How Feasibility Analyses are Used to Develop a Preferred Resiliency Project Alternative:

Examples from Crescent Beach Revetment Rehabilitation (Hull) and North Scituate Beach Nourishment

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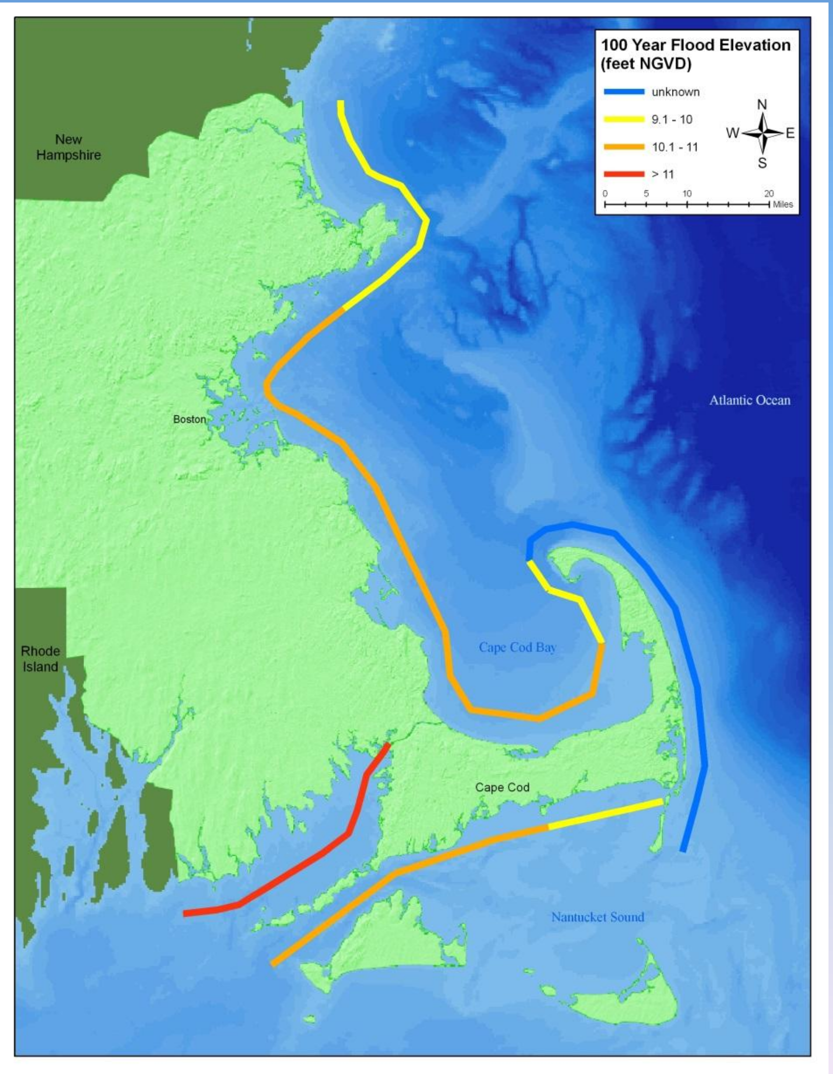
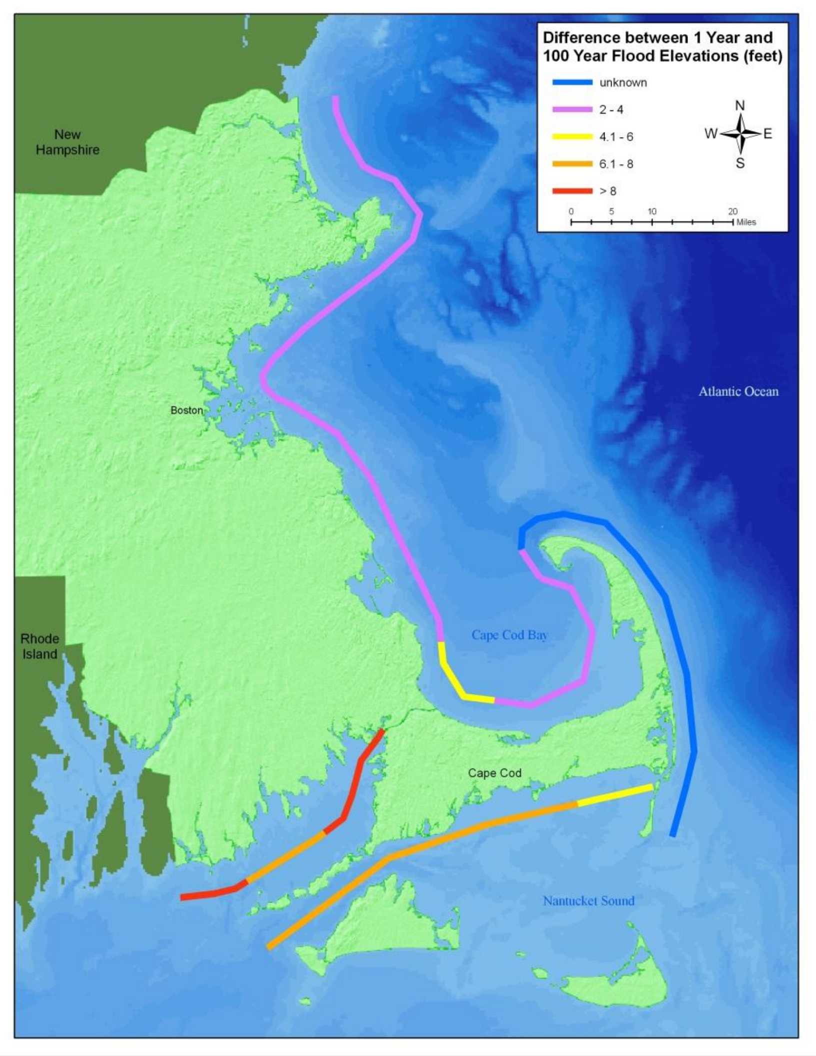
What do we need to understand?

- littoral cell and coastal processes
- shoreline change and shoreline type (geology)
- relative sea-level rise
- coastal engineering structures
- wave climate (storm wave forces/overtopping)
- storm susceptibility (repetitive loss properties)
- environmental implications
- costs (both initial construction and maintenance)

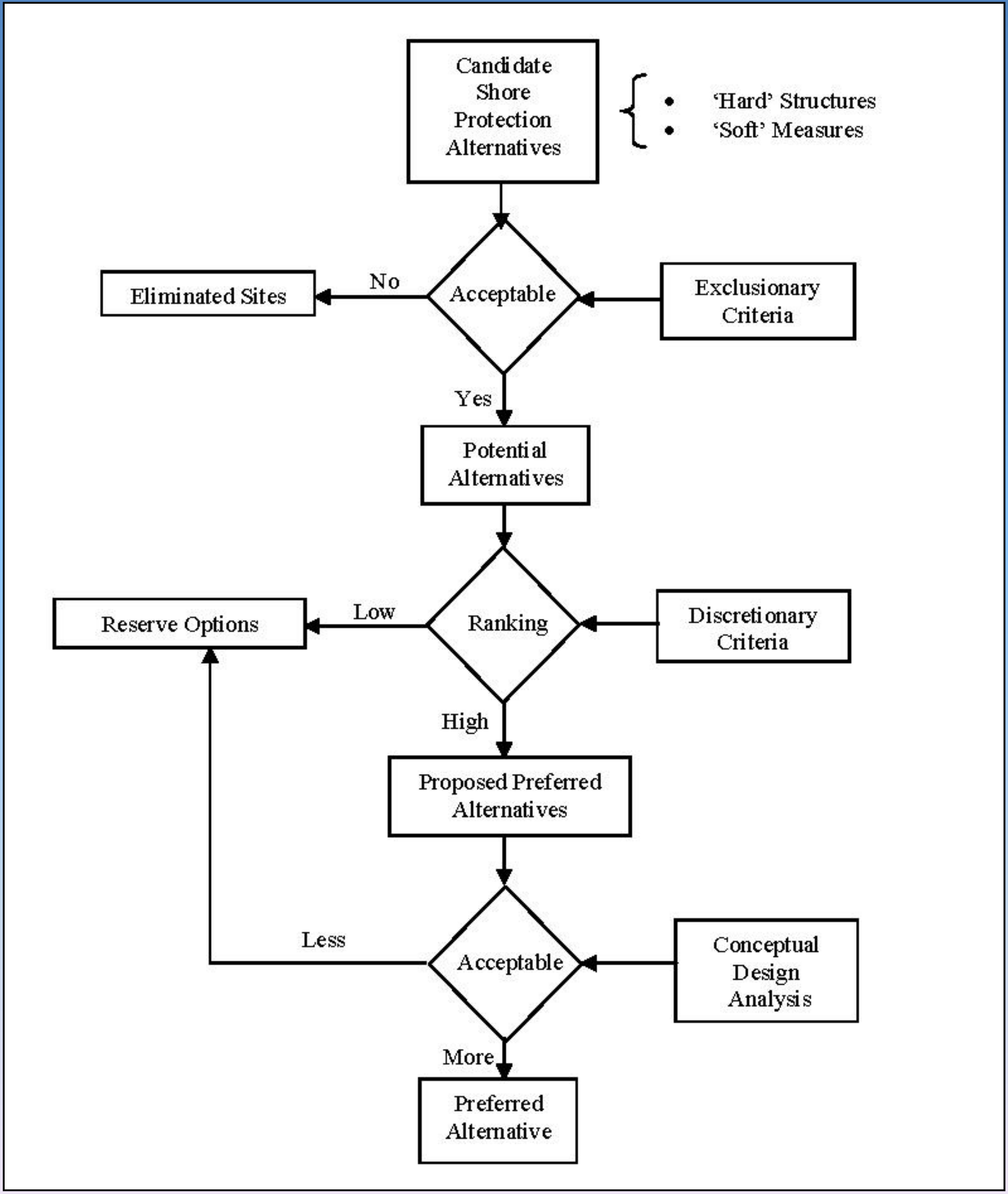
What Makes the Massachusetts Shoreline Unique?
Influence of Storms





