Town of Falmouth
Climate Change Vulnerability Assessment and Adaptation Planning

Public Presentation

October 29, 2019

Town of Falmouth Primary Contact:
Jennifer McKay
Conservation Agent
Conservation Department

Project Manager:
Elise Leduc
Coastal Scientist
Woods Hole Group

Project Team:
Brittany Hoffnagle
Environmental Scientist
Woods Hole Group

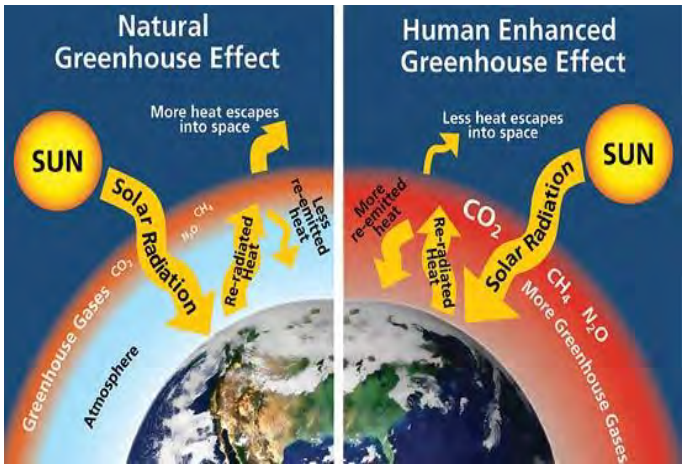
Vulnerability Assessment and Adaptation Planning
Presentation Outline

- Project Background and Need
- Analysis Methods
- Vulnerability Assessment Results
    1. Municipal Asset Results
    2. Natural Resources Impacts
- Recommended Actions

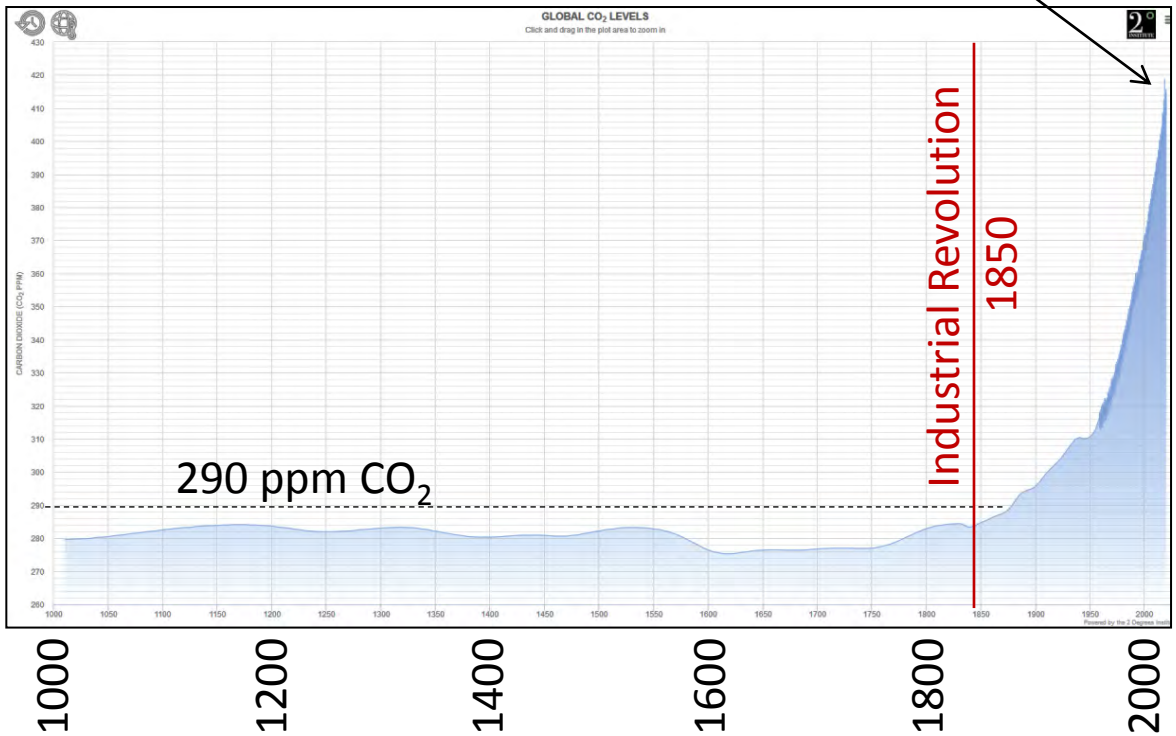
Project Background and Need

Climate Change – What's happening and why?

- Increasing concentrations of heat-trapping greenhouse gases, such as CO_2, are primarily responsible for the climate changes observed in the industrial era, especially over the last seven decades



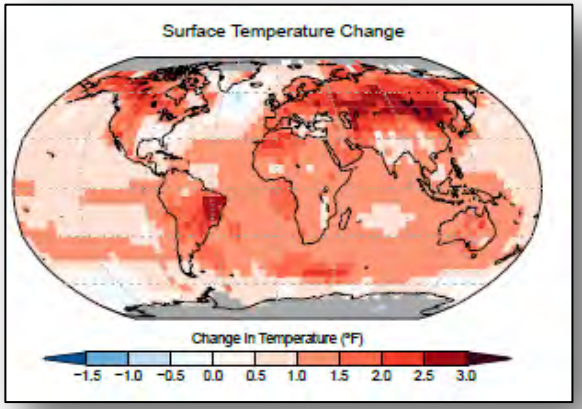
CO2 concentration > 400ppm
(9/23/19 from Mauna Loa Station)



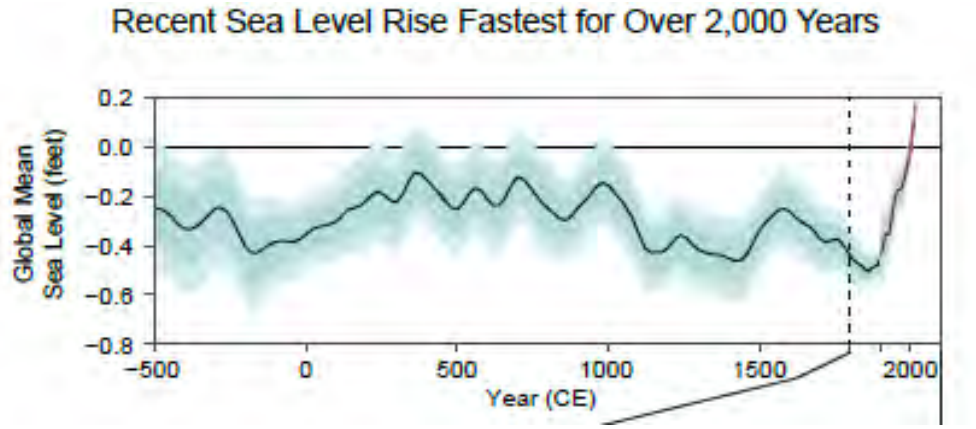
Project Background and Need

Climate Change – What's happening and why?

- Thousands of studies by researchers worldwide have documented temperature increases at the Earth's surface and in the ocean

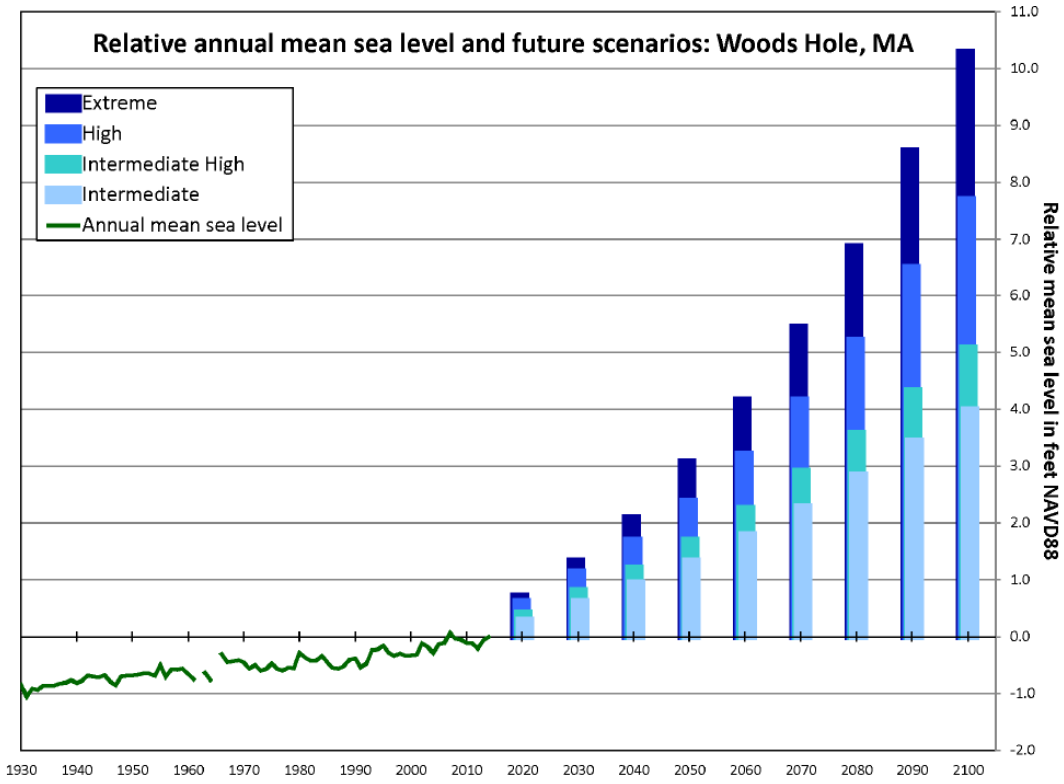


- Seas are warming and rising, and flooding is becoming more frequent along the U.S. coastline.



Project Background and Need
Climate Change – What's happening and why?

- Warmer oceans and melting ice caps will continue to contribute to sea-level rise in the future



Statewide hydrodynamic modeling uses "High" Scenario

High	Extremely unlikely to exceed (99.5%) under RCP8.5	1.1	2.4	4.2	7.7
	• Unlikely to exceed (83%) under RCP8.5 when accounting for possible ice sheet instabilities • Extremely unlikely to exceed (95%) under RCP4.5 when accounting for possible ice sheet instabilities				

Climate Change Flood Vulnerability Assessment

Project Goals and Objectives

- Provide data on likely future flooding scenarios
- Identify potential flooding impacts to municipally-owned infrastructure
- Identify potential sea-level rise impacts to natural resources
- Identify and prioritize potential adaptation strategies to reduce risk

Climate Change Flood Vulnerability Assessment
Project Methods

- Assess risk for each asset
  - Risk (R) = Probability of Flooding (P) x Consequence of Flooding (C)

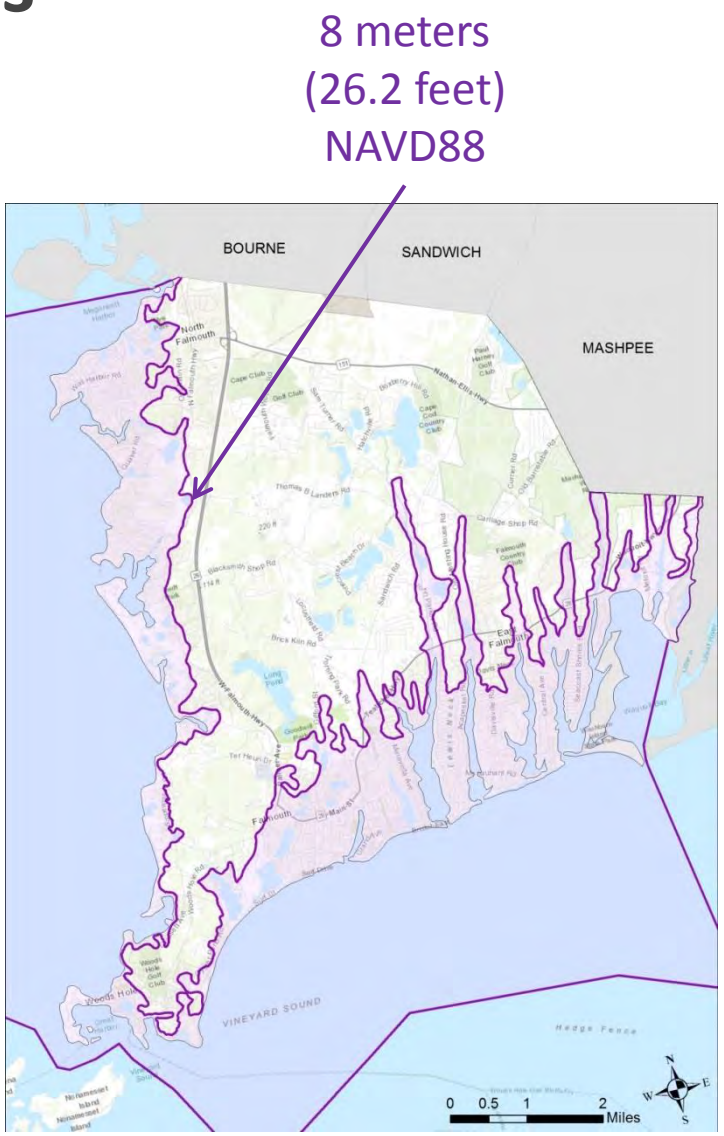
- 5 step process:
  1. Determine critical assets
  2. Determine consequence of flooding score
  3. Determine critical elevations
  4. Obtain probability of exceedance data
  5. Calculate risk scores and rankings

Step 1: Determine critical assets

The following municipally owned assets within the model grid were included in the analysis:

- Buildings
- Above ground utilities (e.g., wastewater lift stations)
- Roads and bridges
- Parking lots
- Recreational facilities (e.g., baseballs fields, tennis courts, etc.)
- Shining Sea Bike Path
- Trunk River sewer main

- Boat ramps
- Coastal infrastructure (e.g., seawalls, jetties, groins, etc.)



Step 2: Determine consequence of flooding

Rating	Area of Service Loss	Duration of Service Loss	Cost of Damage	Impact on Public Safety & Emergency Services	Impact on Important Economic Activities	Impact on Public Health & Environment
5	Whole town/city	> 30 days	> $10m	Very high	Very high	Very high
4	Multiple neighborhoods	14 - 30 days	$1m - $10m	High	High	High
3	Neighborhood	7 - 14 days	$100k - $1m	Moderate	Moderate	Moderate
2	Locality	1 - 7 days	$10k - $100k	Low	Low	Low
1	Property	< 1 day	< $10k	None	None	None

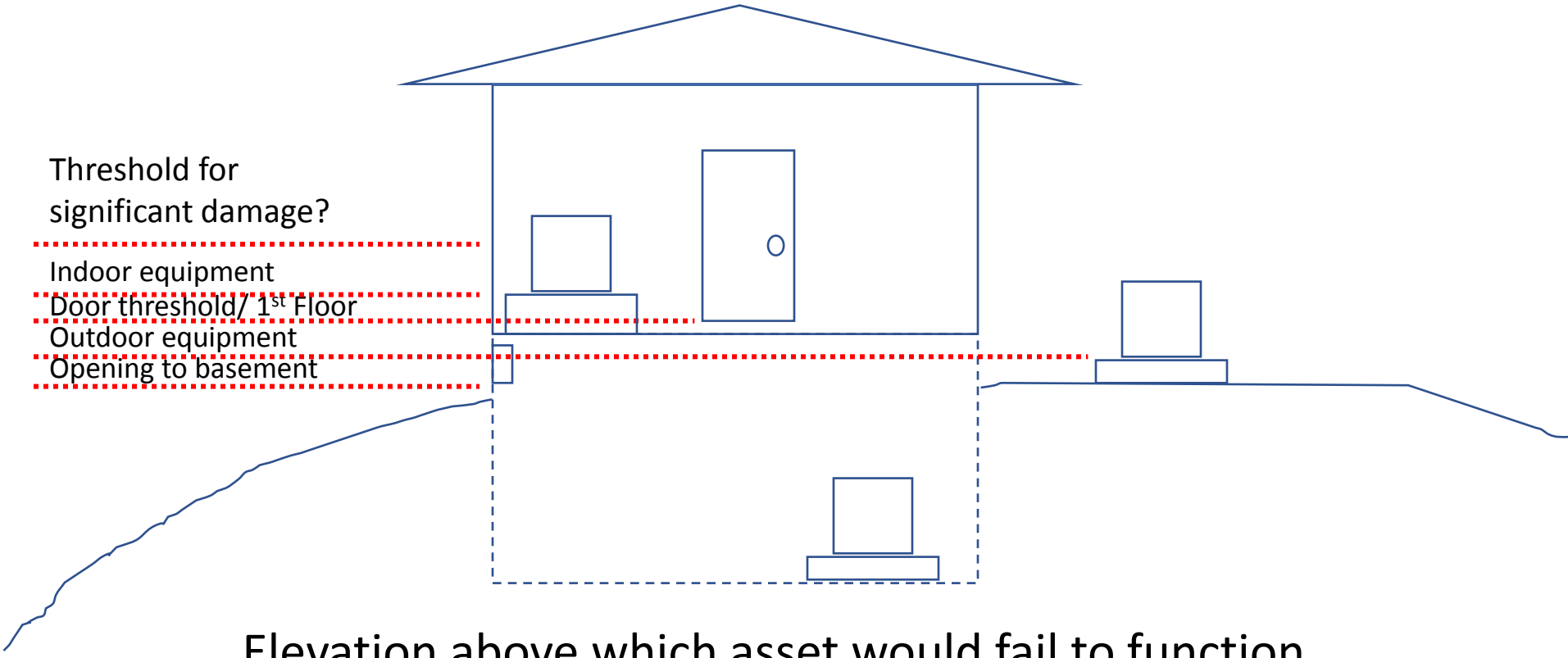
Risk (R) = Probability of Flooding (P) x **Consequence of Flooding (C)**

