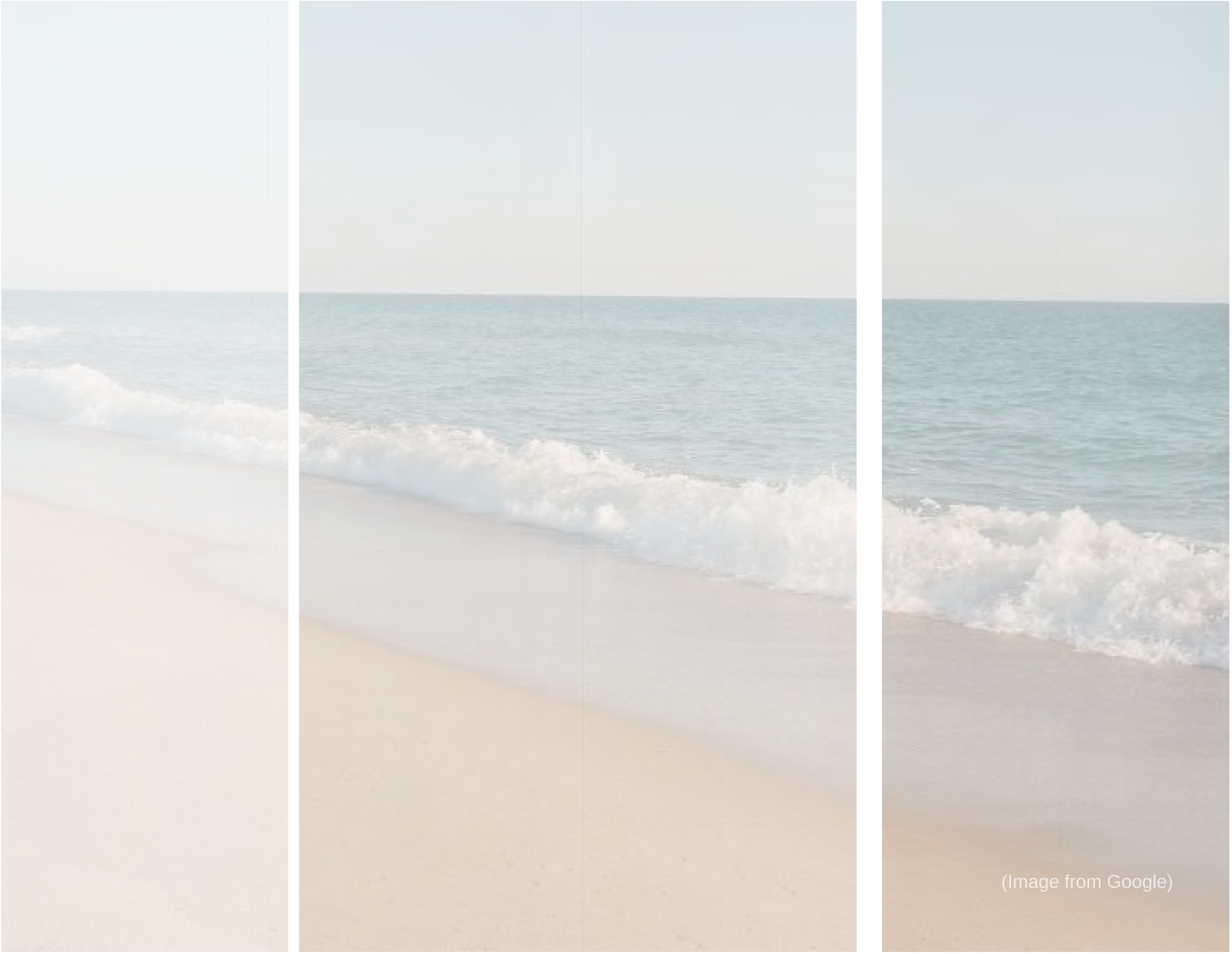
LEARNINGS

– Sea level rise directly affects the intensity of damage in a storm event. Not only do a few feet of rise change the overall topography of the site over time, but hurricanes are more frequent and much more disastrous in the short term. This knowledge was gained and really put into perspective from seeing the CERI projections with and without SLR. We were able to pinpoint vulnerable areas and direct our energy into protecting them with this knowledge.

– Cost-benefit analysis plays a large role in building resiliency in a community. People's perception of risk living in an area fluctuates the housing market, whether or not their perception is realistic. Many do not want to pay extra for open space or green infrastructure, despite being susceptible to increased inundation and wave energy from SLR without it. Resource economic students did a lot of equations, surveying, and research that landscape architects do not usually do. It was an in-depth look at how our work, as well as its intended users, affect the economy.

– Using a multi-disciplinary process is an extremely integrated and thorough method to design a space and plan for the future. Sharing research and collaborating ensures that we are learning as much as we can through the site analysis phase, in order to better accomodate for the site's unique constraints and threats. As landscape architects, there was no way for us to get a better understanding of Misquamicut's issues with SLR without collaborating with the ocean engineering students. Their projections were invaluable later on in the design process, and allowed us to brainstorm more effective mitigation strategies.

– Looking back at past storm events and pictures of damage from historical hurricanes in Misquamicut is a great way to visualize what kind of damage to expect from future disasters. It is interesting to see how the community has changed and responded to these events, and even more interesting to see how it has not. In many ways the residents have adapted to increased surge and intense damage; many have even begun the process of lifting their houses. This research into the past allowed us to understand how the communtiy has developed and filled in over time. This helped us decide what direction the community should aim for in the presence of a changing landscape and prepare for history to repeat itself.



(Image from Google)

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URI Senior Ocean Engineering class
URI Senior Resource Economics class

URI Senior Landscape Architecture class
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