Properties with Multiple Flood Insurance Claims

High Storm Susceptibility Leads to More Frequent Flood Damage



Solving Coastal Erosion and Storm Damage Problems

We need to understand the problem prior to developing potential solutions

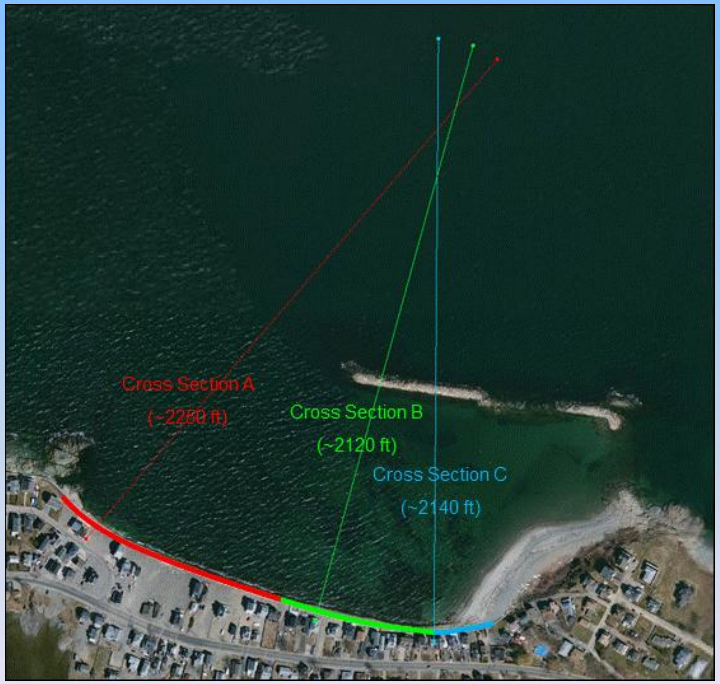
Project Purpose and Need
(Clear and Objective)

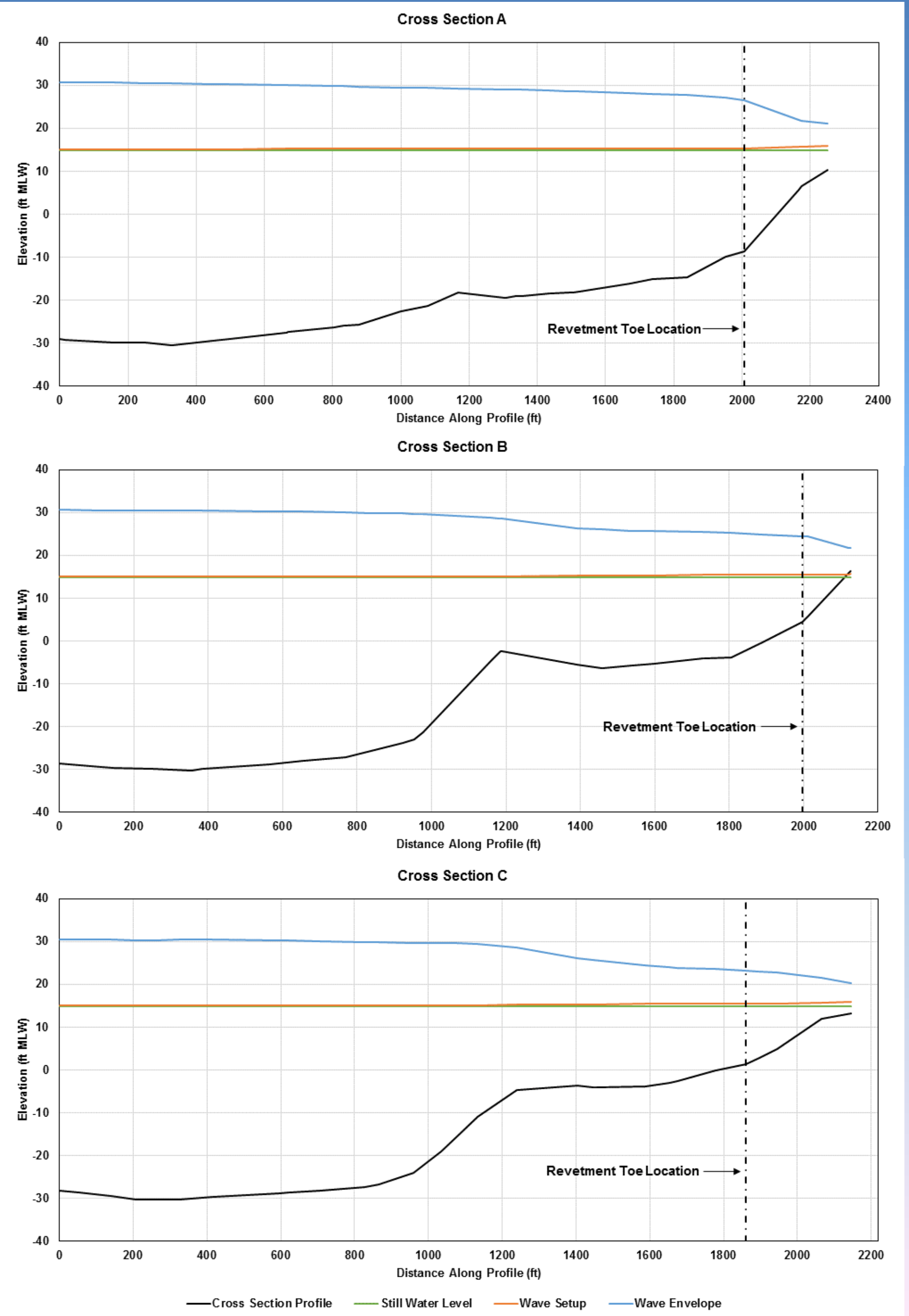
- Long-term shore protection
  - Reduce damages to public infrastructure and residential property behind seawall
  - Maintain emergency access during and after storm events
- Shore resiliency
  - Prevent further beach lowering and erosion
  - Provide long-term shoreline stability
- Minimize environmental impacts


Crescent Beach
Hull, MA

Existing Conditions

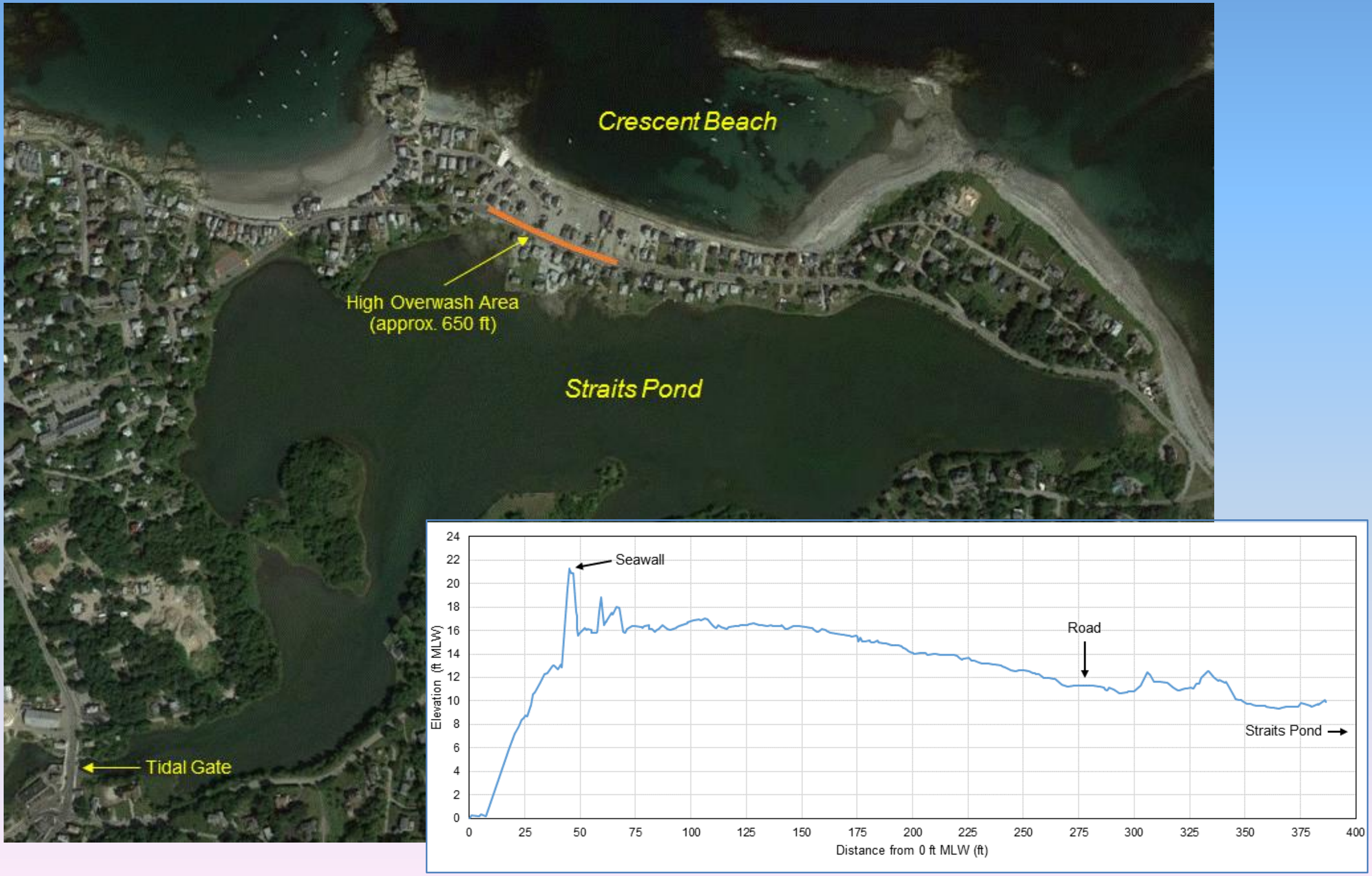
- Breakwater is under-resolved with 164 ft grid spacing (Cross Section B and C)