Step 2: Determine consequence of flooding

Asset Name	Area of Service Loss	Duration of Service Loss	Cost of Damage	Impact on Public Safety & Emergency Services	Impact on Important Economic Activities	Impact on Public Health & Environment	Total Consequence Score
Town Hall - Main Building	5	3	3	4	4	4	77
Town Hall - Storage Shed	1	2	1	1	1	1	23
Chamber of Commerce	4	3	3	1	4	1	53
Department of Public Works - Fuel Tanks	4	2	2	4	2	4	60
Falmouth Police Department - Main Building	5	3	4	5	2	3	73
Falmouth Police Department - Shed	1	2	1	2	1	1	27
Falmouth Library Main	5	3	3	2	3	1	57
East Falmouth Public Library	3	3	3	2	2	1	47

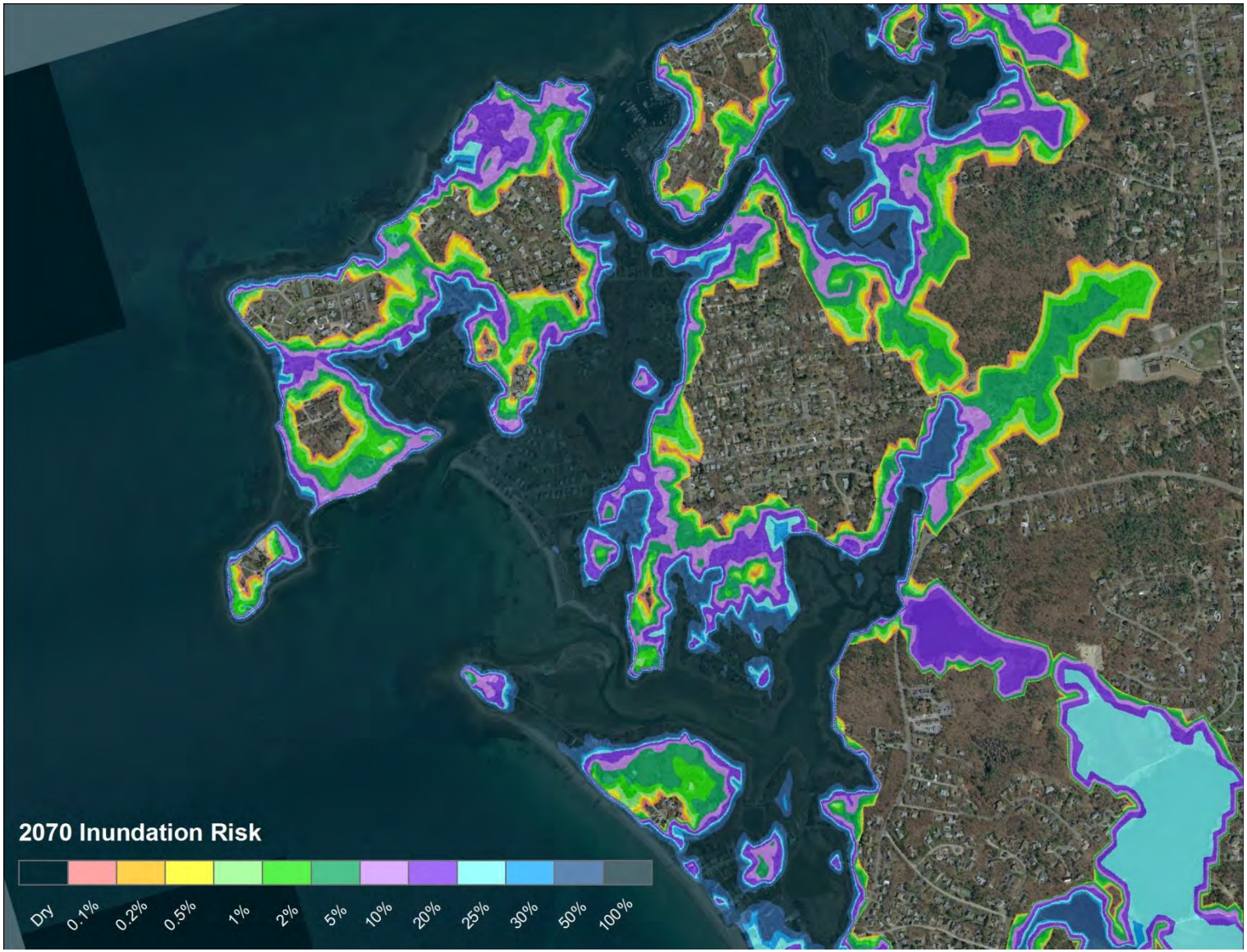
Risk (R) = Probability of Flooding (P) x **Consequence of Flooding (C)**

Step 3: Determine critical elevations

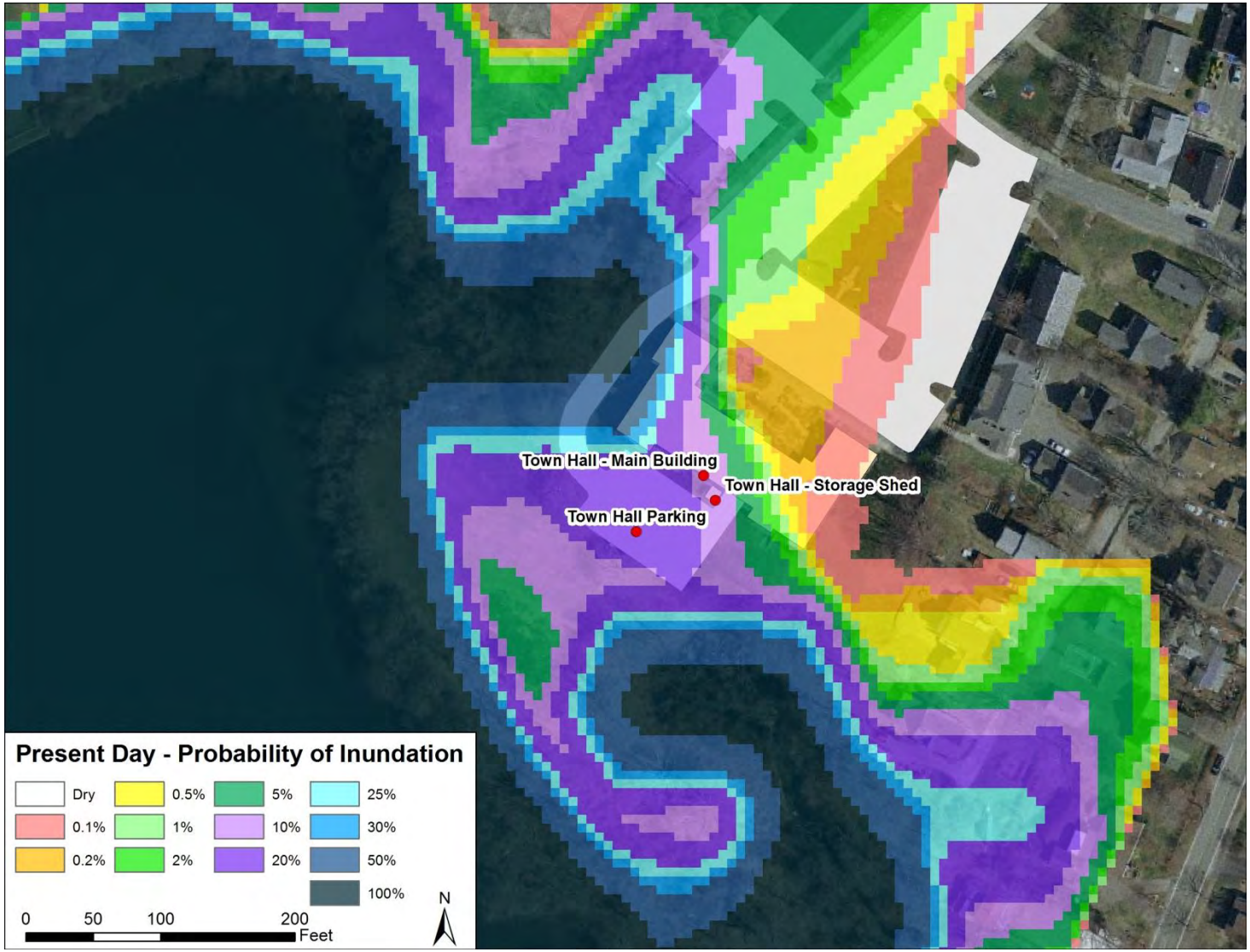


Elevation above which asset would fail to function

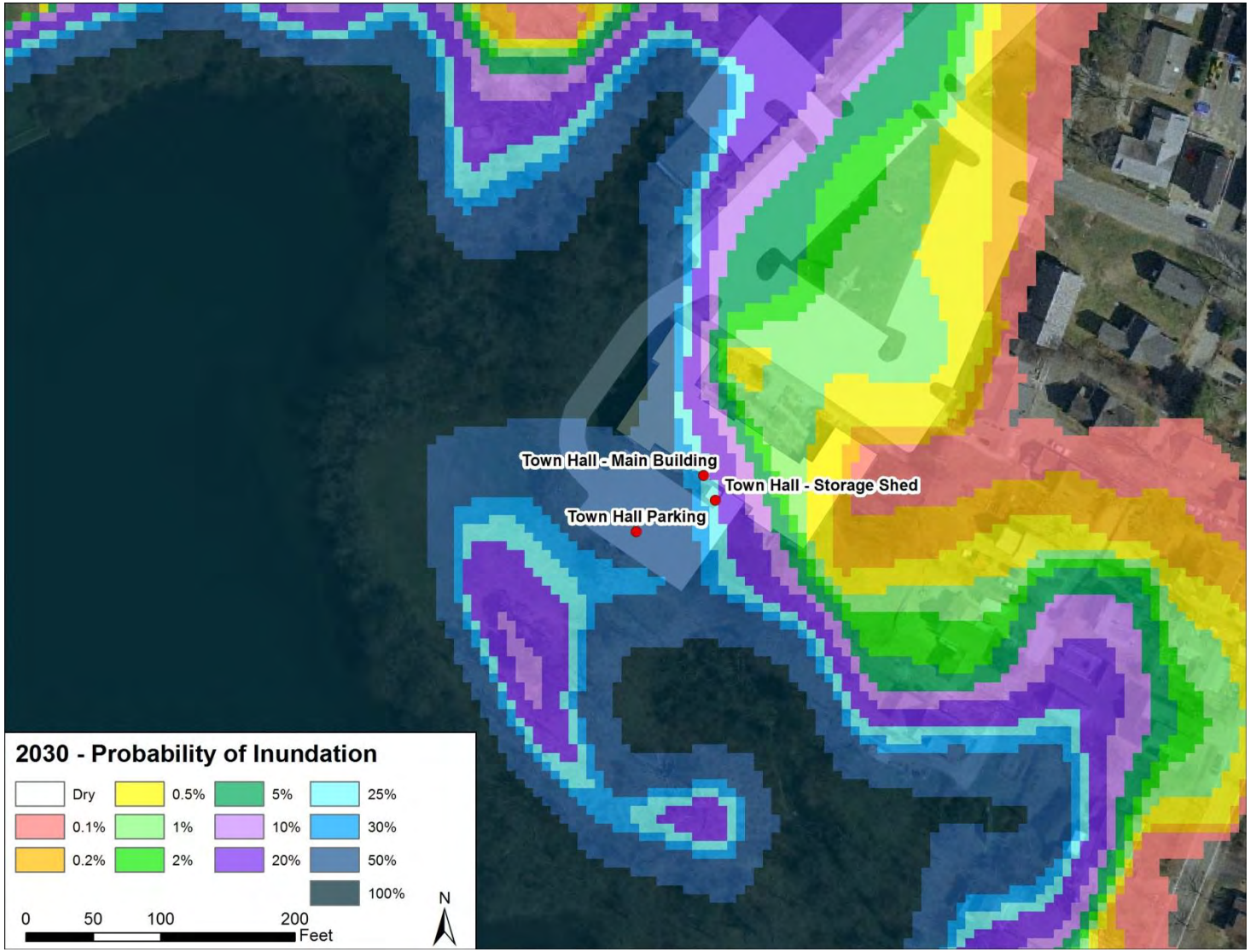
Step 4: Obtain Probability of Exceedance Data



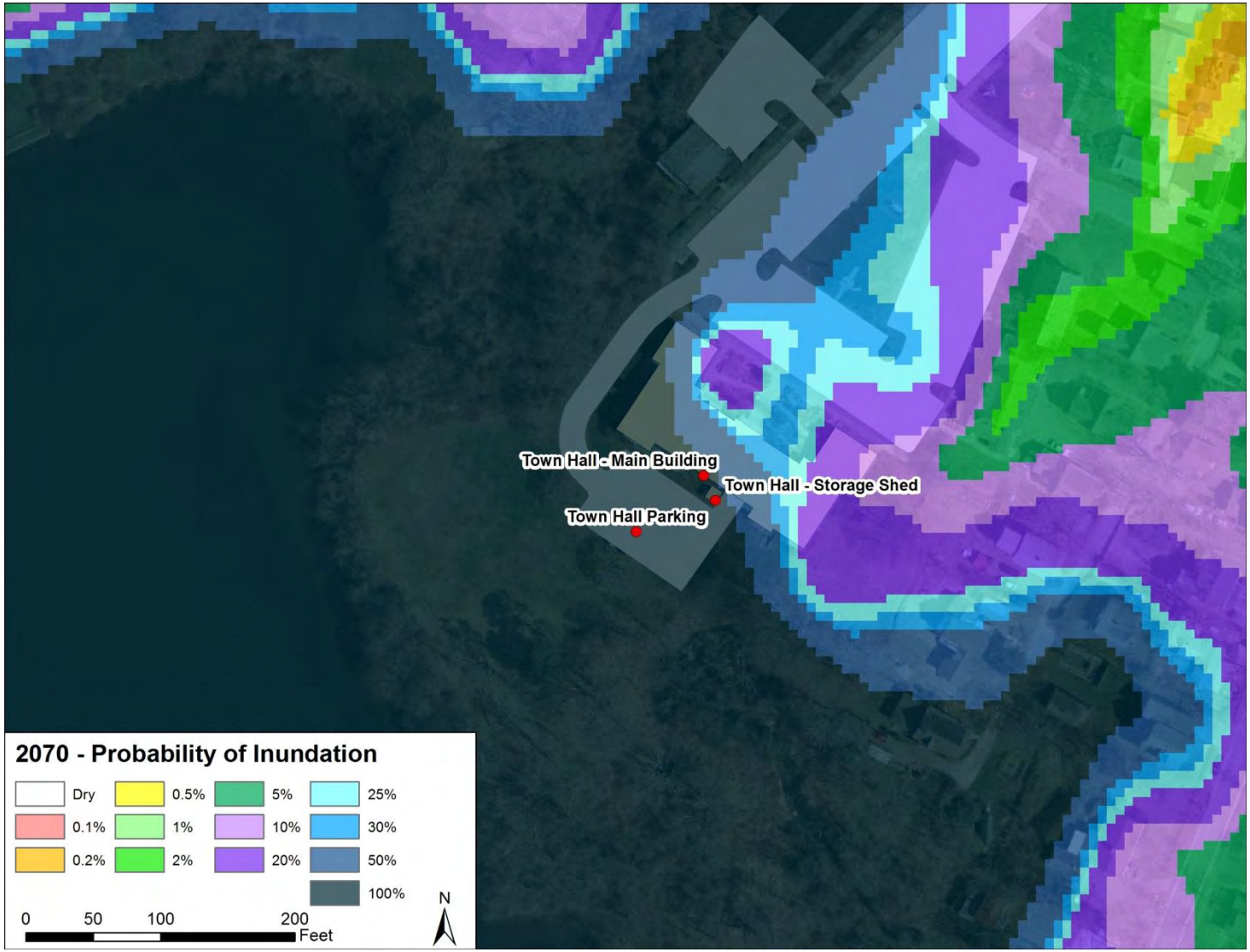
Step 4: Obtain Probability of Exceedance Data