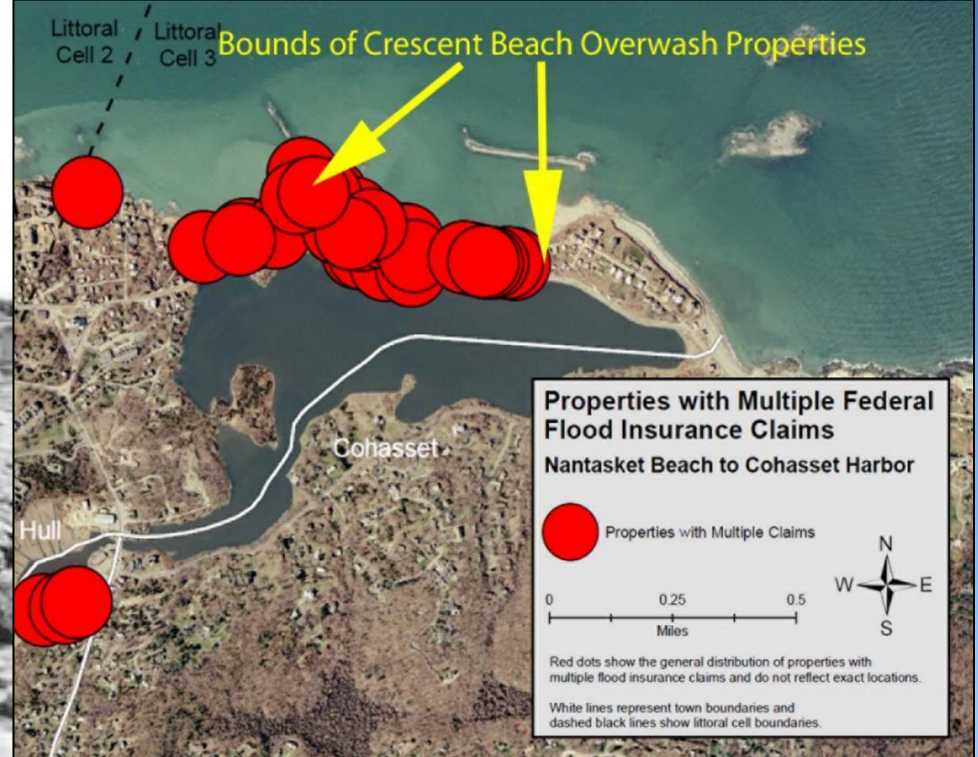




Existing Conditions - Straits Pond

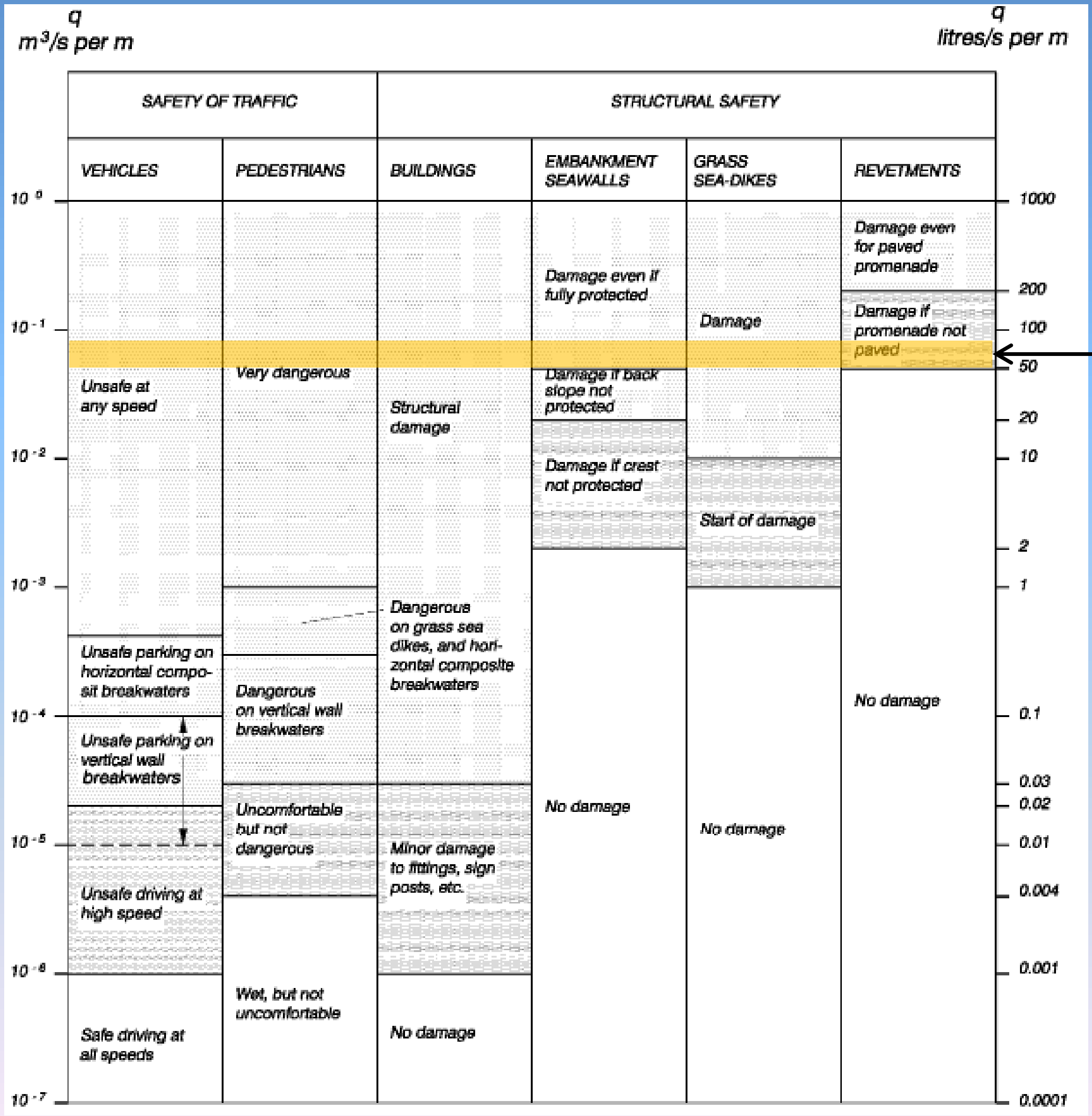
- Overtopped water and overwash from Crescent Beach flows into Straits Pond





Littoral Cell 2
Littoral Cell 3
Bounds of Crescent Beach Overwash Properties
Cohasset
Hull
Properties with Multiple Federal Flood Insurance Claims
Nantasket Beach to Cohasset Harbor
Properties with Multiple Claims
N
W
E
S
0
0.25
0.5
Miles
Red dots show the general distribution of properties with multiple flood insurance claims and do not reflect exact locations.
White lines represent town boundaries and dashed black lines show littoral cell boundaries.

Critical Average Overtopping Values



Estimated overtopping during January 27, 2015 blizzard

Shore Protection Alternatives

1. No Action

Benefits	Disadvantages
• None	• Continued overtopping and storm damage to homes and public infrastructure • Further decay and failure of existing revetment and seawall structures • Increased future costs to repair or rehabilitate the structure

Shore Protection Alternatives

2. Beach Nourishment

Benefits	Disadvantages
• Restoration of the lost aerial and sub-tidal beach • Nourishment will provide wave dissipation and storm protection • Creation of a recreational resource	• Severe impacts and/or destruction of inter-tidal and sub-tidal habitats, benthic communities, and nearshore resources areas • Challenging design due to steep nearshore slope • Regular and episodic maintenance and re-nourishment required (short design life) • Does not address or repair the failing coastal infrastructure • Impacts to the community during construction due to the large number of trucks trips required to deliver the nourishment material to the project site

Shore Protection Alternatives

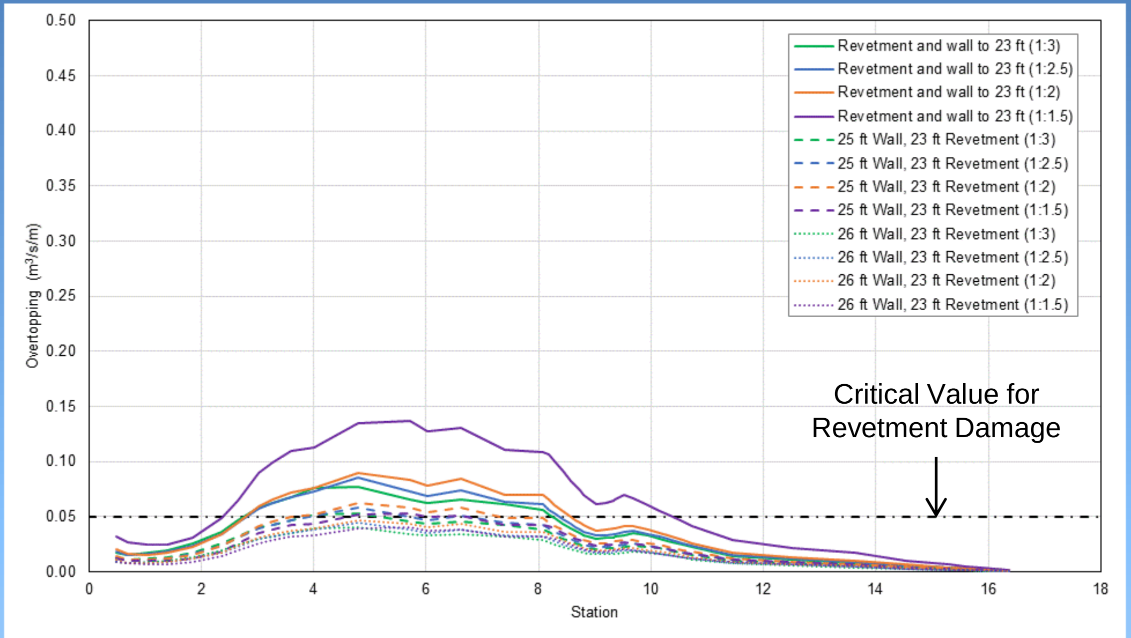
4. Rehabilitation of the Existing Revetment and Seawall

Benefits	Disadvantages
• The reconstructed structures will increase wave dissipation, reduce wave over topping, and provide a greater level of storm protection • Minimizes impacts to nearshore and offshore benthic and aquatic resources relative to other shore protection measures	• Wave overtopping during severe events could still result in potential damage • Minor impacts to the benthic resources immediately in front of the structure during construction • <u>Limited permanent impacts for area of expanded structure footprint</u>

Option 4, 5 & 6

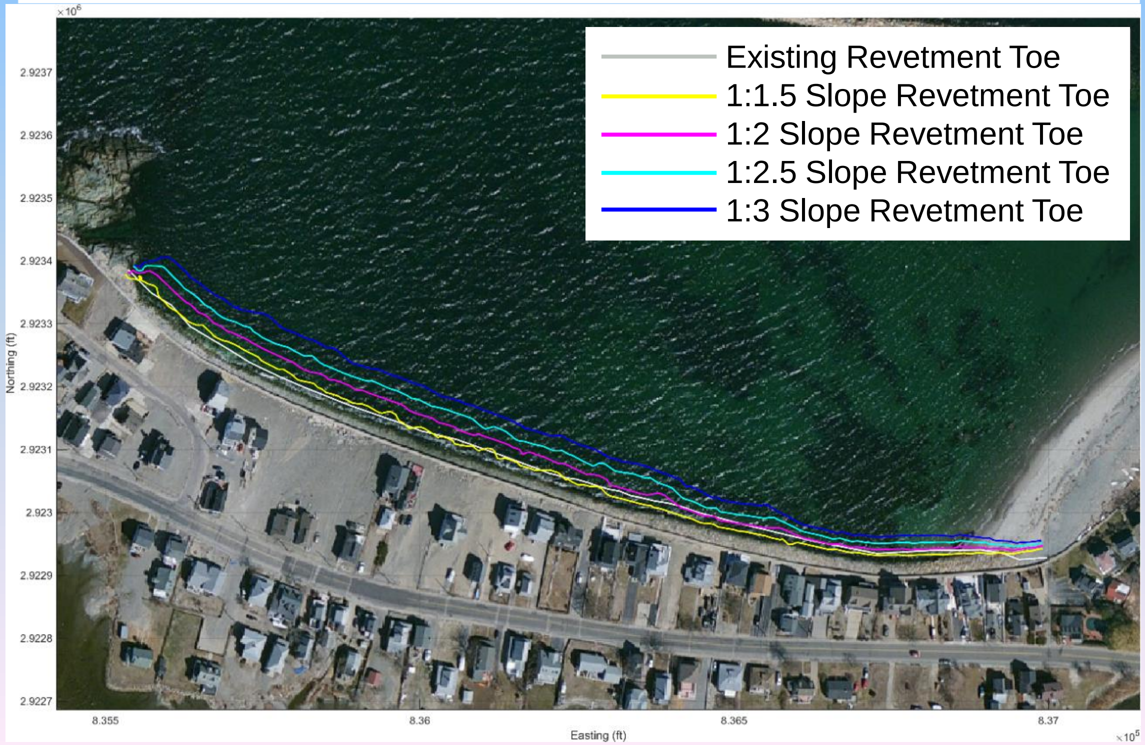
23 ft MLW Revetment

- Overtopping estimated by Pedersen (1996)

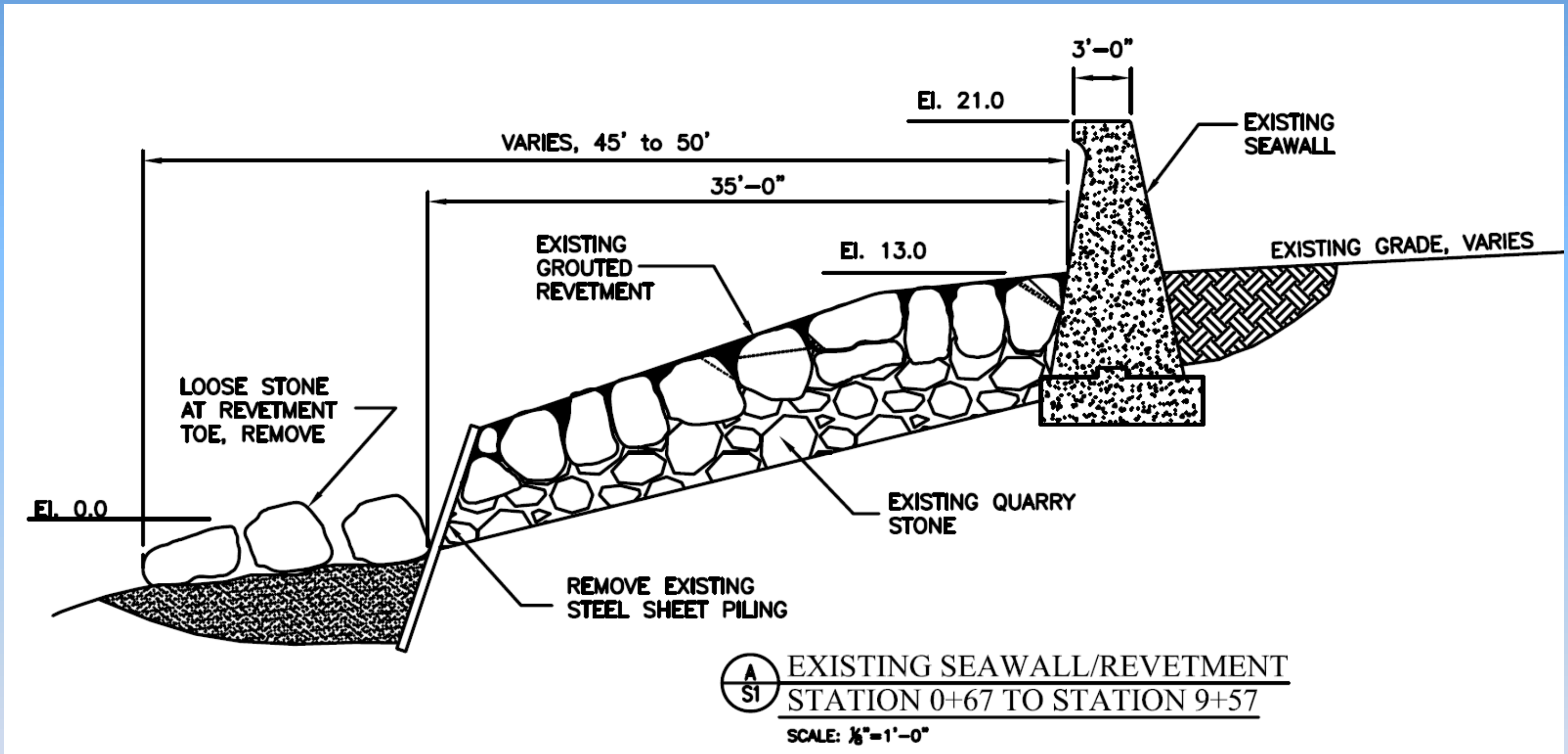


Average distance from proposed revetment toe to existing revetment toe.

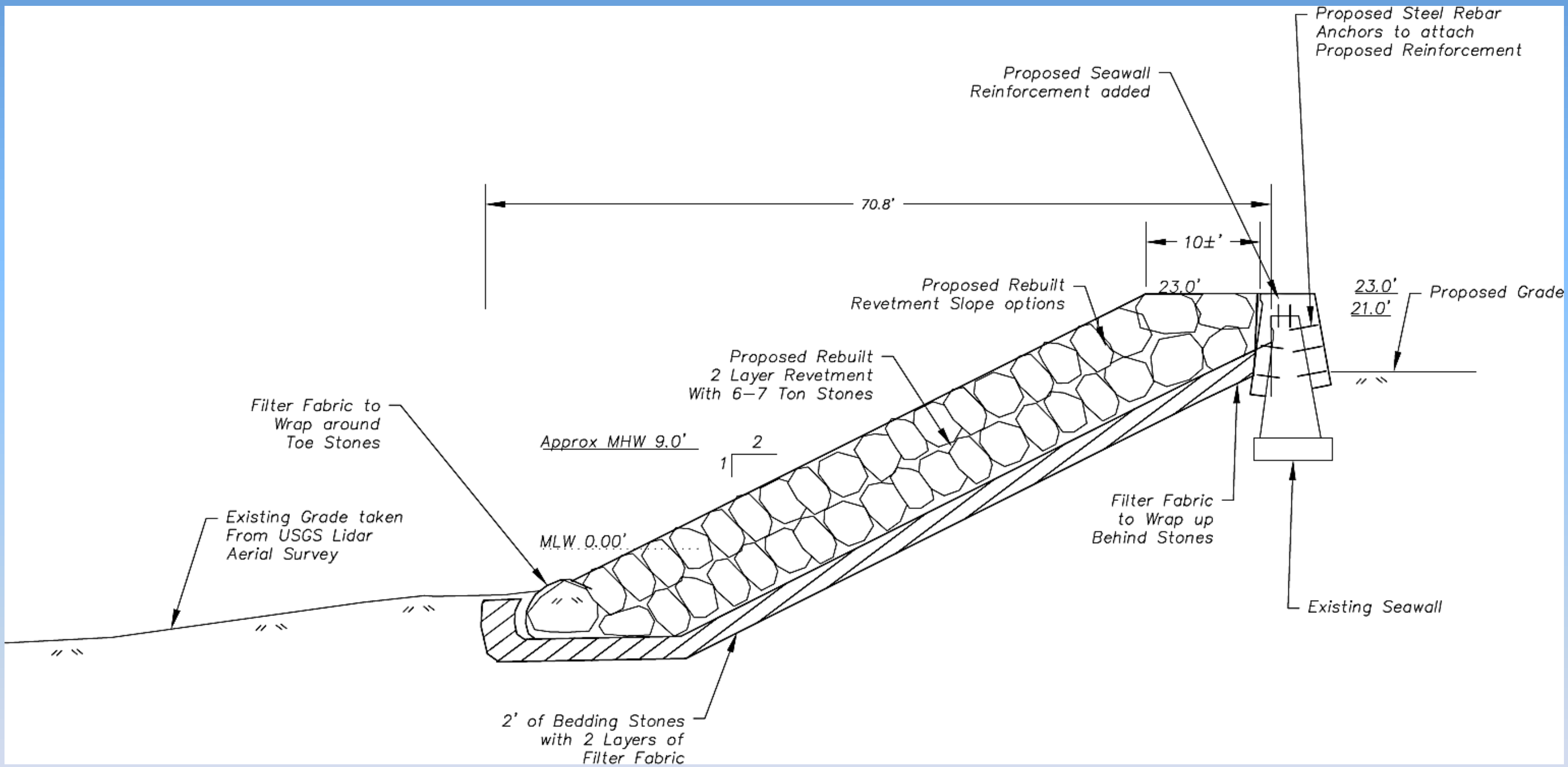
Revetment Slope	Station 0+50 to 10+00 23 ft MLW	Station 10+25 to 16+25 23 ft MLW
1:1.5	12 ft	-11 ft
1:2	30 ft	0 ft
1:2.5	46 ft	13 ft
1:3	72 ft	23 ft