Step 4: Obtain Probability of Exceedance Data



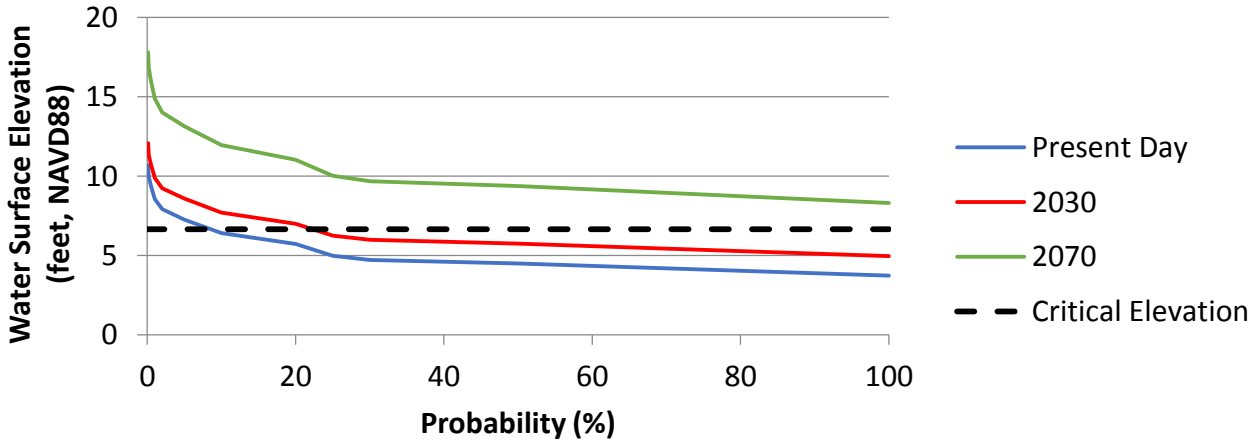
Step 4: Obtain Probability of Exceedance Data



Step 4: Obtain Probability of Exceedance Data

Town Hall: Critical elevation = 6.7 feet (NAVD88)

% Probability	Present		2030		2070	
	Flood Elevation	Depth Above Critical Elev.	Flood Elevation	Depth Above Critical Elev.	Flood Elevation	Depth Above Critical Elev.
0.1	10.7	4.0	12.1	5.4	17.8	11.1
0.2	10.0	3.3	11.3	4.7	16.8	10.2
0.5	9.4	2.7	10.7	4.1	16.0	9.3
1	8.5	1.9	9.9	3.2	14.9	8.2
2	7.9	1.3	9.2	2.6	14.0	7.4
5	7.3	0.6	8.6	1.9	13.1	6.5
10	6.4	dry	7.7	1.0	12.0	5.3
20	5.7	dry	7.0	0.3	11.0	4.4
25	5.0	dry	6.2	dry	10.0	3.4
30	4.7	dry	6.0	dry	9.7	3.0
50	4.5	dry	5.7	dry	9.4	2.7
100	3.7	dry	5.0	dry	8.3	1.7



Step 5: Calculate Risk Scores and Rankings

Time horizon	Probability of Exceedance	Consequence Score	Risk Score	Weight	Composite Risk Score
Present	5	77	383	0.5	2185
2030	20	77	1533	0.3	
2070	100	77	7667	0.2	

$$R_{comp} = (R_{present} \times W_{present}) + (R_{2030} \times W_{2030}) + (R_{2070} \times W_{2070})$$

Step 5: Calculate Risk Scores and Rankings

Top 20 ranked buildings and structures

Rank	Asset Name	Asset Type	Consequence Score	Present Probability (%)	2030 Probability (%)	2070 Probability (%)	Composite Risk Score
1	Park Road Sewer Lift Station	Sewer	37	100	100	100	3667
2	Old Dock Road Pier Upwellers	Marine	40	50	100	100	3000
3	Woods Hole Draw Bridge Hut	Marine	57	25	50	100	2692
4	Old Dock Road Pier Shed	Marine	33	50	100	100	2500
5	Old Silver Beach (South) Pedestrian Ramp	Rec	33	50	100	100	2500
6	Town Hall - Main Building	Admin	77	5	20	100	2185
7	Mitchell Bathhouse	Rec	43	20	50	100	1950
8	Inner Harbor Upwellers	Marine	40	10	50	100	1600
9	Woods Hole Sewer Lift Station	Sewer	53	5	10	100	1360
10	Surf Drive Sewer Lift Station	Sewer	43	10	20	100	1343
11	Woods Hole Community Building	Admin	37	10	20	100	1137
12	Inner Harbor - Electrical Shed	Marine	50	1	5	100	1100
13	Inner Harbor - Charter Boat Shed	Marine	33	10	25	100	1083
14	Woods Hole Draw Bridge Hut Generator	Marine	43	5	5	100	1040
15	Town Hall - Storage Shed	Admin	23	5	20	100	665
16	Woods Hole Sewer Lift Station Wet Well	Sewer	47	1	5	50	560
17	Inner Harbor - Garage	Marine	40	0.5	2	50	434
18	Inner Harbor Sewer Lift Station	Sewer	57	0.2	1	30	363
19	Old Silver Beach (North) Bathhouse	Rec	43	1	2	25	264
20	Mullen Hall School - Main Building	School	63	0	0	20	253

Step 5: Calculate Risk Scores and Rankings

Top 20 ranked roads

Rank	Asset Name	Consequence Score	Present Probability (%)	2030 Probability (%)	2070 Probability (%)	Composite Risk Score
1	Water St (Luscombe Ave to Drawbridge)	67	99	99	100	6635
2	Chapoquoit Rd (Little Neck Bars Rd to Bridge)	57	95	100	100	5546
3	Clinton Ave (Swing Lane to Scranton)	67	73	83	100	5464
4	Scranton Ave (Lowry Road to Clinton)	67	69	83	100	5312
5	Waquoit Hwy (Waquoit Landing Rd to Childs River)	53	100	100	100	5300
6	Menauhant Rd (Grand to Maravista)	53	100	100	100	5300
7	Surf Dr (Mill Rd to Bywater Ct)	53	95	97	100	5115
8	Clinton Ave (Swing Ln to Sheridan Ave)	63	68	77	100	4859
9	Surf Dr (Elm Rd to Mill Rd)	57	77	87	100	4805
10	Menauhant Rd (Foster Rd to Central)	57	73	91	100	4768
11	West Ave	53	86	90	100	4766
12	Nashawena St (Lummis Ln to Pine Island Cir)	47	100	100	100	4700
13	Nashawena St (Cordwood Landing Rd to Swift St)	60	66	78	99	4579
14	Old Dock Rd (Bowline Rd to Chapoquoit Rd)	60	68	75	97	4568
15	Quissett Harbor Rd	53	79	83	100	4455
16	Mill Rd (Hedge Ln to Seagull Ln)	57	66	78	100	4363
17	Mill Rd (Seagull Ln to Surf Dr)	57	64	75	100	4260
18	Menauhant Rd (Acapesket Rd to Green Harbor Rd)	43	98	98	100	4234
19	Nashawena St (Pine Island Cir to Cordwood Landing Road)	60	61	73	89	4206
20	Chapoquoit Rd (Little Neck Bars Rd to Chapoquoit Rd)	57	67	70	96	4189

Step 5: Calculate Risk Scores and Rankings

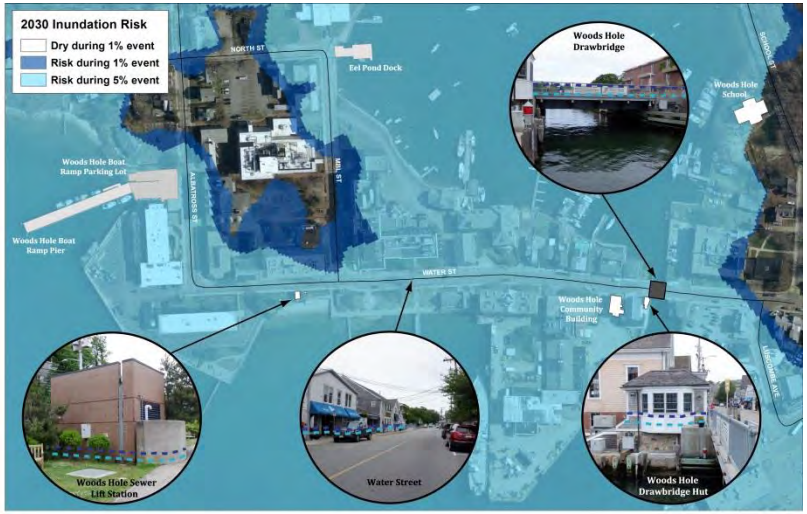
Top 20 ranked assets (overall)

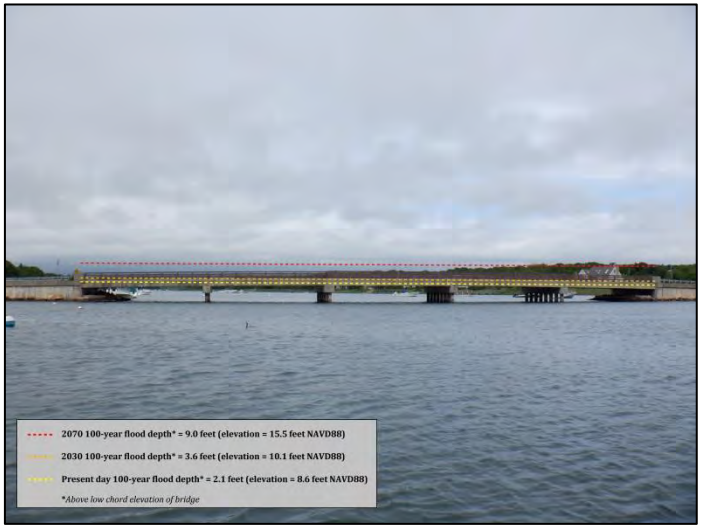
Rank	Asset Name	Asset Type	Consequence Score	Present Probability (%)	2030 Probability (%)	2070 Probability (%)	Composite Risk Score
1	Water St (Luscombe Ave to Drawbridge)	Road	67	99	99	100	6635
2	Chapoquoit Rd (Little Neck Bars Rd to Bridge)	Road	57	95	100	100	5546
3	Clinton Ave (Swing Ln to Scranton Ave)	Road	67	73	83	100	5464
4	Menauhant Road (At Bristol Beach/Little Pond)	Bridge	53	100	100	100	5333
5	Scranton Ave (Lowry Rd to Clinton Ave)	Road	67	69	83	100	5312
6	Waquoit Hwy (Waquoit Landing Rd to Childs River)	Road	53	100	100	100	5300
7	Surf Dr (Mill Rd to Bywater Ct)	Road	53	95	97	100	5115
8	Trunk River Sewer Main	Sewer Main	50	100	100	100	5000
9	Clinton Ave (Swing Ln to Sheridan Ave)	Road	63	68	77	100	4859
10	Surf Dr (Elm Rd to Mill Rd)	Road	57	77	87	100	4805
11	Nashawena St (Lummis Ln to Pine Island Cir)	Road	47	100	100	100	4700
12	Falmouth Harbor Dock (6)	Docks & Piers	47	100	100	100	4667
13	Nashawena St (Cordwood Landing Rd to Swift St)	Road	60	66	78	99	4579
14	Old Dock Rd (Bowline Rd to Chapoquoit Rd)	Road	60	68	75	97	4568
15	Mill Rd (Hedge Ln to Seagull Ln)	Road	57	66	78	100	4363
16	Falmouth Harbor Clinton Ave Wharf	Docks & Piers	43	100	100	100	4333
17	Falmouth Harbor Dock (1)	Docks & Piers	43	100	100	100	4333
18	Falmouth Harbor Dock (2)	Docks & Piers	43	100	100	100	4333
19	Falmouth Harbor Dock (3)	Docks & Piers	43	100	100	100	4333
20	Falmouth Harbor Dock (4)	Docks & Piers	43	100	100	100	4333

Vulnerability Assessment – Other Deliverables

Asset Specific Visualizations

- Asset Specific Visualizations
  - Mitchell Bathhouse
  - Green Pond Bridge
  - Water Street





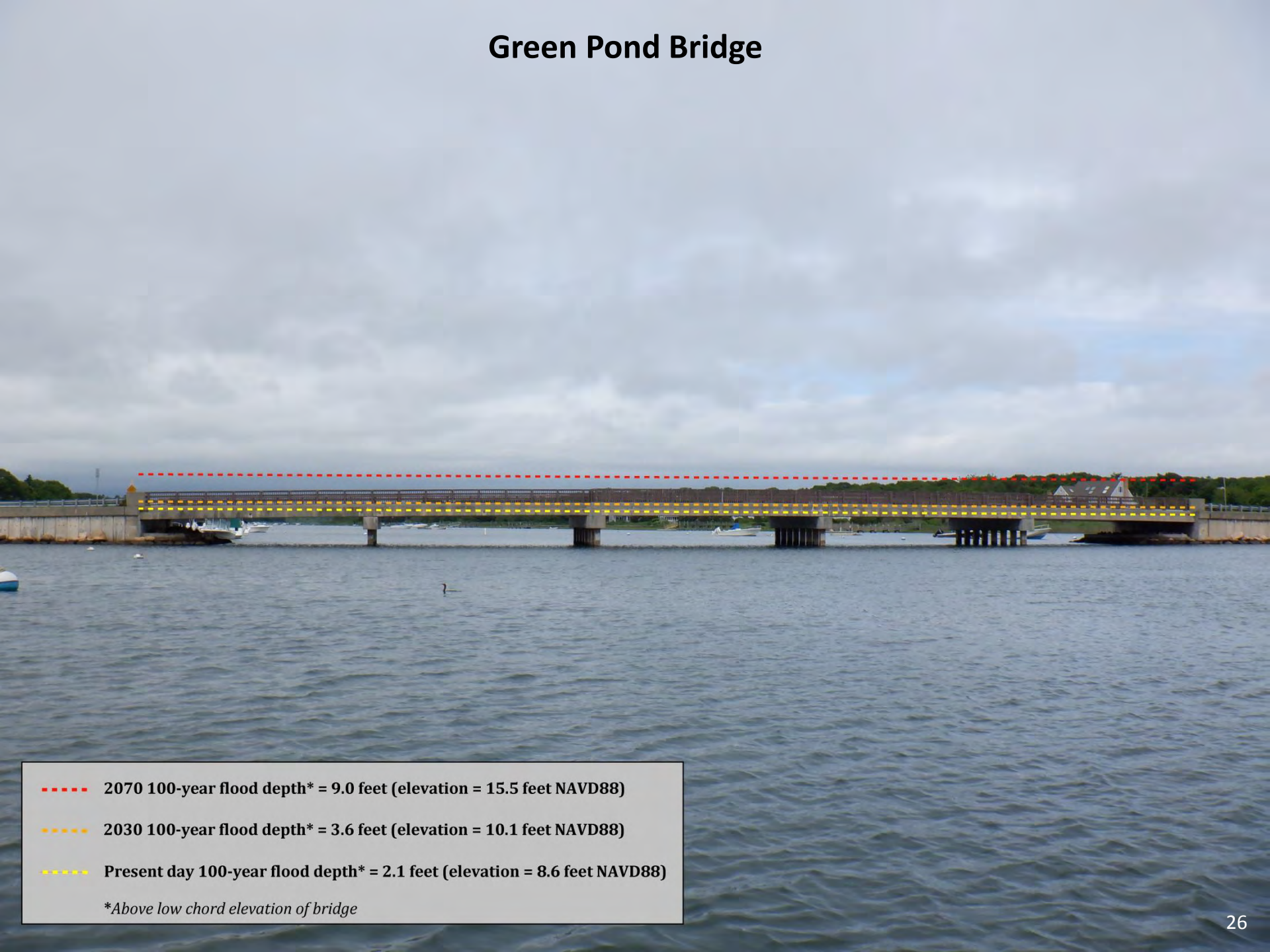
Mitchell Bathhouse


2019 100-year event


2030 100-year event


2070 100-year event

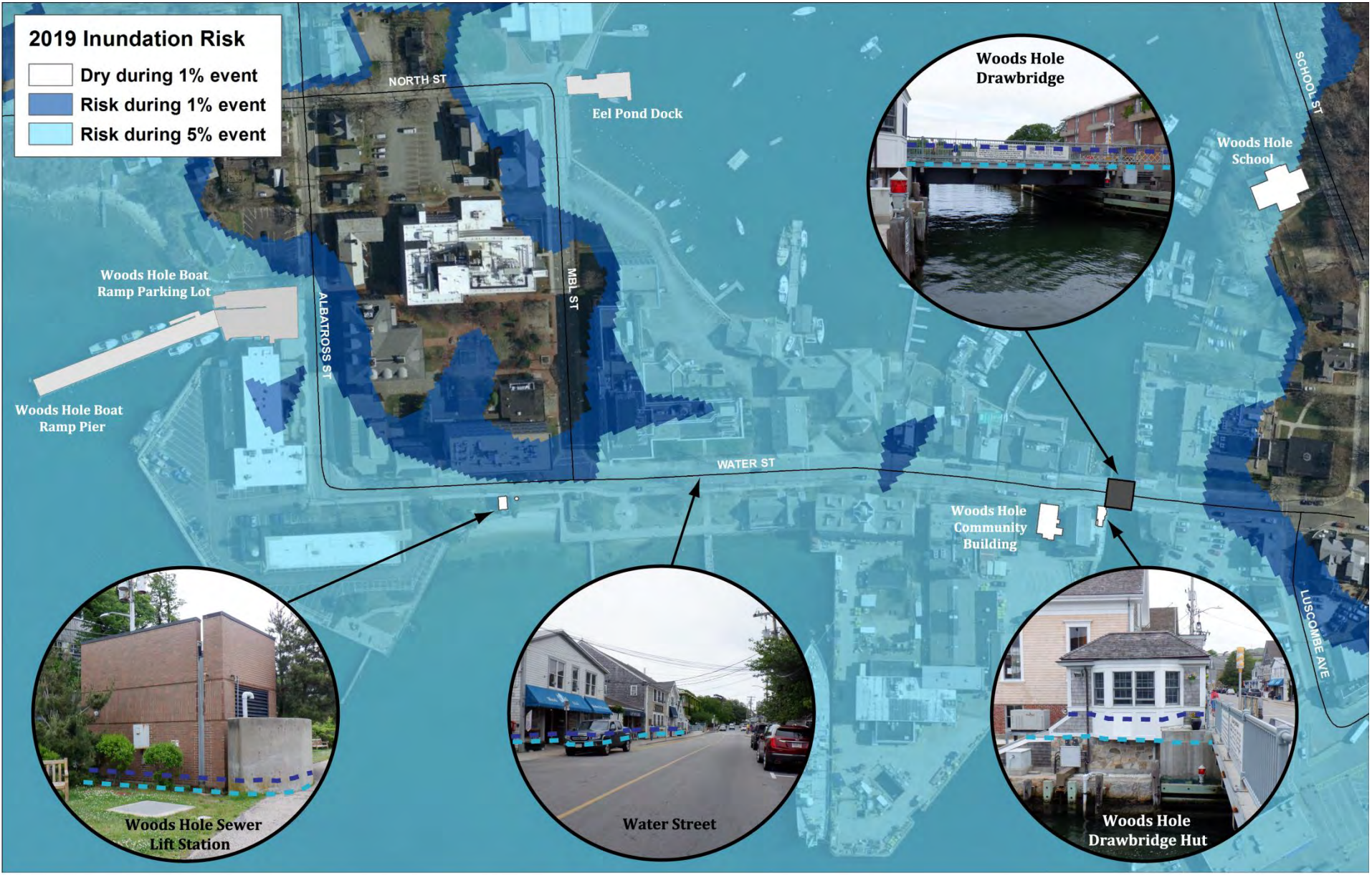
Green Pond Bridge

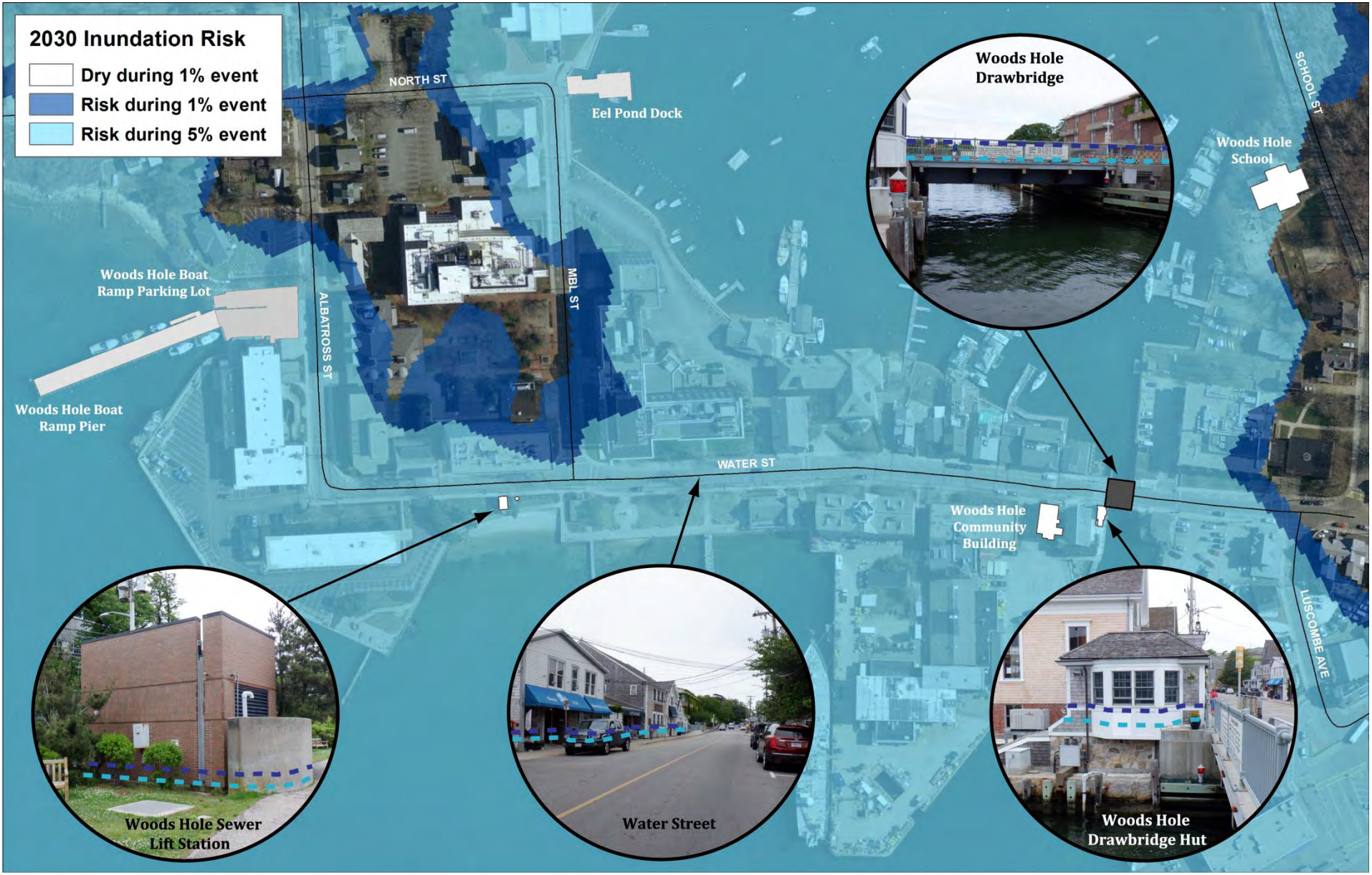


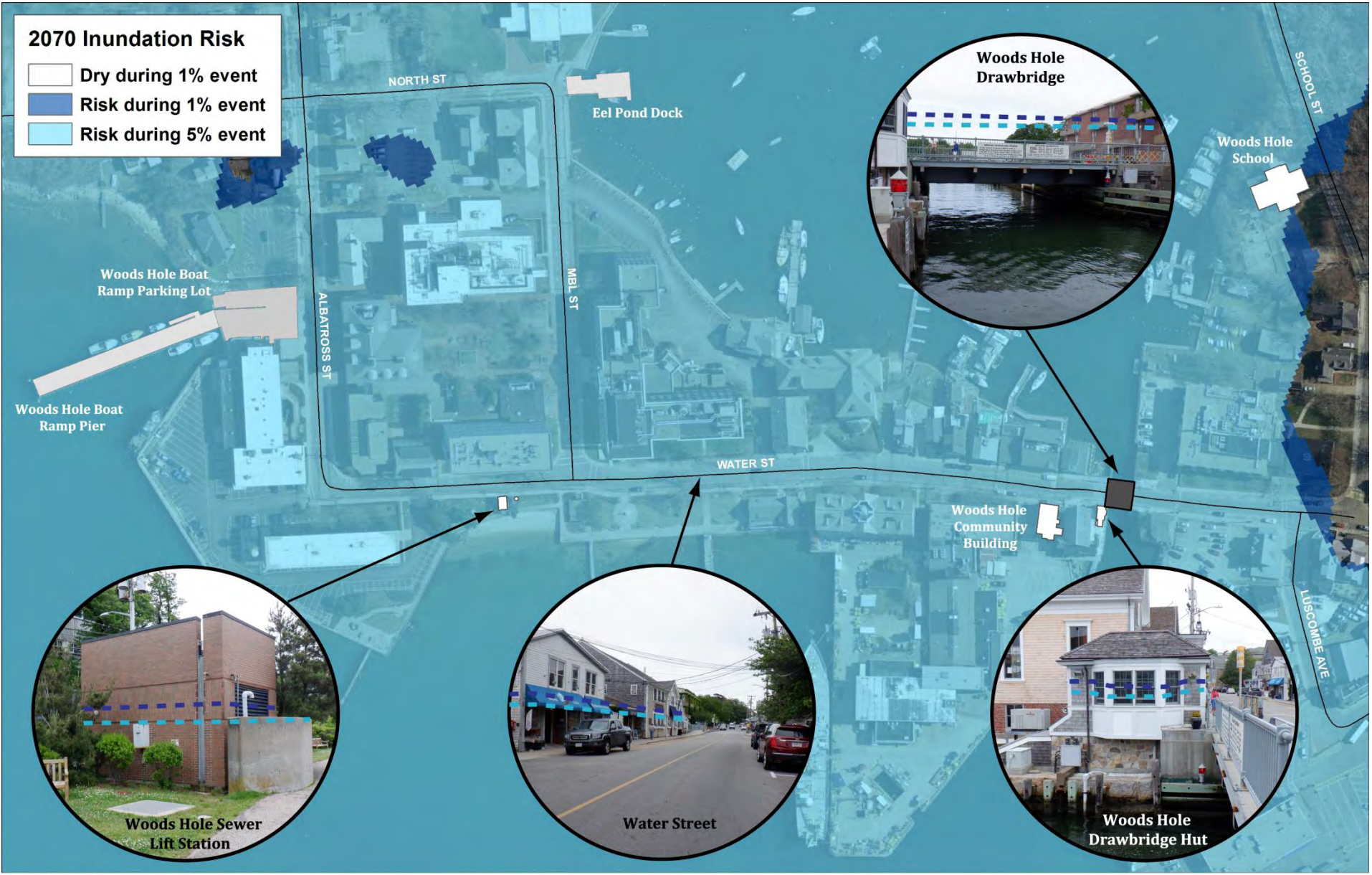

2019 100-year event


2030 100-year event


2070 100-year event


2019 Inundation Risk
Dry during 1% event
Risk during 1% event
Risk during 5% event
NORTH ST
Eel Pond Dock
Woods Hole Drawbridge
SCHOOL ST
Woods Hole School
Woods Hole Boat Ramp Parking Lot
ALBATROSS ST
MBL ST
Woods Hole Boat Ramp Pier
WATER ST
Woods Hole Community Building
LUSCOMBE AVE
Woods Hole Sewer Lift Station
Water Street
Woods Hole Drawbridge Hut


2030 Inundation Risk
Dry during 1% event
Risk during 1% event
Risk during 5% event
NORTH ST
Eel Pond Dock
Woods Hole Drawbridge
SCHOOL ST
Woods Hole School
Woods Hole Boat Ramp Parking Lot
ALBATROSS ST
MBL ST
Woods Hole Boat Ramp Pier
WATER ST
Woods Hole Community Building
LUSCOMBE AVE
Woods Hole Sewer Lift Station
Water Street
Woods Hole Drawbridge Hut

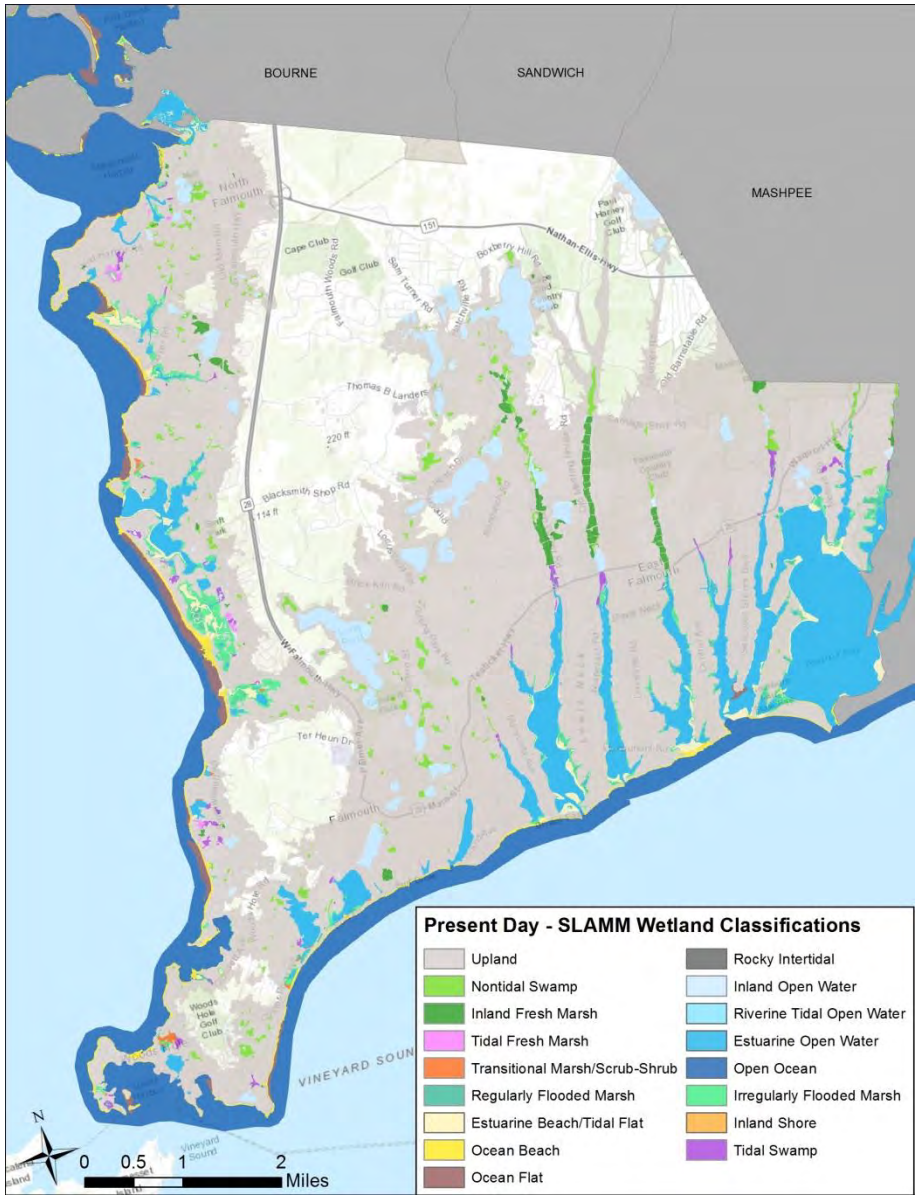

2070 Inundation Risk
Dry during 1% event
Risk during 1% event
Risk during 5% event
NORTH ST
Eel Pond Dock
Woods Hole Drawbridge
SCHOOL ST
Woods Hole School
Woods Hole Boat Ramp Parking Lot
ALBATROSS ST
MBL ST
Woods Hole Boat Ramp Pier
WATER ST
Woods Hole Community Building
LUSCOMBE AVE
Woods Hole Sewer Lift Station
Water Street
Woods Hole Drawbridge Hut