Existing Typical Cross Section



Proposed Design for Station 0+00 to 10+00



North Scituate Beach Nourishment

Existing Conditions

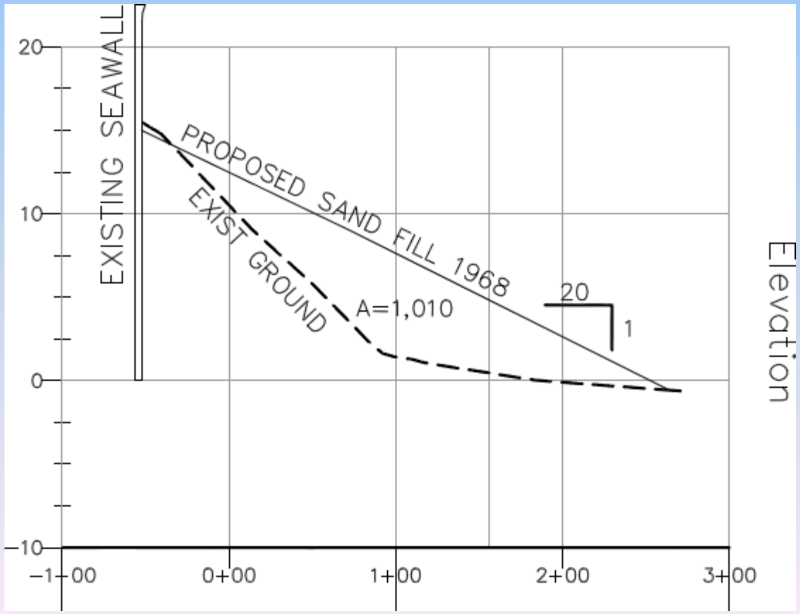
- 2007 South Shore Coastal Infrastructure Inventory found that the majority of the seawall and revetment is in Fair condition with evidence of wall cracking and spalling, loose and/or slumping stones, and undermined seawall footings at several locations
- Water marks on stones indicate that much of the revetment is below water at high tide
- While submerged, the revetment does not efficiently dissipate wave energy, therefore the seawall is the primary means of shore protection during storms

Slumping revetment stones
Undermined seawall footing

Exposed seawall toe
Exposed rebar

Project Area History

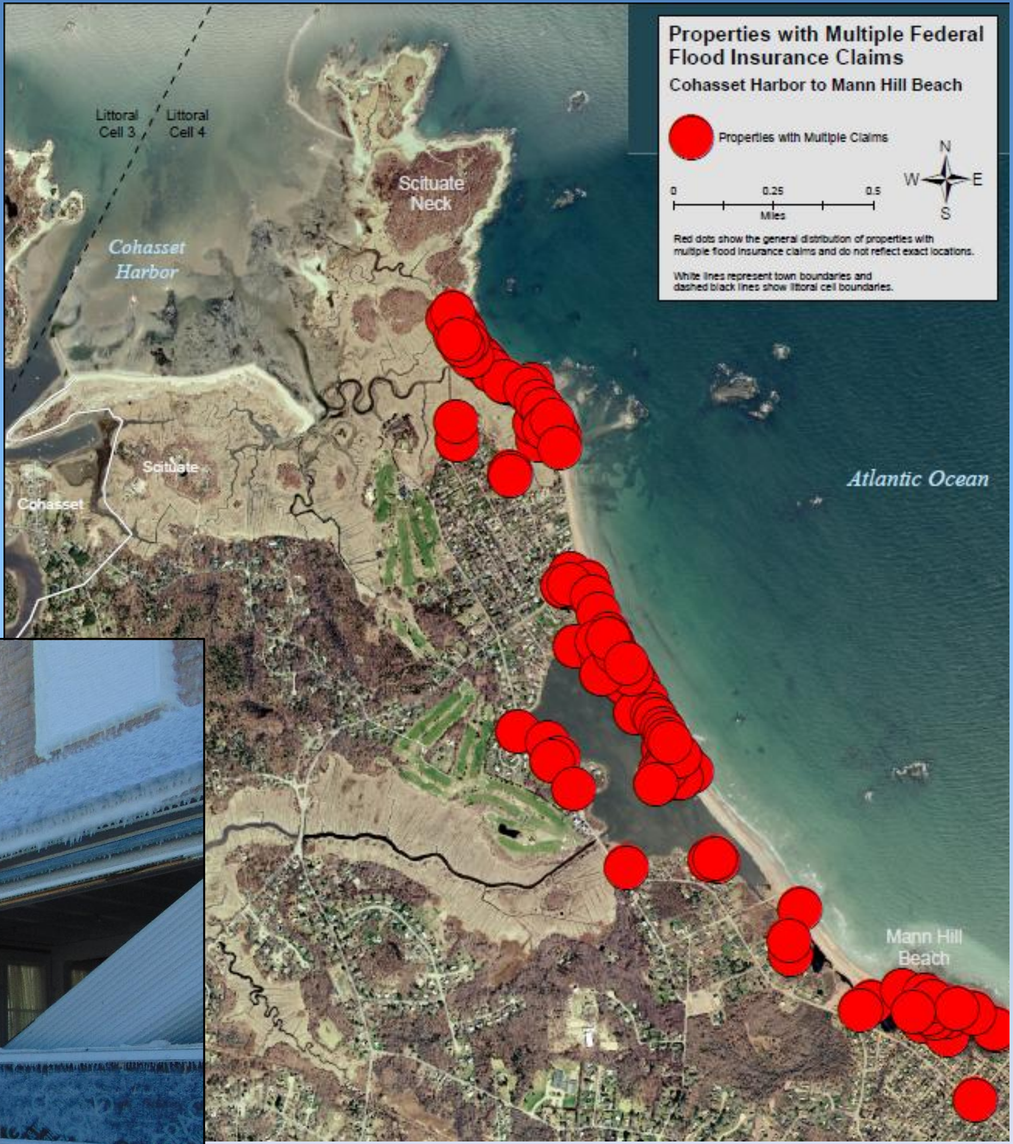
- A beach nourishment project was completed by USACE in 1967 with an approximate length of 2,500 feet and a total volume of 160,000 cubic yards
- Seawall and revetment repair plans have been documented since the late 1940's



Evacuation Route

Damages

- 75 homes behind seawall are considered repetitive loss properties
- Nearly $9.5M in contents and structural damages have been claimed from these 75 homes from 1978 to 2010

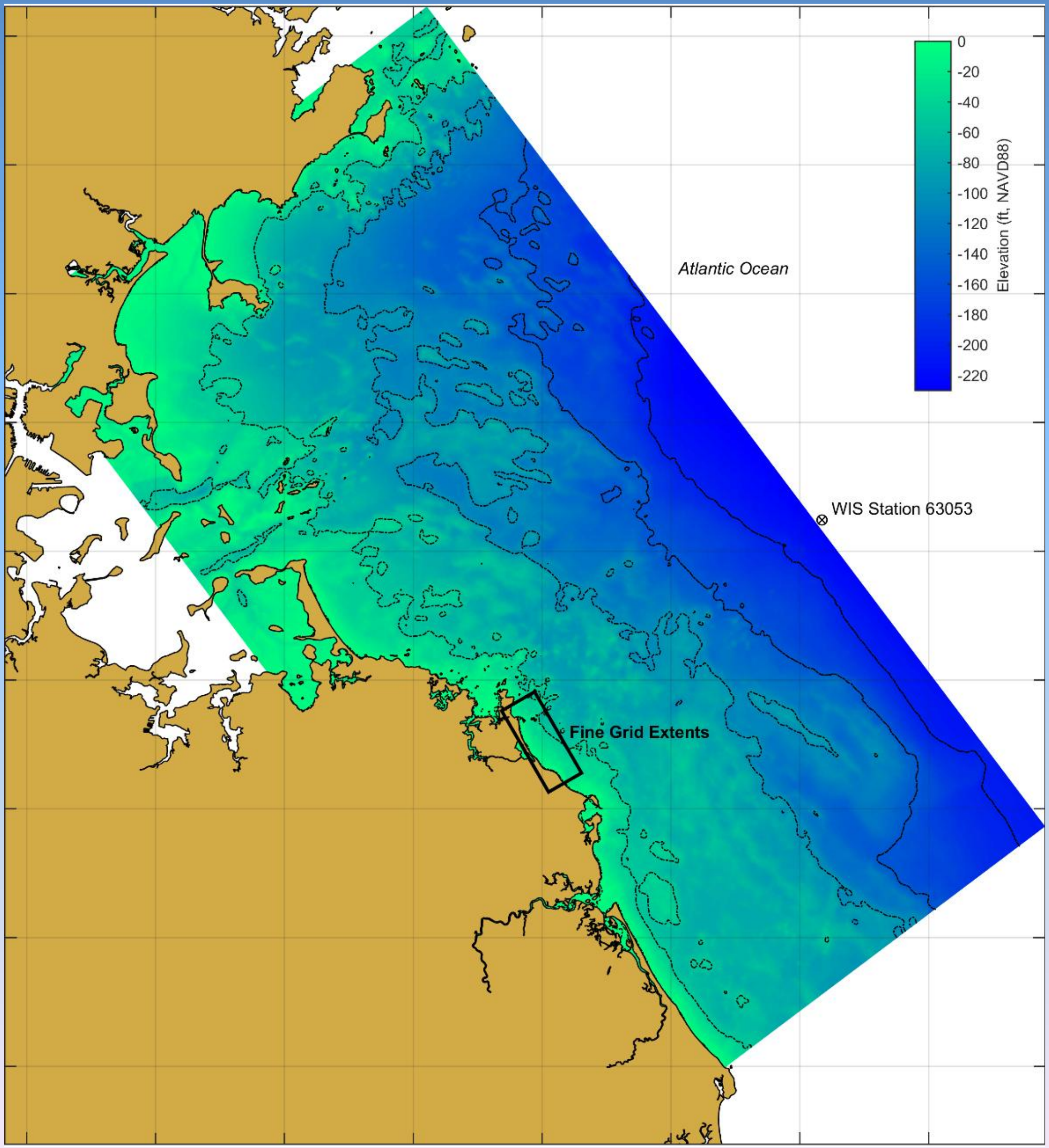


Map from MCZM South Shore Coastal Hazards Characterization Atlas

Winter Storm Juno 2015

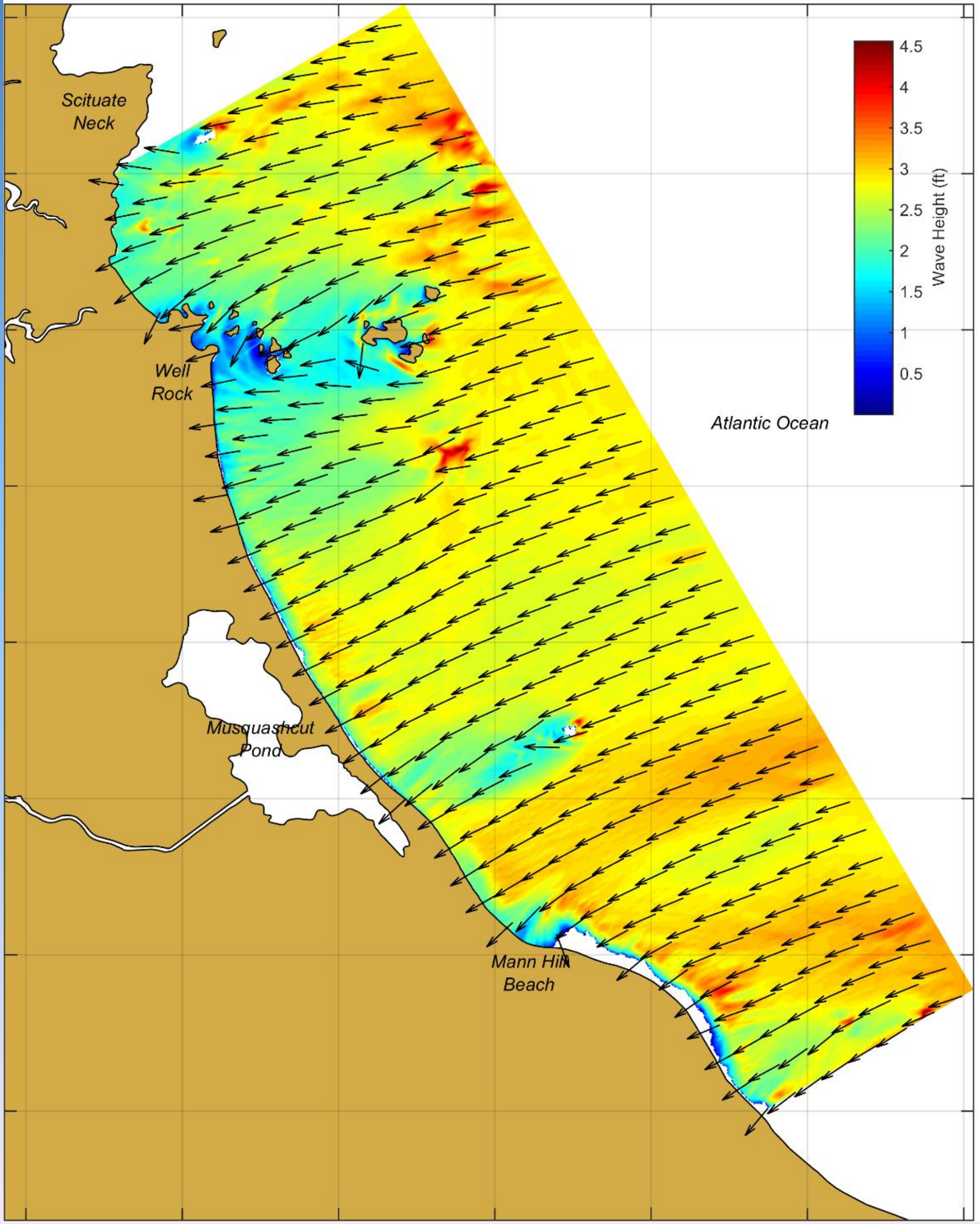
SWAN Model Grid

- 328 ft (100 m) grid spacing
- Bathymetry from 2010 USACE LIDAR survey

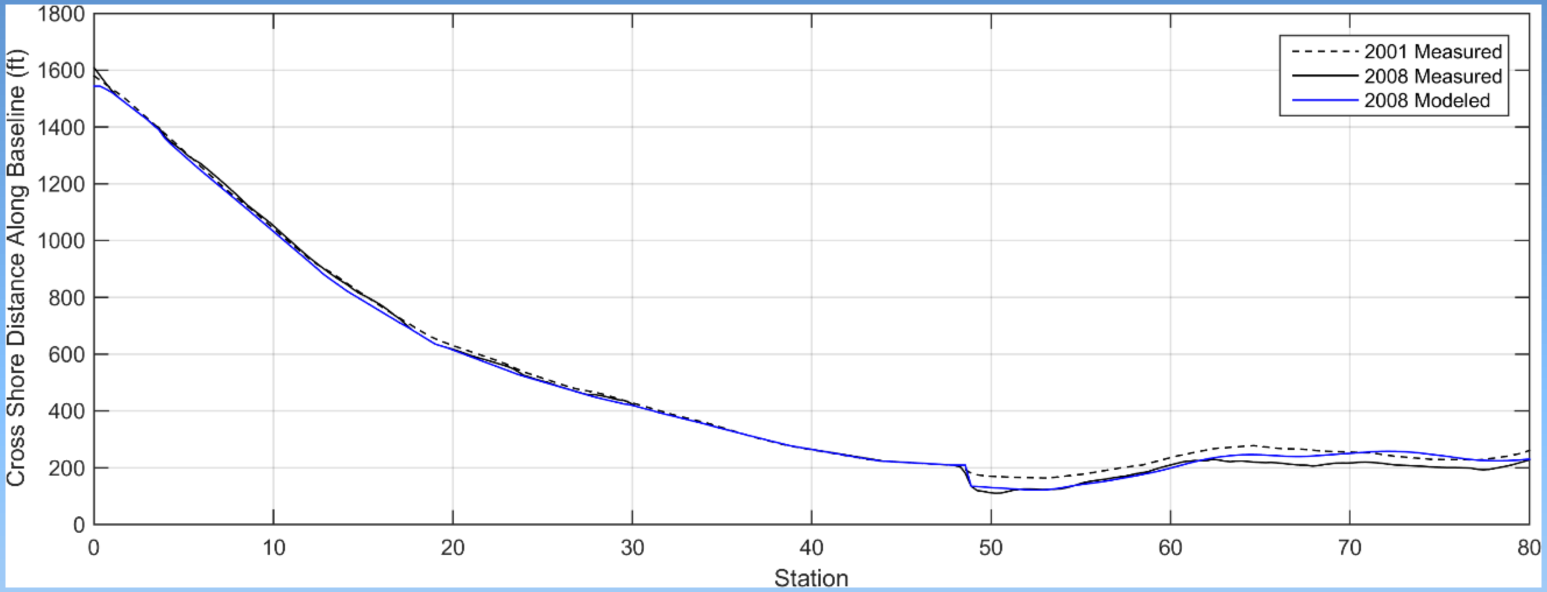


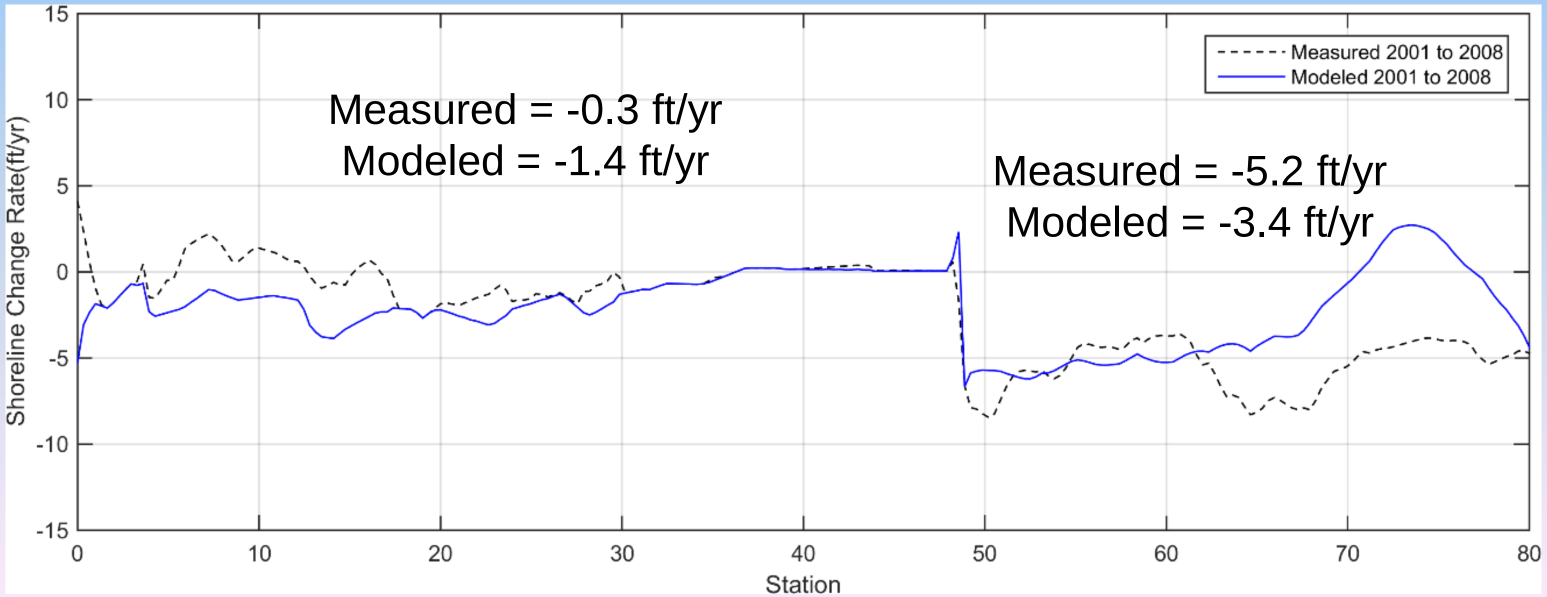
SWAN Model Results

- Case 7 shown
- Wave height = 3.1 ft
- Wave period = 7.6 s
- Wave direction = 80 deg



Shoreline Evolution Model Results





Shore Protection Alternatives

1. No Action

Benefits	Disadvantages
• None	• Continued overtopping and storm damage to homes and public infrastructure