Vulnerability Assessment

Assessment of Impacts to Natural Resources: SLAMM Results

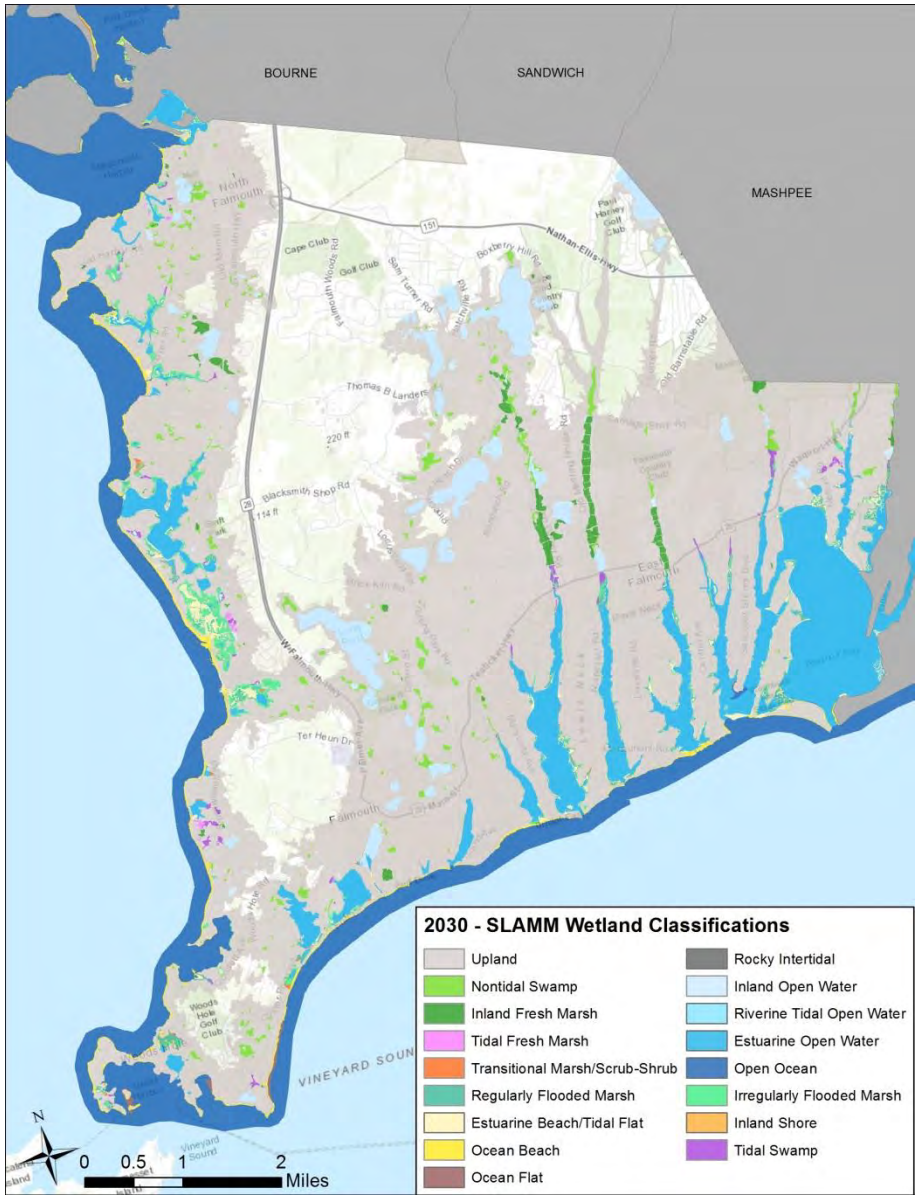
Vulnerability Assessment

SLAMM Results – Present Day



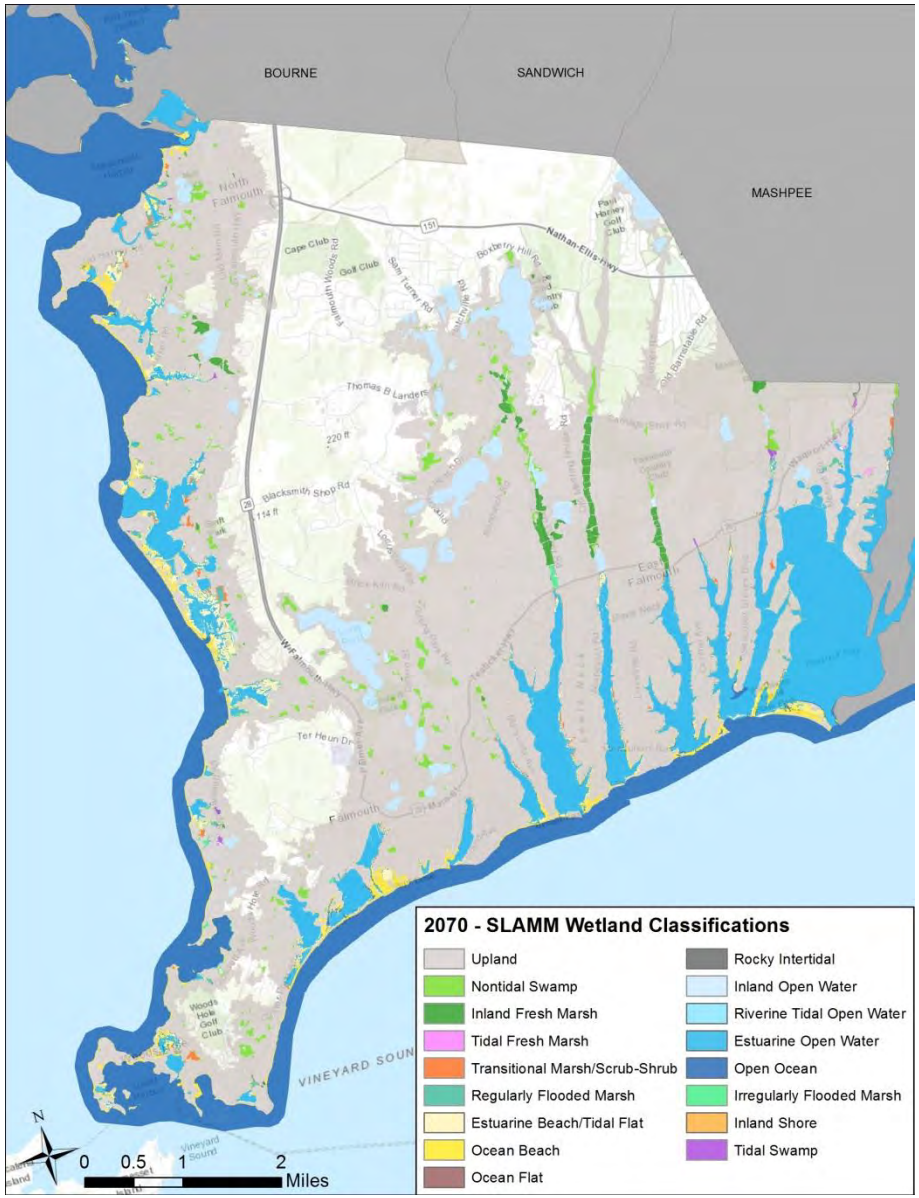
Vulnerability Assessment

SLAMM Results – 2030



Vulnerability Assessment

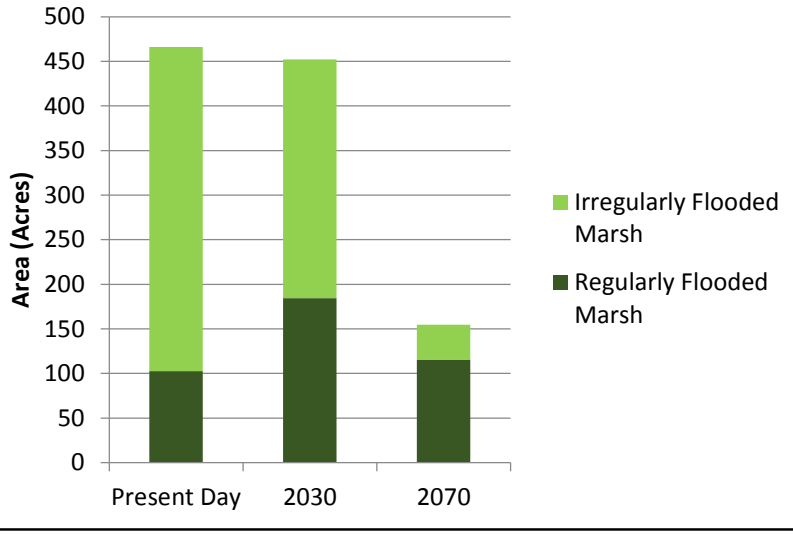
SLAMM Results – 2070

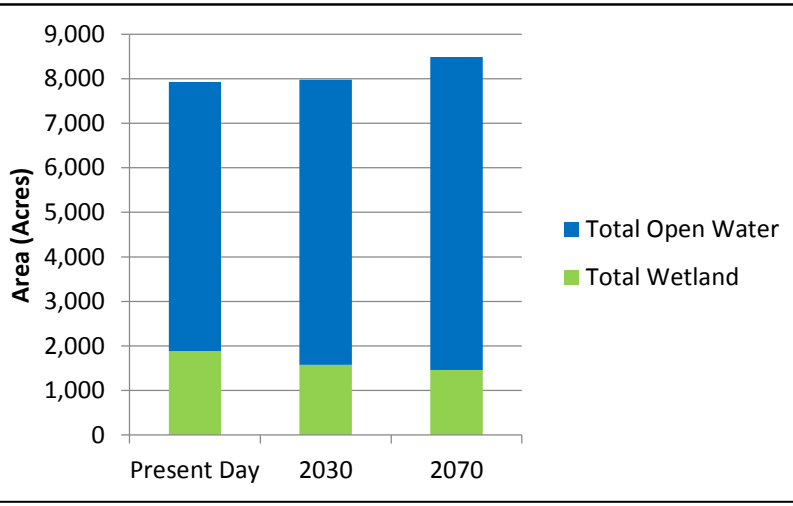


Vulnerability Assessment

SLAMM Results – Townwide Changes

	Area (acres)		
	Present Day	2030	2070
Upland	16,689.6	16,640.3	16,134.5
Nontidal Swamp	327.4	326.5	302.7
Inland Fresh Marsh	209.1	206.6	192.2
Tidal Fresh Marsh	23.0	17.4	6.1
Transitional Marsh/Scrub-Shrub	17.7	20.6	80.5
Regularly Flooded Marsh	102.6	184.5	115.7
Estuarine Beach/Tidal Flat	273.8	226.5	336.5
Ocean Beach	274.7	228.4	368.0
Ocean Flat	206.1	30.6	0.9
Inland Open Water	952.5	948.9	895.9
Estuarine Open Water	2,099.2	2,225.1	2,737.9
Open Ocean	2,989.1	3,227.5	3,389.3
Irregularly Flooded Marsh	363.6	267.8	38.8
Tidal Swamp	89.2	67.1	18.8





Vulnerability Assessment

SLAMM Results – Site-specific Changes

All public beaches:

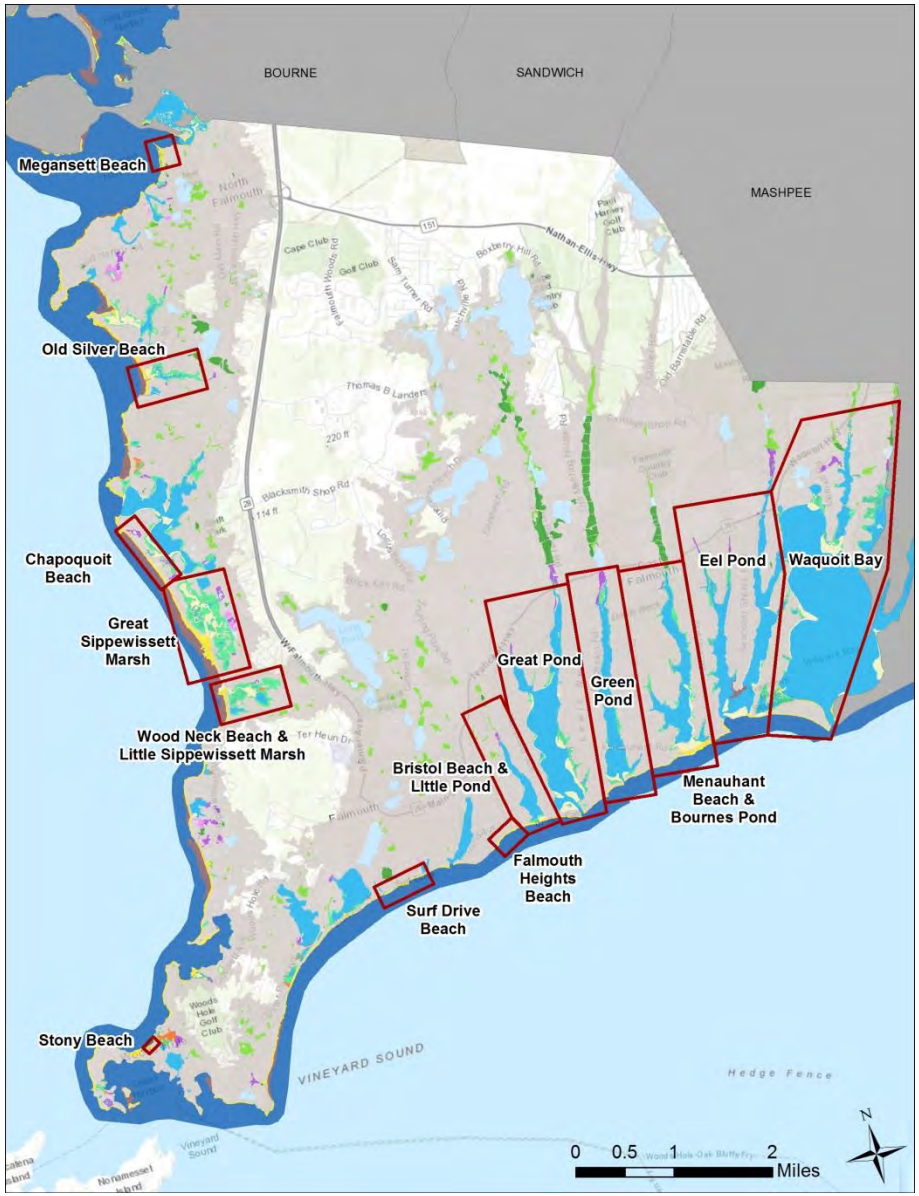
- Bristol Beach
- Chapoquoit Beach
- Falmouth Heights Beach
- Megansett Beach
- Menauhant Beach
- Old Silver Beach
- Stoney Beach
- Surf Drive Beach
- Wood Neck Beach

Other major coastal wetlands:

- The marsh system behind Old Silver Beach
- Great Sippewissett Marsh
- Little Sippewissett Marsh
- Little Pond
- Great Pond
- Green Pond
- Bournes Pond
- Eel Pond
- Waquoit Bay

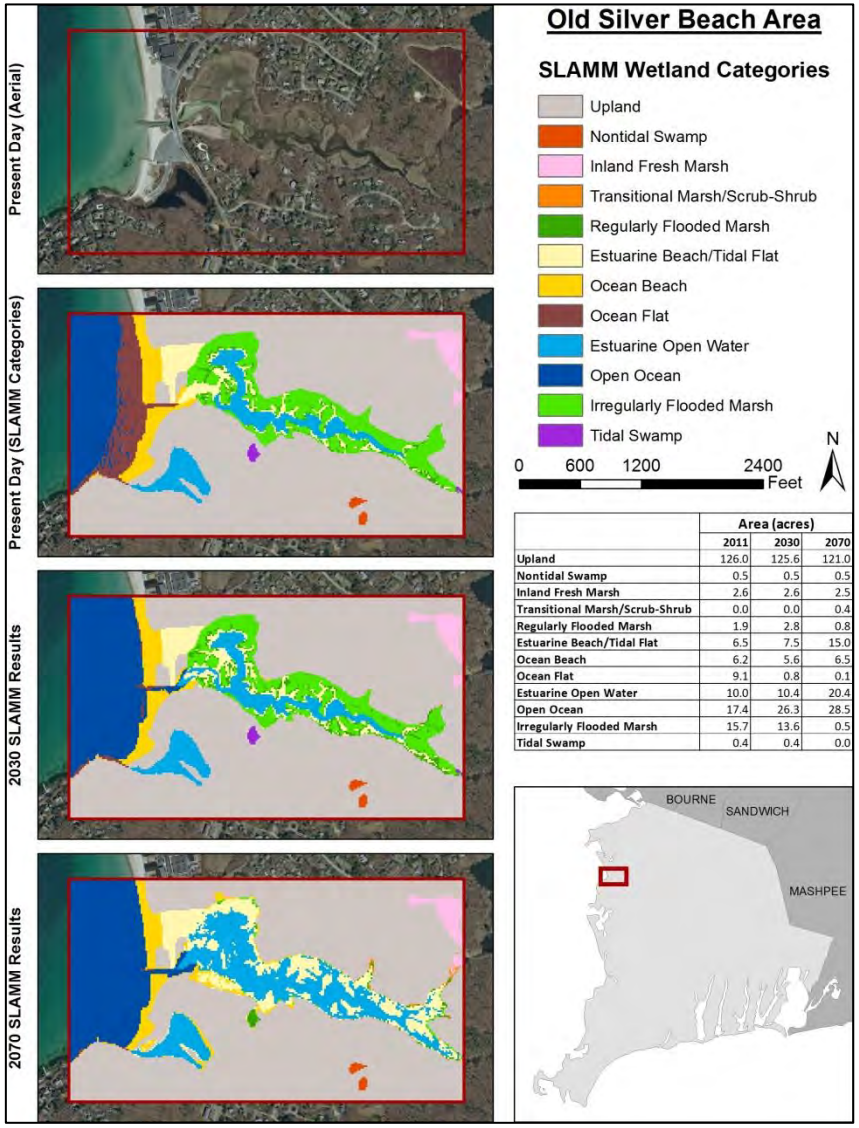
Vulnerability Assessment

SLAMM Results – Site-specific Changes

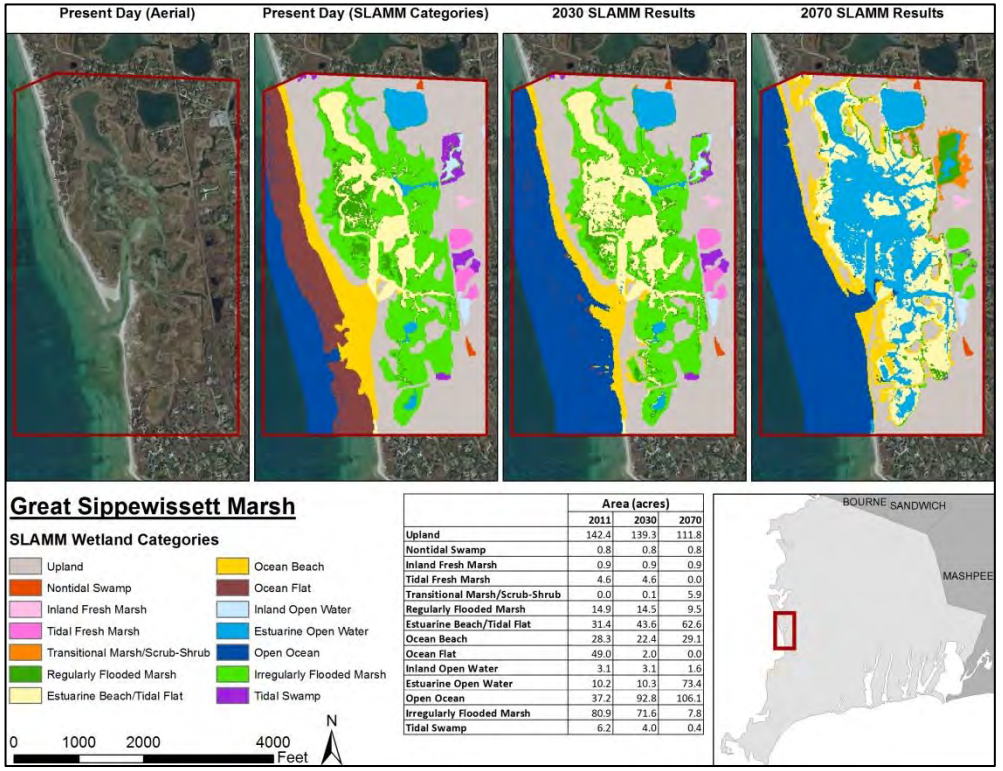


Vulnerability Assessment

SLAMM Results – Site-specific Changes



	Area (acres)		
	2011	2030	2070
Upland	126.0	125.6	121.0
Nontidal Swamp	0.5	0.5	0.5
Inland Fresh Marsh	2.6	2.6	2.5
Transitional Marsh/Scrub-Shrub	0.0	0.0	0.4
Regularly Flooded Marsh	1.9	2.8	0.8
Estuarine Beach/Tidal Flat	6.5	7.5	15.0
Ocean Beach	6.2	5.6	6.5
Ocean Flat	9.1	0.8	0.1
Estuarine Open Water	10.0	10.4	20.4
Open Ocean	17.4	26.3	28.5
Irregularly Flooded Marsh	15.7	13.6	0.5
Tidal Swamp	0.4	0.4	0.0