Shore Protection Alternatives

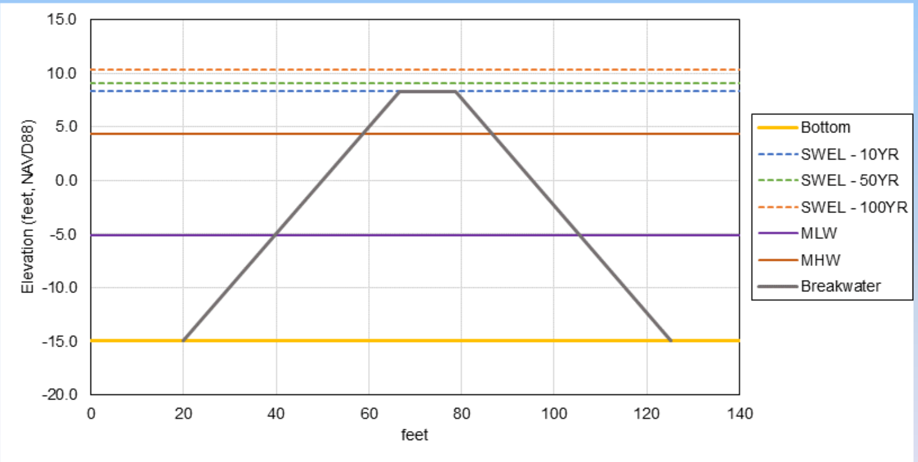
2. Nearshore Breakwater

Benefits	Disadvantages
• The structure will provide wave dissipation and storm protection especially for lower period wave events • Reduce wave overtopping and storm damage along the shoreline • Potential increase in habitat depending on the breakwater approach selected (WADS™ or Reef Balls™)	• Impacts and/or destruction of sub-tidal habitats and benthic communities beneath the template of the breakwater • The structure will be visible for all stages of the tide • Navigation hazard for mariners entering or exiting the mooring field • Impacts to the community during construction due to the large number of trucks trips required to deliver the structure material to the project site • Will not restore the beach

Nearshore Breakwater

Preliminary design:

- Approx. 3,300 ft total length
- Approx. 400 ft offshore
- Crest elevation of 13.5 ft NAVD88 (emerged during entire tide cycle)
- Total stone volume of 133,000 CY
- Footprint of 6.3 acres
- Approx. cost: $23,000,000



Shore Protection Alternatives

3. Repair Seawall and Rebuild Revetment

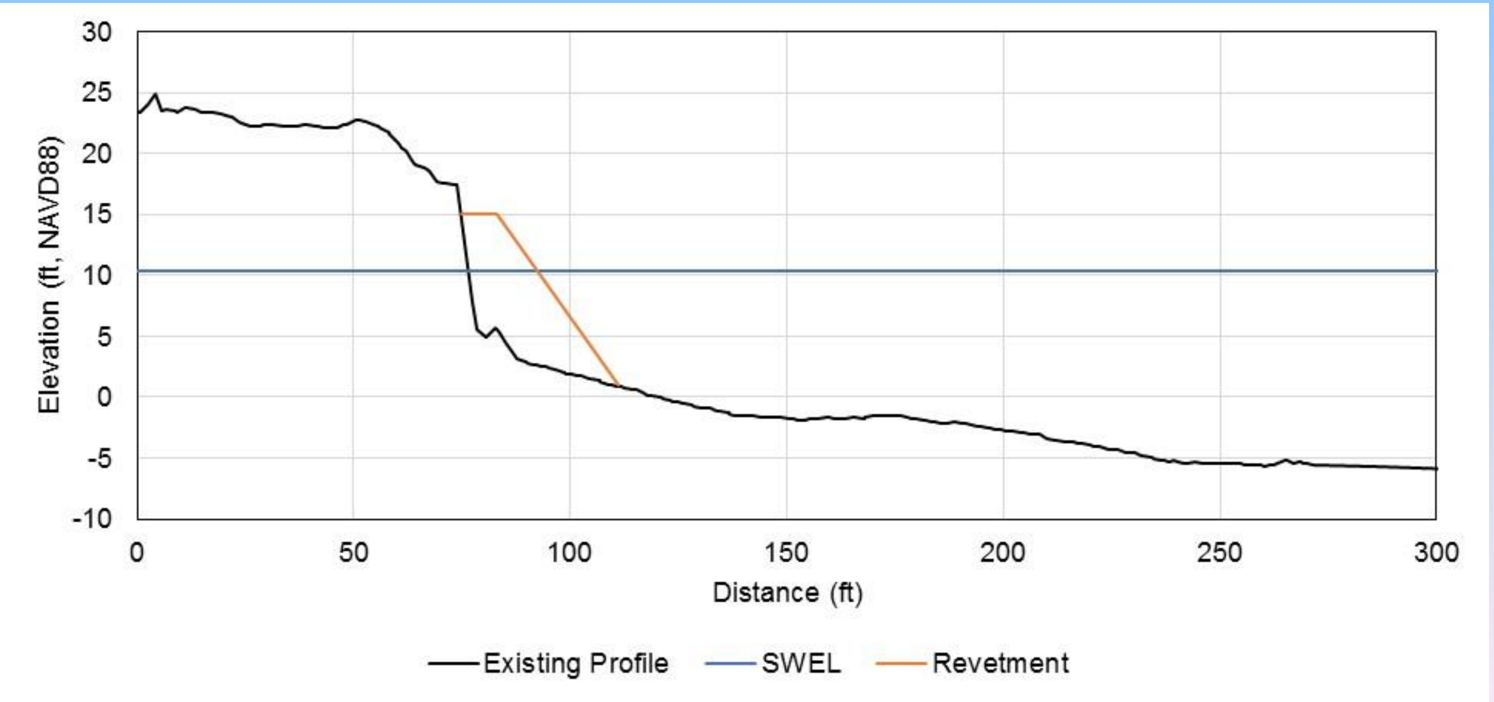
Benefits	Disadvantages
• The rebuilt revetment will increase wave dissipation, reduce wave overtopping, and provide a greater level of storm protection	• Will not restore the beach • Beach lowering in front of revetment is expected to continue • Minor impacts to the benthic resources immediately in front of the structure during construction

Wave Overtopping – Winthrop Beach

Repair Seawall and Rebuild Revetment

Preliminary revetment design for 100-year storm:

- 15 ft NAVD88 revetment crest
- 1V:2H slope
- Designed toe extents ~40 ft from wall
- Approx. 60% overtopping reduction
- 113,000 CY of armor stone required
- Footprint approximately 4.2 acres
- Approximate cost: $32,000,000



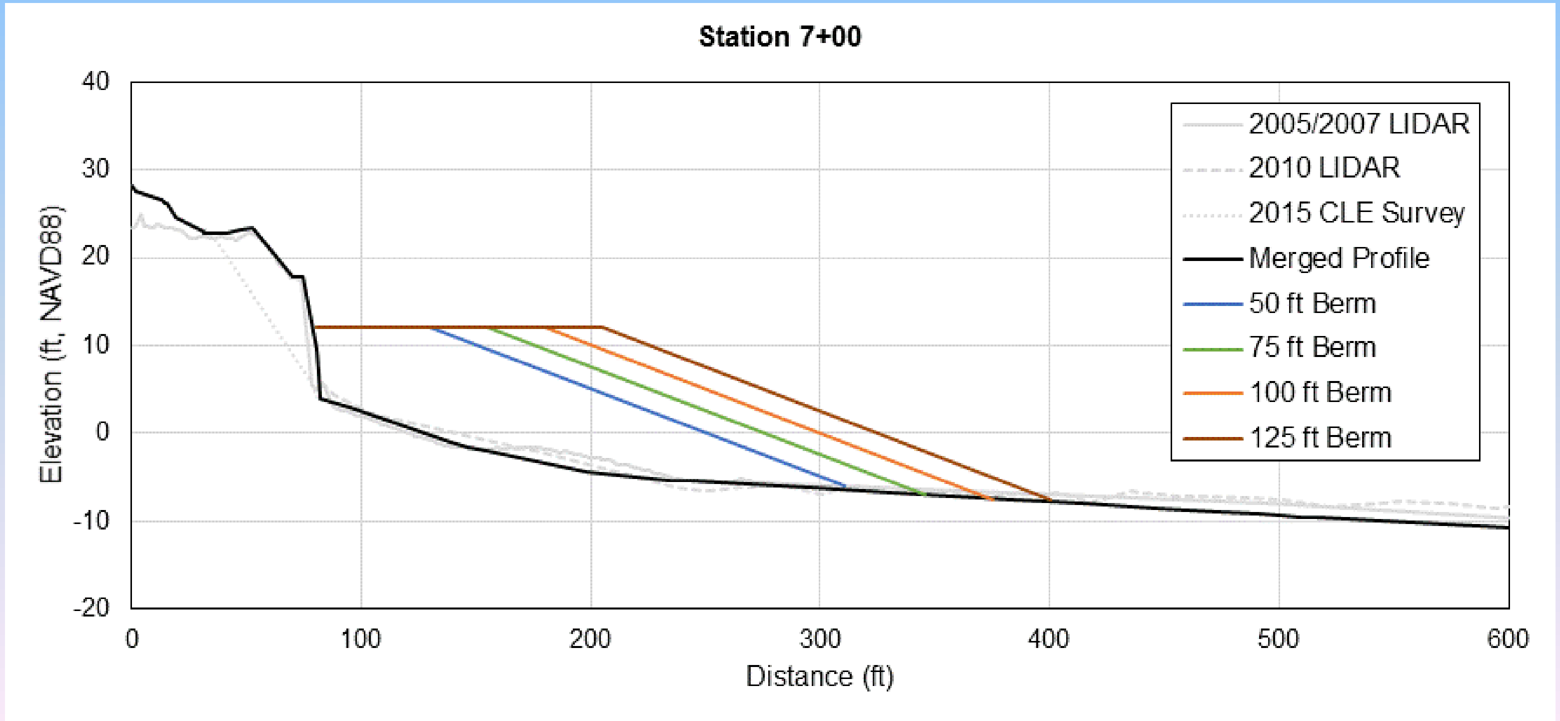
Shore Protection Alternatives

4. Beach Nourishment

Benefits	Disadvantages
• Restoration of the lost aerial and sub-tidal beach • Nourishment will provide wave dissipation and storm protection • Creation of a recreational resource • Provides downdrift sediment supply in the long-term	• Impacts and/or destruction to inter-tidal and sub-tidal habitats, benthic communities, and nearshore resources areas • Regular and episodic maintenance and re-nourishment required • Impacts to the community during construction due to the large number of trucks trips required to deliver the nourishment material to the project site