	Area (acres)		
	2011	2030	2070
Upland	142.4	139.3	111.8
Nontidal Swamp	0.8	0.8	0.8
Inland Fresh Marsh	0.9	0.9	0.9
Tidal Fresh Marsh	4.6	4.6	0.0
Transitional Marsh/Scrub-Shrub	0.0	0.1	5.9
Regularly Flooded Marsh	14.9	14.5	9.5
Estuarine Beach/Tidal Flat	31.4	43.6	62.6
Ocean Beach	28.3	22.4	29.1
Ocean Flat	49.0	2.0	0.0
Inland Open Water	3.1	3.1	1.6
Estuarine Open Water	10.2	10.3	73.4
Open Ocean	37.2	92.8	106.1
Irregularly Flooded Marsh	80.9	71.6	7.8
Tidal Swamp	6.2	4.0	0.4

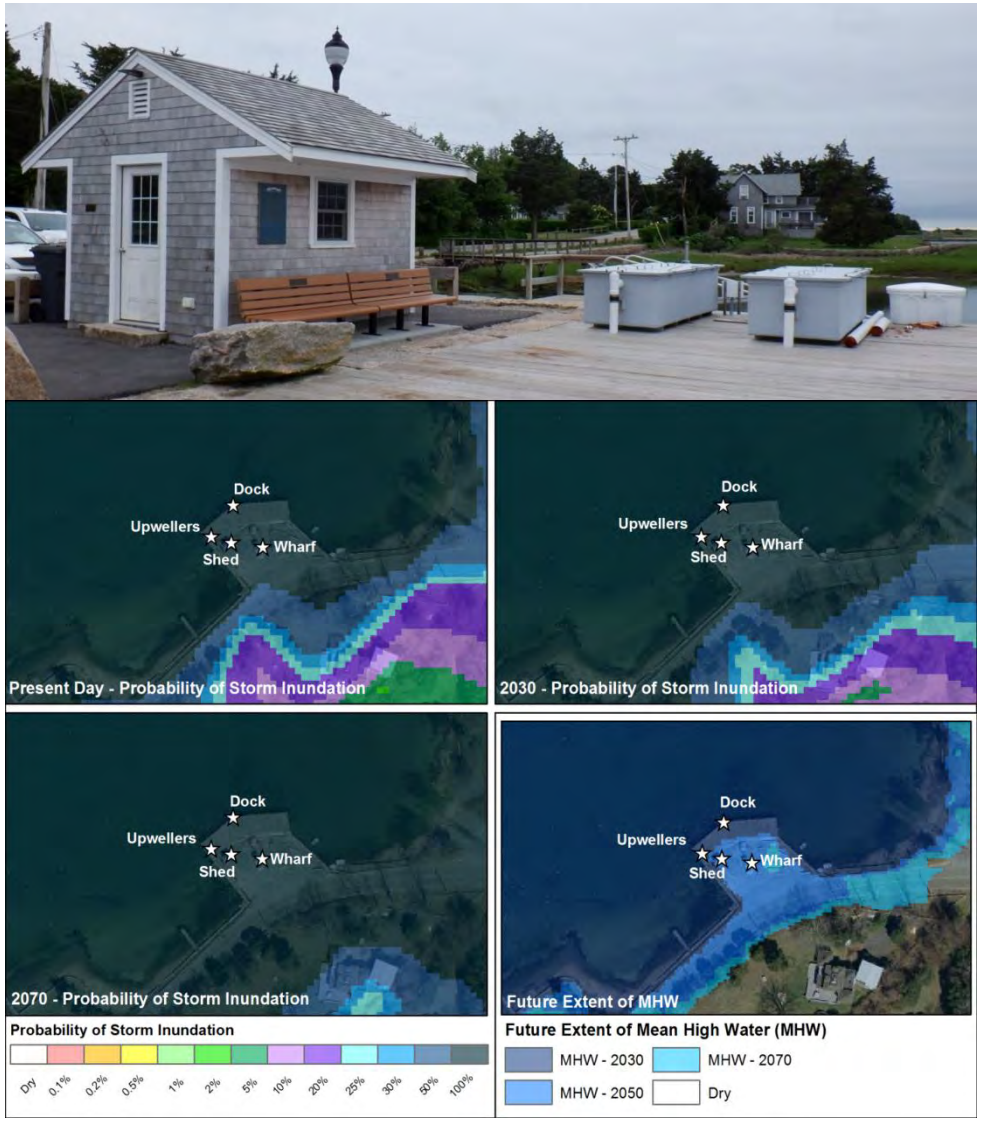
Develop Adaptation Strategies

Recommendations for site specific, asset-based adaptations:

1. Park Road Sewer Lift Station
2. Old Dock Road Dock, Upwellers and Shed
3. Woods Hole Drawbridge Hut
4. Town Hall
5. Old Silver Beach Parking Lot
6. Falmouth Harbor Docks (1-12)
7. Green Pond Dock (2)
8. Taft Park – Baseball Field, Tennis Courts, and Playground
9. Shining Sea Bike Path (Chapoquoit Road → Bumblebee Hill Road)
10. Chapoquoit Road
11. Corner of Clinton Ave and Scranton Ave
12. Waquoit Highway/Rt 28 Bridge (@ Childs River)
13. Menauhant Road Bridge (at Bristol Beach/Little Pond)

Develop Adaptation Strategies

Old Dock Road Pier Assets



Recommendations:

Present - Wet floodproof the shed; ensuring that nothing inside is damaged during a flood event.

Present - Properly secure upwellers so they cannot be dislodged.

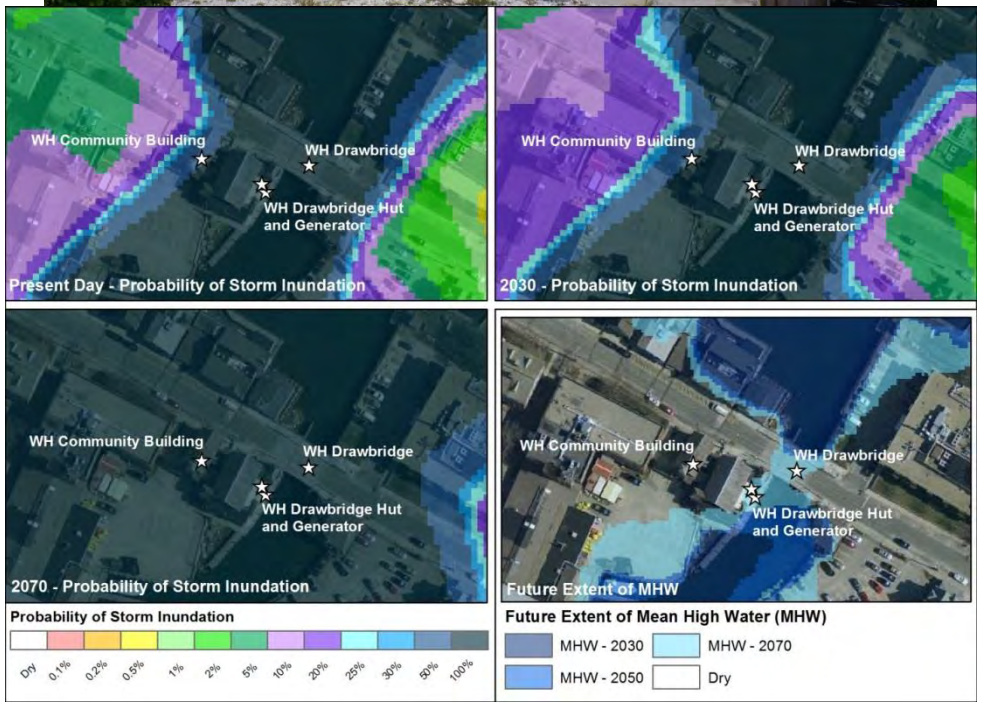
Present - Assess the pier to ensure it is structurally robust enough to withstand storm conditions.

2050/2070 - By 2050, daily MHW will overtop the pier, as well as impact Old Dock Road. In the long-term, this area will have to be redesigned.

- Raising the structure in its current location would require raising Old Dock Road and the water main.
- A portion of Old Dock Road could be abandoned, creating a dead end road that terminates at the relocated pier and associated boat ramp.

Develop Adaptation Strategies

Woods Hole Drawbridge Hut



Recommendations:

Present - Dry floodproof the bulkhead to protect the interior mechanics of the drawbridge hut.

Present - Determine whether the submersible pump in the metal box to the right of the bulkhead is still necessary. If so, raise this component.

2030 - Dry floodproof the upper room of the drawbridge hut to protect the vital electrical equipment that's inside.

2030/2050 - Evaluate the viability and necessity of the Woods Hole Drawbridge and Drawbridge Hut in the long-term. (See the regional adaptation discussion for the Woods Hole area.)

Develop Adaptation Strategies

Town Hall

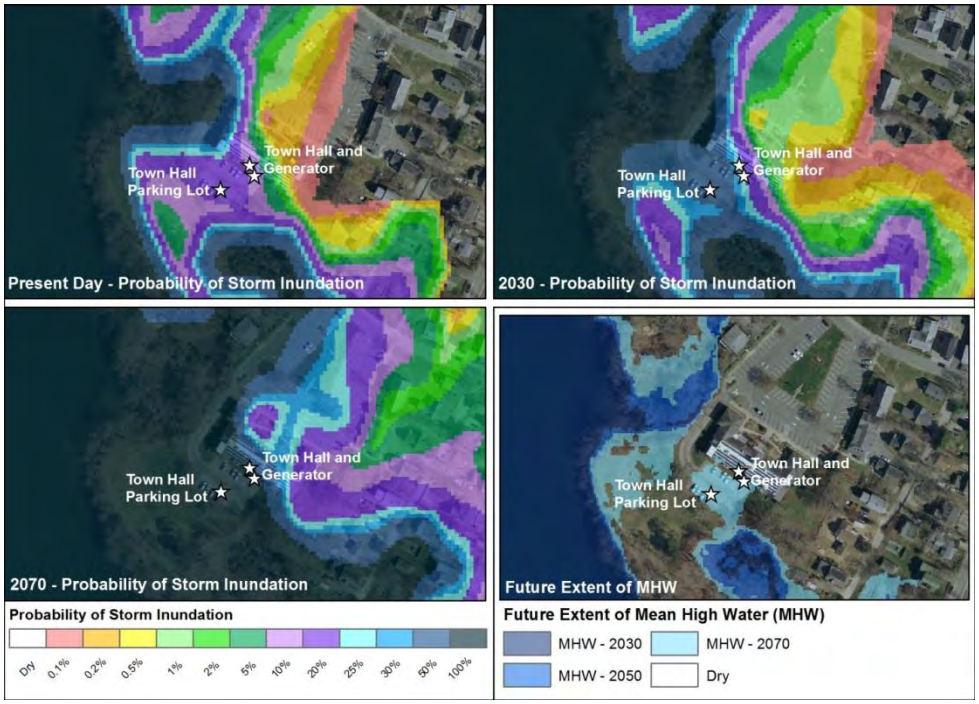
Recommendations:

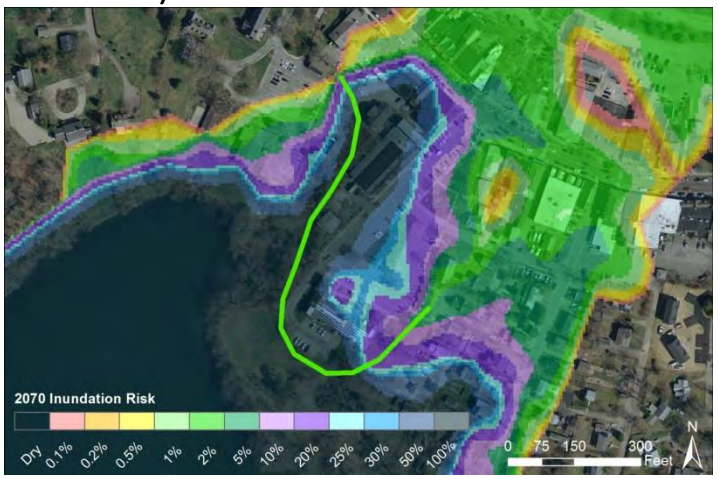
Present - Dry floodproof the lower floor of Town Hall to protect the interior spaces

Present/2030 - A berm-like landscaping feature (~1000 feet) could be constructed to reduce the likelihood of flooding (co-benefits for a number of local businesses).

2070 - Consider relocating the Town Hall. This could involve purchasing land or utilizing a vacant lot already owned by the Town and constructing a new building. Alternatively, a suitable existing building elsewhere could be acquired/repurposed.

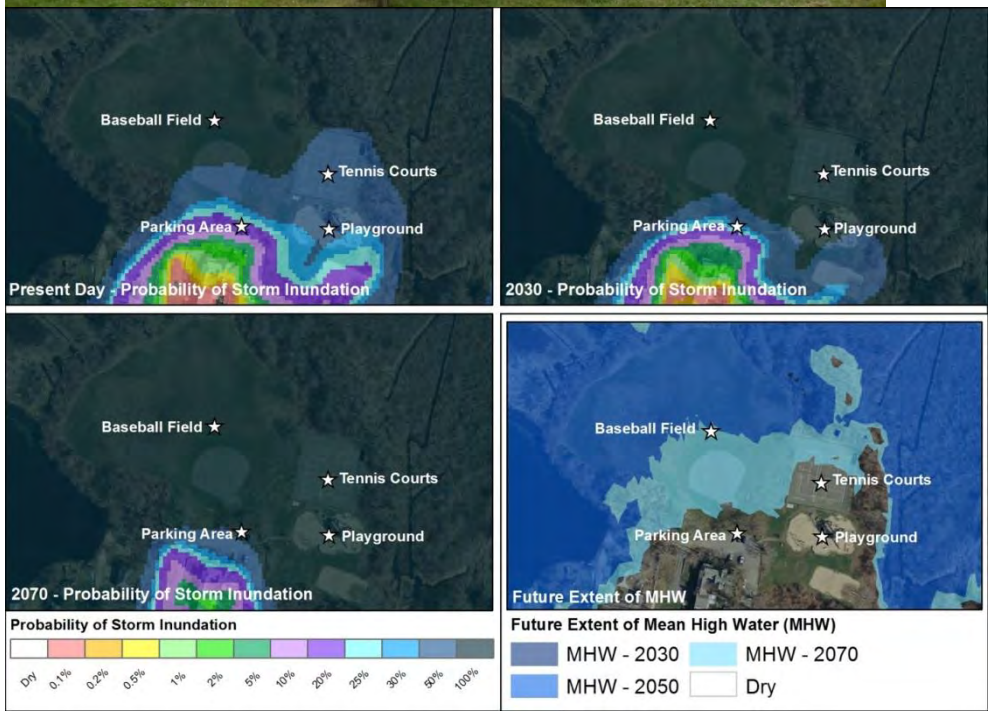
(If the berm is constructed, the current building could potentially last up to or beyond 2070; the Town could monitor how SLR has been evolving before making a decision.)





Develop Adaptation Strategies

Taft Park – Woods Hole



Recommendations:

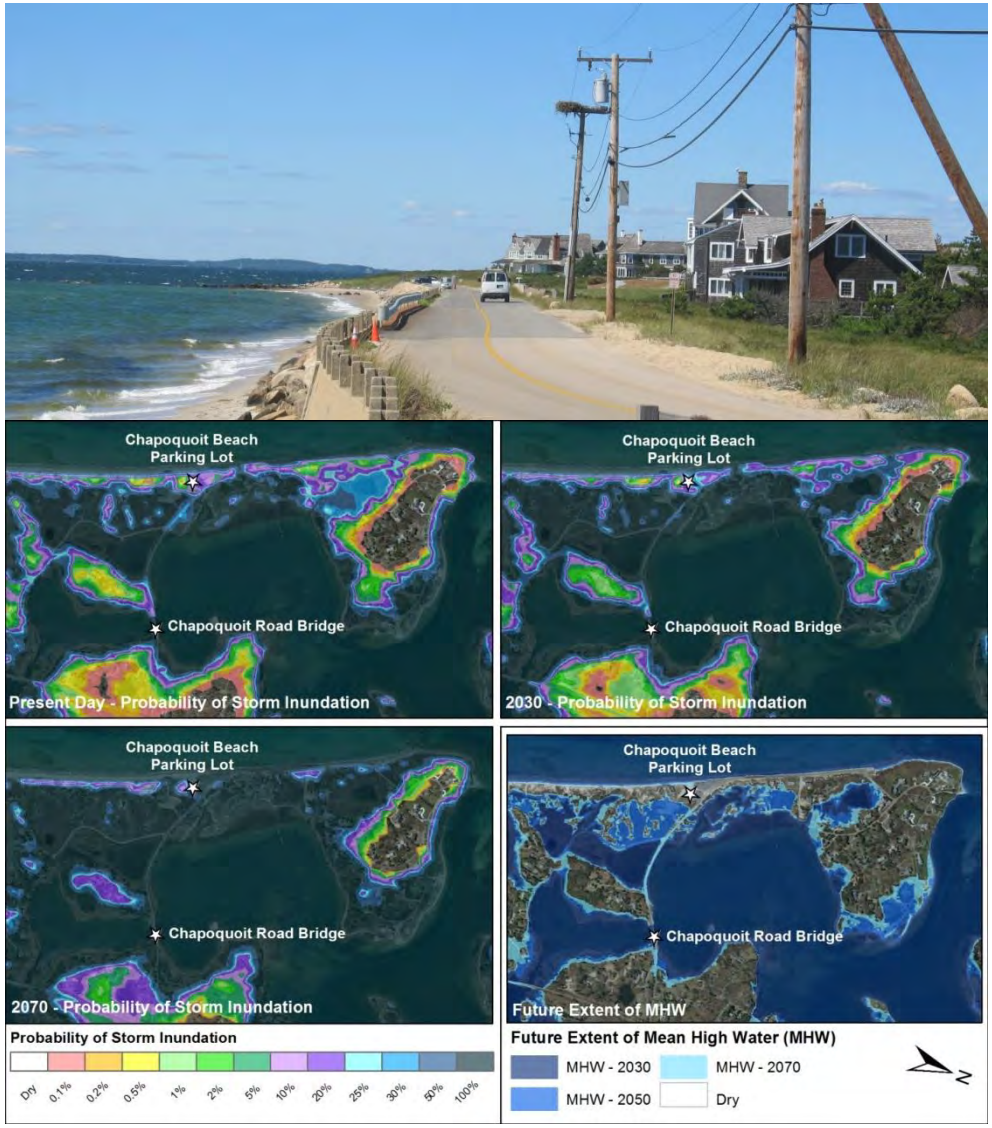
Present - No action. Although costly improvements should not be made to the baseball field.

2050/2070 - Consider looking for alternate locations to relocate these recreational assets.

2050/2070 - Consider transitioning Taft Park into a natural wetland area. Walking trails and/or boardwalks could be added to maintain the open space and recreational use.

Develop Adaptation Strategies

Chapoquoit Road



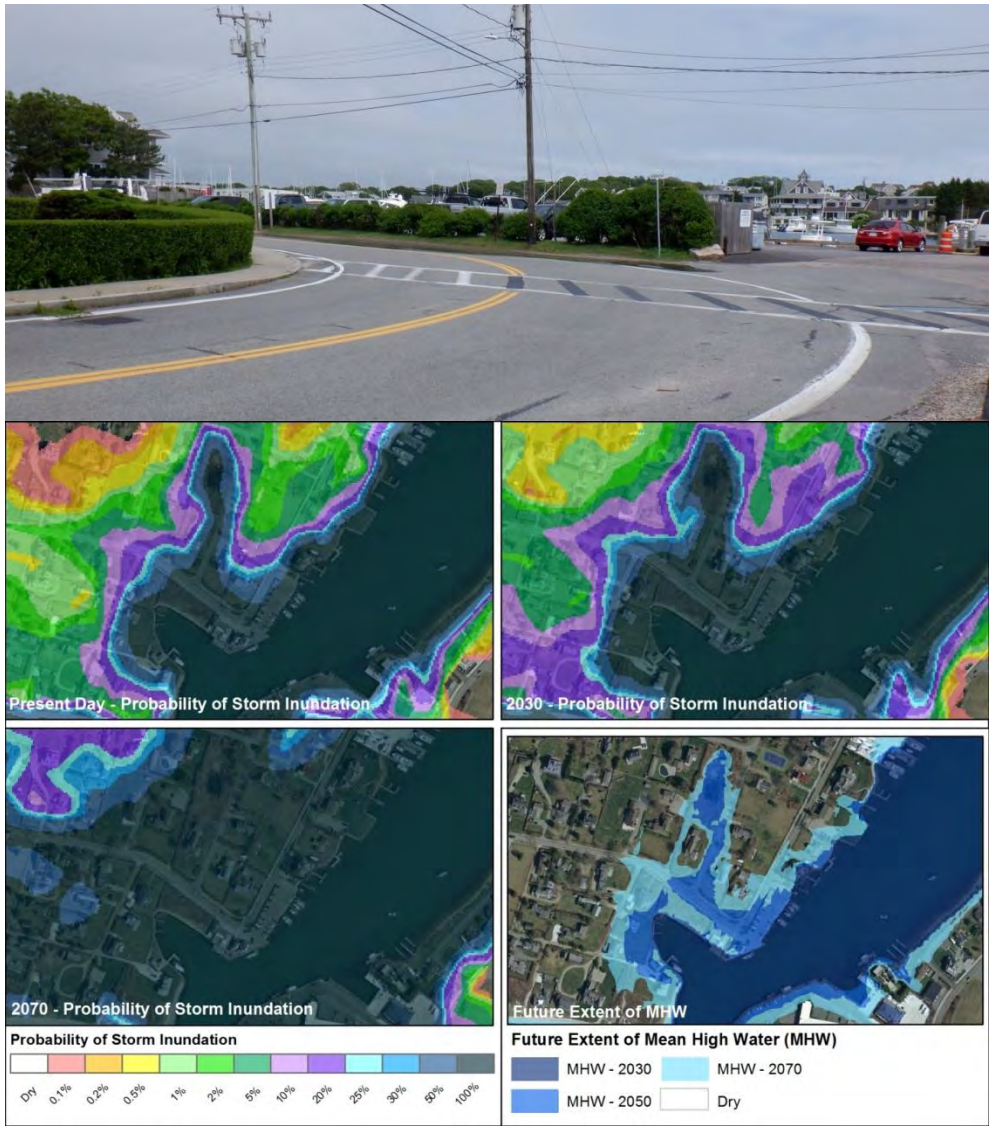
Recommendations:

Present - Due to the likelihood of roadway inundation during storms, and the disruption in transportation and emergency access this would cause, mandatory evacuations should be considered for the Chapoquoit neighborhood prior to a major storm.

2070 - Daily tidal inundation of the road by 2070 will require intervention to maintain regular access to the Chapoquoit peninsula in the future. Raising the road would require elevating the roadway from Old Dock Road to the Chapoquoit Beach parking lot (a 2,000–foot length of road).

Develop Adaptation Strategies

Clinton Ave and Scranton Ave



Recommendations:

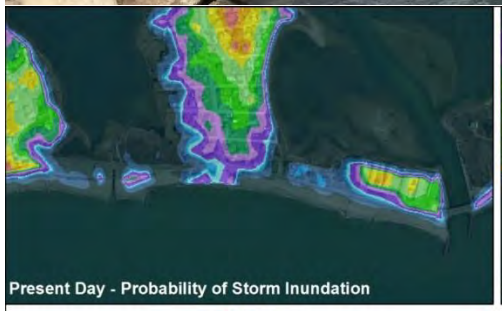
Present/2030 - Install or enhance bulkhead along shoreline to reduce the risk of flooding from minor storm events.

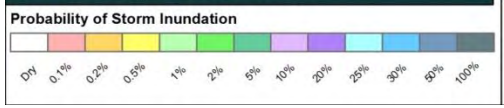
2050 - Install a multi-property resiliency feature to address minor flooding and more commonly occurring storms.

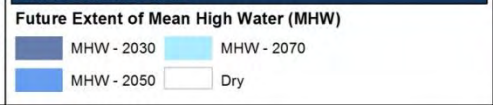
2070 - Rethink the use of this corner in the long-term. This may include a waterfront park and/or natural wetland feature, an elevated resiliency feature, an elevated or rerouted roadway, or some combination of all these adaptations.

Develop Adaptation Strategies

Menauhant Road Bridge (at Little Pond)







Recommendations:

Present/2030 - Inspect bridge to ensure it is structurally sound and able to withstand floodwaters and daily tidal impacts; make repairs as necessary.

2030 - Construct a temporary berm on the Little Pond side of Menauhant Road, west of the bridge, to protect the roadway from daily tidal inundation (this could be designed to function through 2050 conditions).

2070 - Elevate 0.5 miles of road, replacing this existing undersized bridge with a wider crossing OR develop a long-term plan for abandonment of this roadway and bridge.

Develop Adaptation Strategies

Recommendations for regional adaptations:

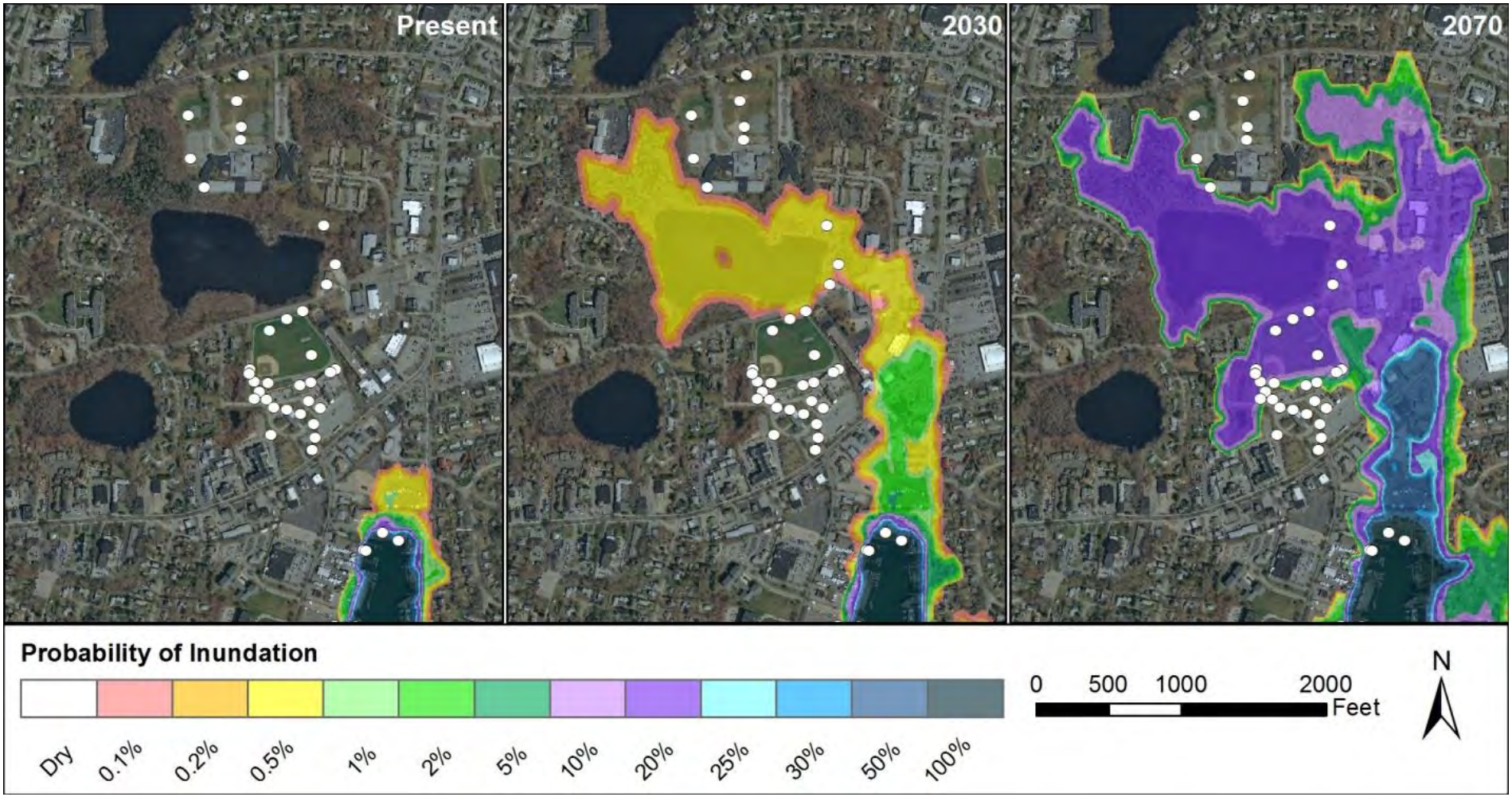
1. Main Street/Top of Falmouth Inner Harbor
2. Woods Hole/Water Street
3. Top of Little Pond/Falmouth Mall

Recommendations for natural resources adaptations:

1. Washburn Island
2. Great Sippewissett Marsh
3. Chapoquoit Road Barrier

Develop Adaptation Strategies

Regional Strategy – Falmouth Harbor/Main Street



Develop Adaptation Strategies

Regional Strategy – Falmouth Harbor/Main Street

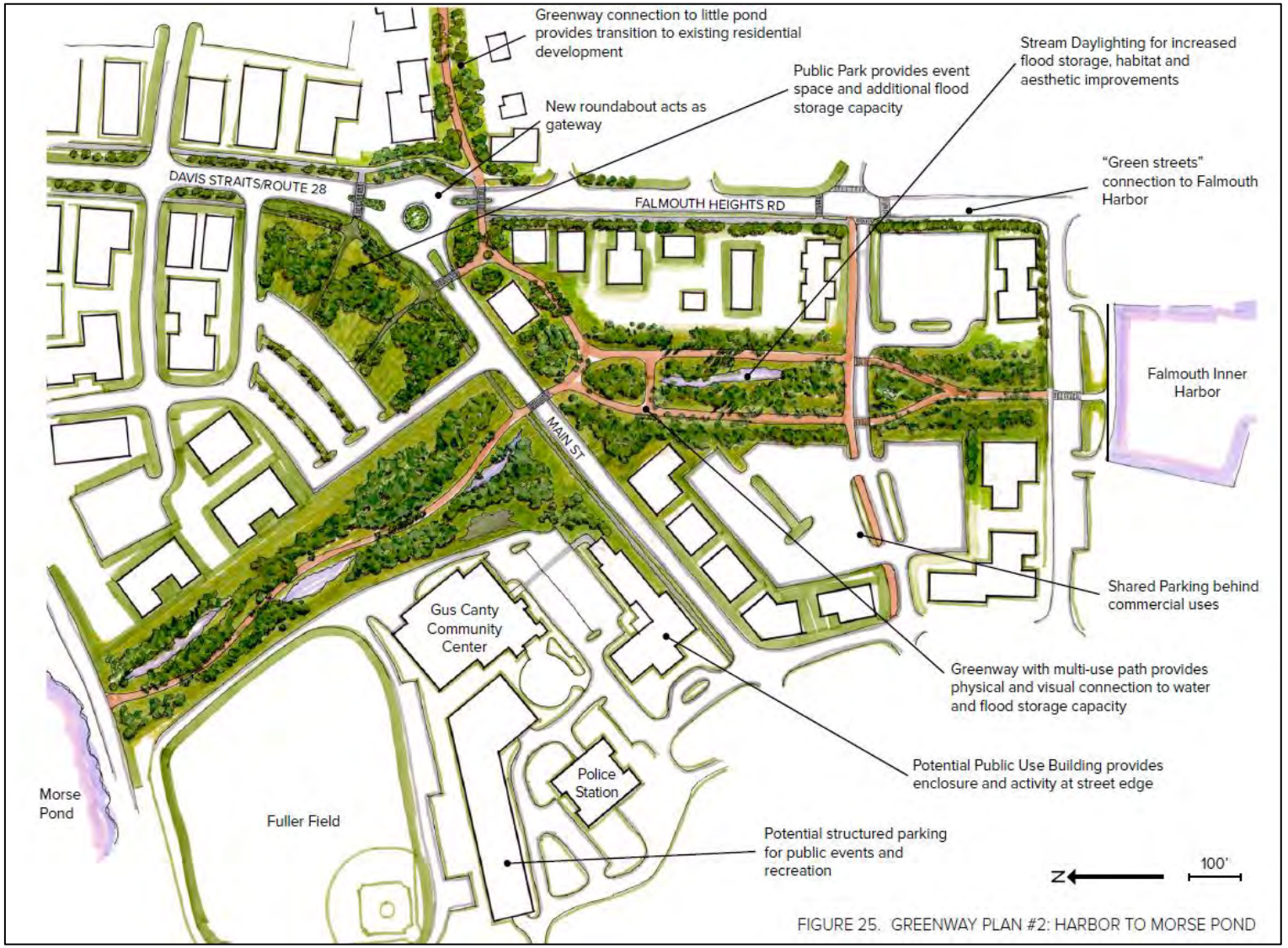
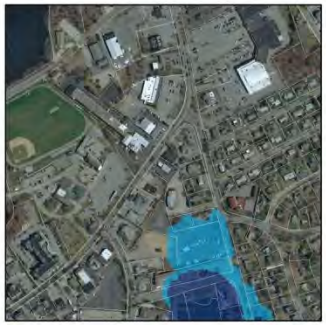


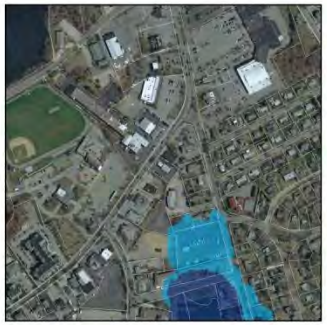
FIGURE 25. GREENWAY PLAN #2: HARBOR TO MORSE POND

Develop Adaptation Strategies

Regional Strategy – Falmouth Harbor/Main Street

PRESENT DAY

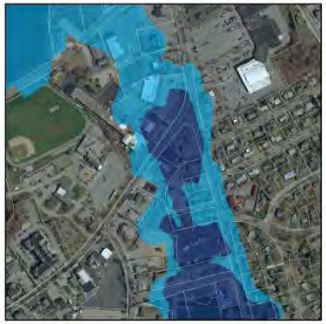




Flood Risk:
The present day flood risk to this area is relatively minor. The 1% chance event (i.e., the 100-year water levels) impact only Robbins Road and the timeshare property across the street from the harbor.