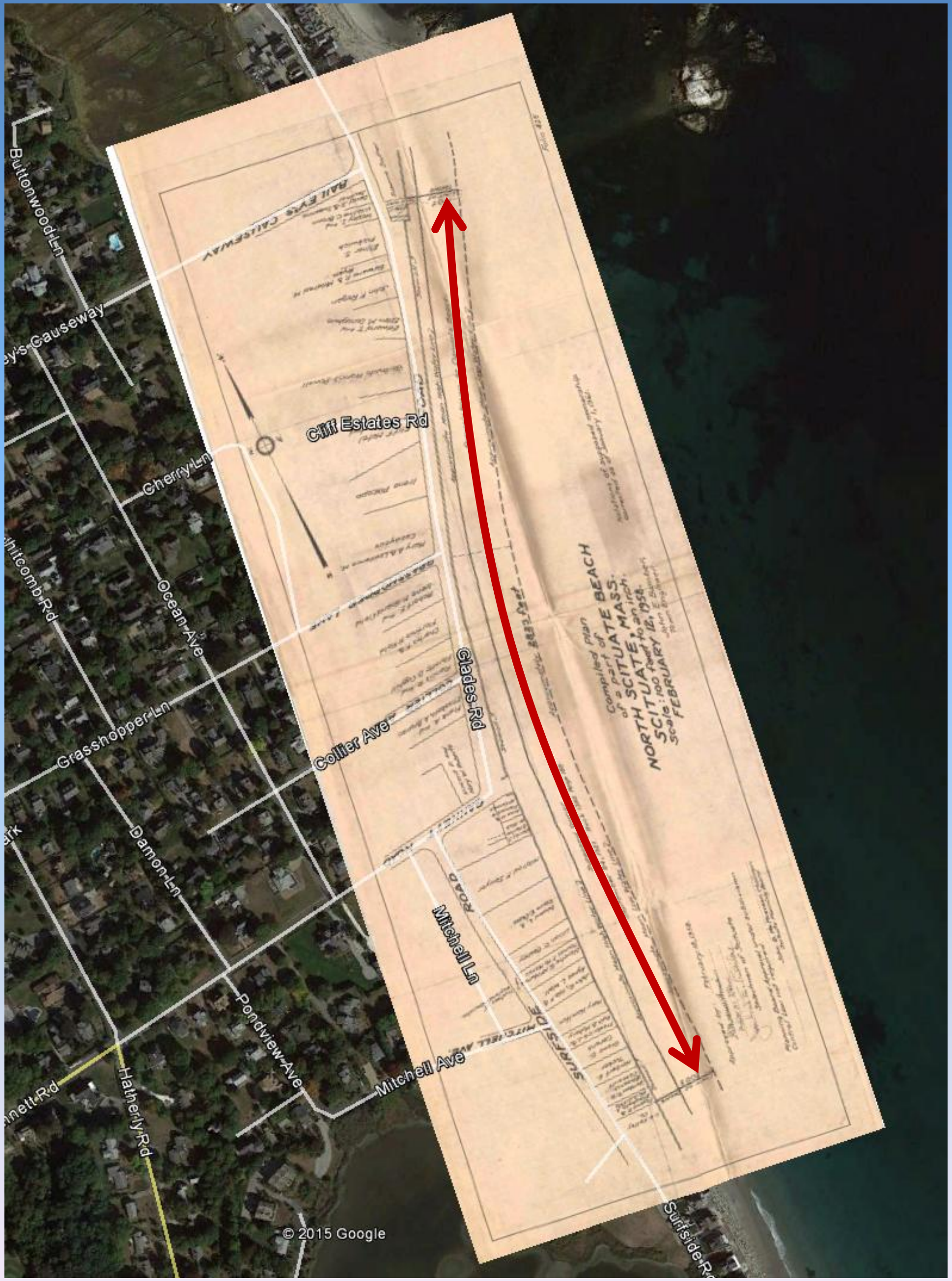
Engineered Beach Nourishment Berm Elevation

Return Period	Wind Speed (mph)	Significant Wave Height - Offshore (ft)	Significant Wave Height - Site (ft)	Peak Wave Period (s)	FEMA SWEL (ft, NAVD88)	$R_{2\%}$ (ft, NAVD88)
10-year	52.3	21.3	7.8	12.3	8.3	10.9
50-year	55.3	26.2	7.8	14.2	9.1	12.0
100-year	57.0	28.2	8.8	14.9	10.3	13.5



Existing Public Easement

- Approximate limits from the beach access parking lot south of Bailey’s Causeway to 350 feet south of Mitchell Avenue

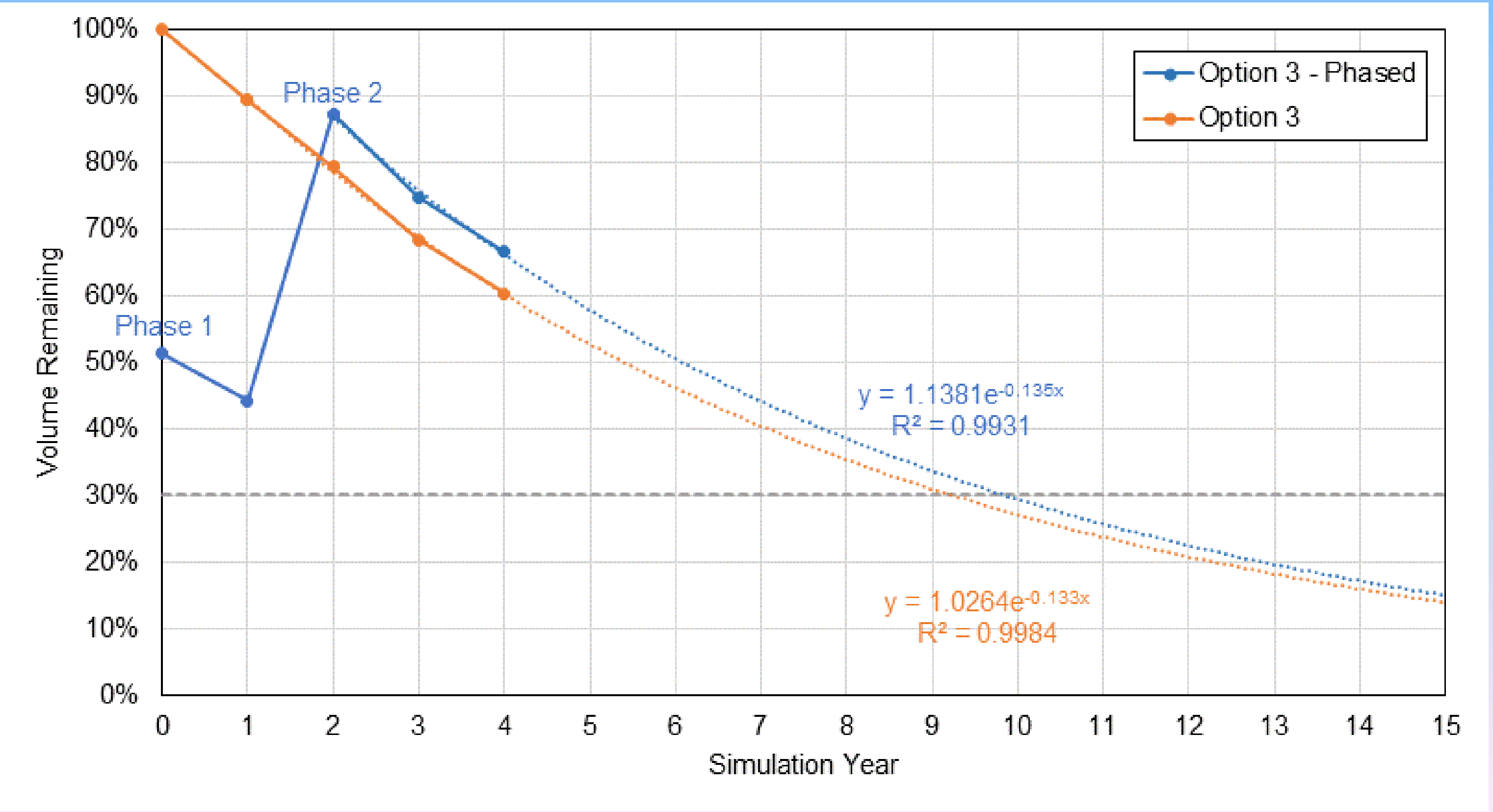


Plan from the Town of Scituate

Phasing – Option 3

- 50% of fill volume placed along southern half of wall (Station 14+00 to 29+00) at Year 0
- 50% of fill volume placed along northern half of wall (Station 3+00 to 14+00) at Year 2

Nourishment Option	Design Life (years)
3 (100 ft berm)	9
3 – phased (100 ft berm)	10



Approximate Cost

Option	Volume (cubic yards)	Design Life (years)	Cost*
1	164,000	6.5**	$5,576,000
2	203,000	7.5 (8 - phased)**	$6,902,000
3	243,000	9 (10 – phased)**	$8,262,000
4	281,000	11**	$9,554,000
5	315,000	6	$10,710,000
6	352,000	8	$11,968,000
7	391,000	10	$13,294,000

* Cost estimated at $34 per cubic yard based on Winthrop Beach nourishment project.

** The design life estimates the length of time that would be required for 70% of the nourishment template for the shorter template (Station 3+00 to 29+00) to migrate beyond Station 49+00 (the termination of the nourishment template for Options 5, 6, and 7).

Summary of Alternatives for North Scituate

Option	Footprint (acres)	Estimated Cost
Nearshore Breakwater	6.2	$23,000,000
Repair Seawall and Rebuild Revetment	4.2	$32,000,000
Beach Nourishment Option 1	14.2	$5,576,000
Beach Nourishment Option 2	15.8	$6,902,000
Beach Nourishment Option 3	17.4	$8,262,000
Beach Nourishment Option 4	18.6	$9,554,000
Beach Nourishment Option 5	27.0	$10,710,000
Beach Nourishment Option 6	28.5	$11,968,000
Beach Nourishment Option 7	30.0	$13,294,000

Questions?