Recommended Actions:
No direct action is needed at this time, but planning and fundraising should begin for 2030 adaptation recommendations.

2030



Flood Risk:
The flood risk due to storm inundation in 2030 will impact a greater area. The 1% chance event (i.e. ,the 100-year water levels) will also impact various business (e.g., Bank of America, Dairy Queen) as well as a portion of Main Street.

Recommended Actions:
1. The waterfront parcel currently owned by the Town should be elevated, using a berm or terraced design, providing flood protection, living shoreline habitat, and recreational space.
2. Raise lift station access hatches to meet berm.
3. Planning and fundraising should begin for 2070 adaptation recommendations.

2070

Flood Risk:
The flood risk in 2070 will impact a greater area. The 1% chance event would impact various businesses along Davis Straits and Main Street.

Recommended Actions:
1. Work with adjacent waterfront landowners to extend the elevated feature around the head of the Harbor to fully protect the flood pathway.
2. Robbins Road could be eliminated for additional berm/park space; traffic could be rerouted through Main Street, or through a new connector road.
3. Optional: The proposed CCC greenway could be constructed, complete with open water way and multi-use trails. Tidal control on the downstream end will be necessary to avoid increased flood risk.

WOODS HOLE GROUP
A CLS COMPANY

Probability of Inundation
- Dry
- 0.1%
- 1%

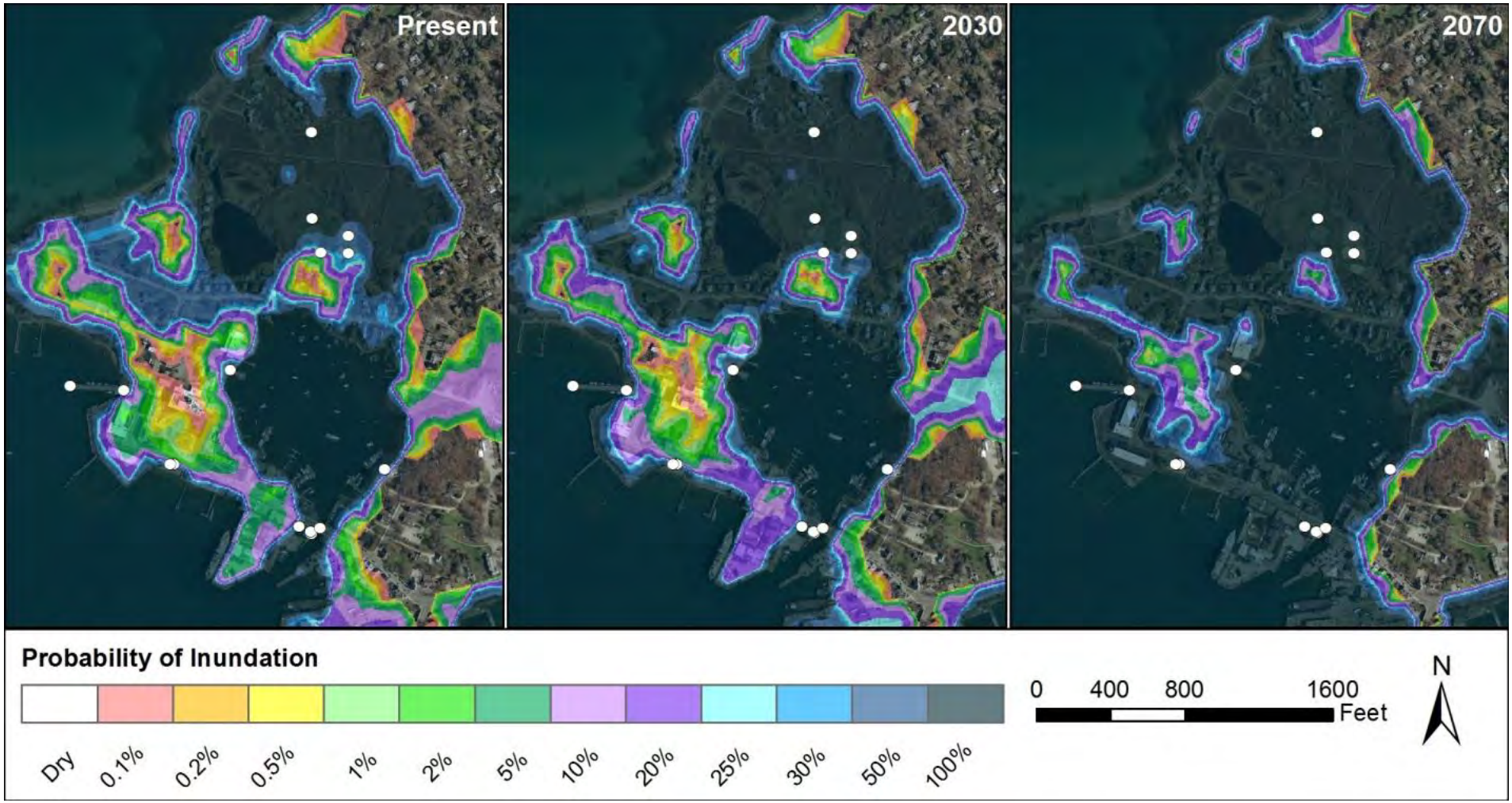
- Proposed Berm
- Proposed New Roadway
- Proposed Trails (CCC)
- Proposed Daylighted Stream (CCC)
- Proposed Greenway (CCC)

0 500 1,000 2,000 Feet

N

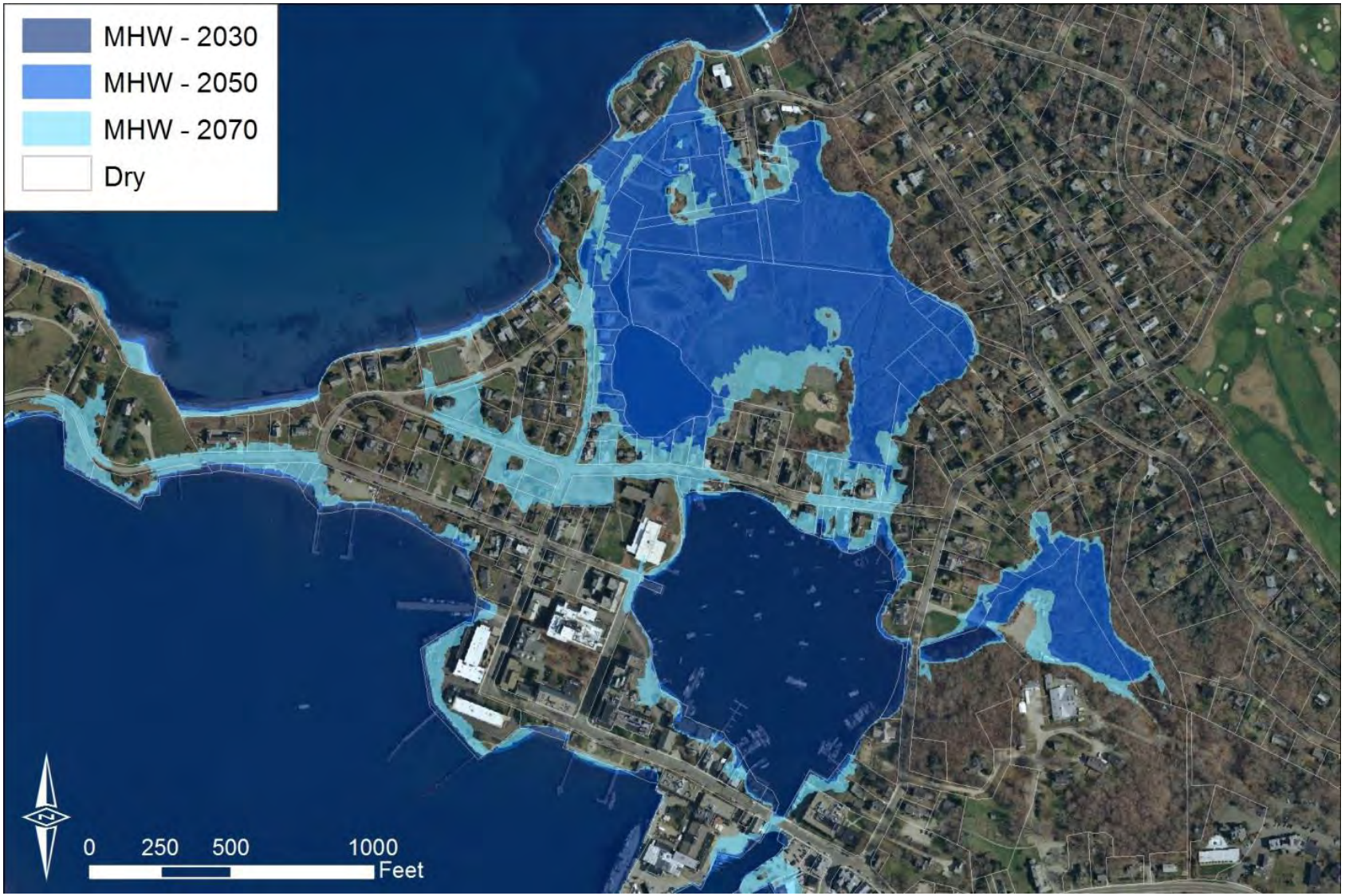
Develop Adaptation Strategies

Regional Strategy – Woods Hole



Develop Adaptation Strategies

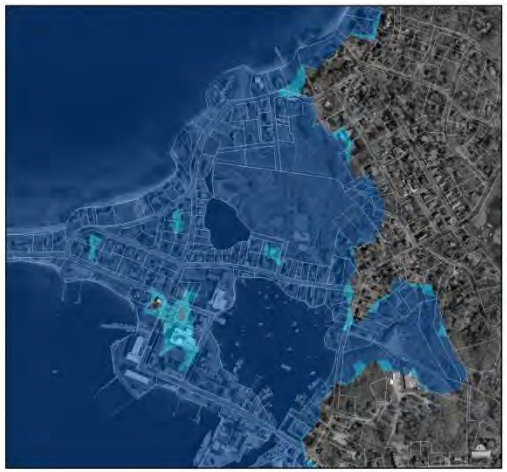
Regional Strategy – Woods Hole

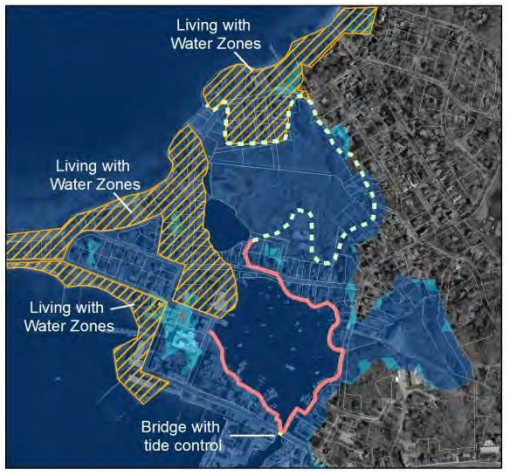


Develop Adaptation Strategies

Regional Strategy – Woods Hole

2030





Flood Risk:
The flood risk due to storm inundation in 2030 will impact an extensive portion of Woods Hole. The 1% chance event will impact numerous facets of town functionality, including roads, homes, and businesses.

Recommended Actions:
1. Prepare Living with Water Zones (elevate buildings, flood proof structures, etc).
2. Begin berm work.
3. Consider Water St. Bridge redesign and installation of tide control structure.

2050/2070

Flood Risk:
The flood risk due to storm inundation in 2050 (pictured) and 2070 continues to increase.

Recommended Actions:
1. Promote salt marsh expansion in Taft Park and School Street area.
2. Develop a new inlet and excavate material to form a new habor area.
3 Use excavated material from new harbor to elevate roads and build higher ground around Water St, Bar Neck Rd, and Spencer Baird Rd.
4. Complete berms around harbor and salt marsh to increase storm protection.
5. (2070) Build bridge leading to Penzance Point.

WOODS HOLE GROUP

Probability of Inundation
- Dry
- 0.1%
- 1%

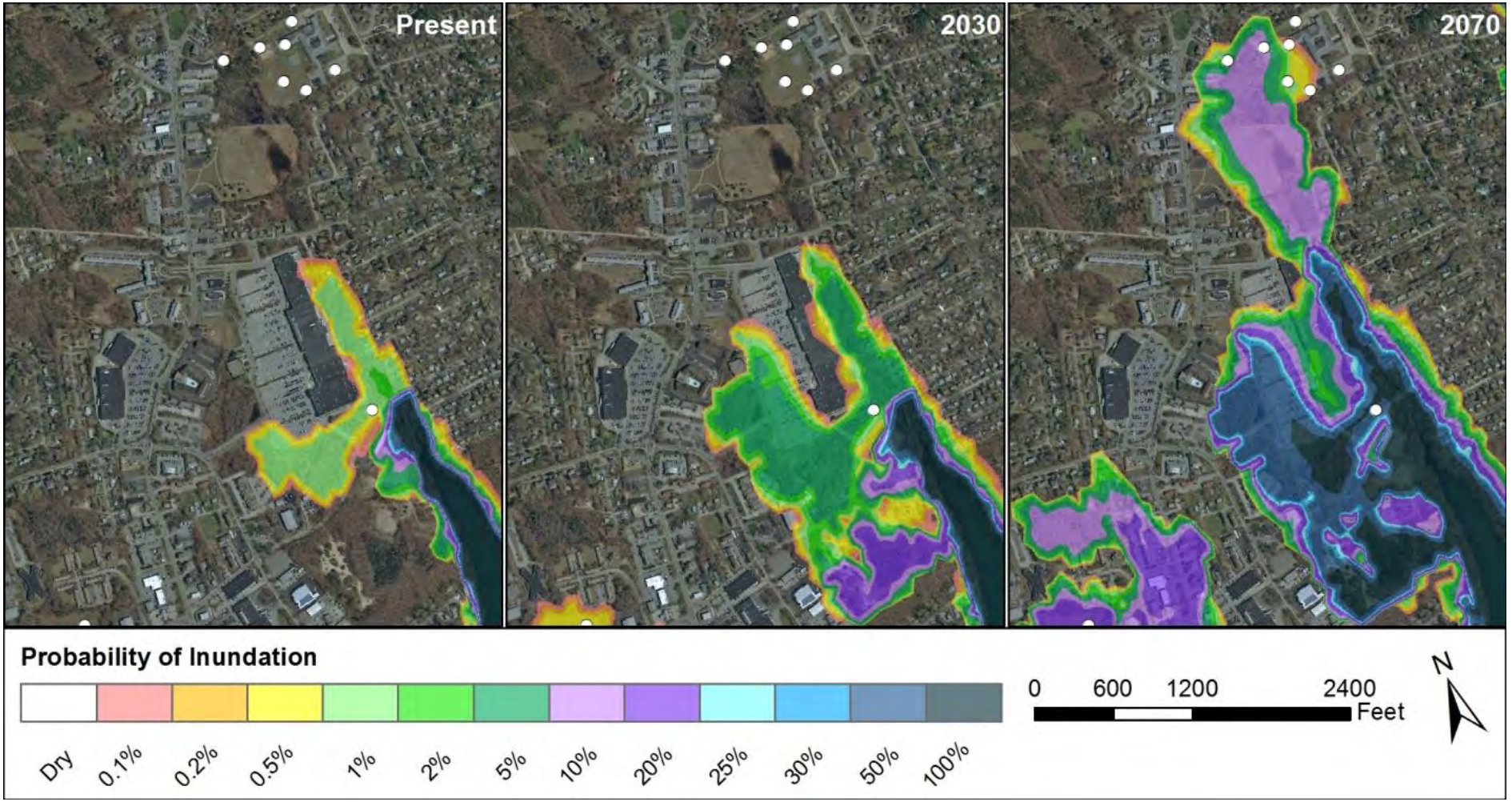
- Proposed Elevated Road Spine
- Proposed Bridge
- Living With Water Zones
- New Harbor
- Potential Salt March Creation
- Harbor Islands (excavated material)
- Harbor Edge Protection
- Natural Edge Berm
- New Harbor Inlet
- Proposed Tidal Creek Channels

0 750 1,500 Feet

N

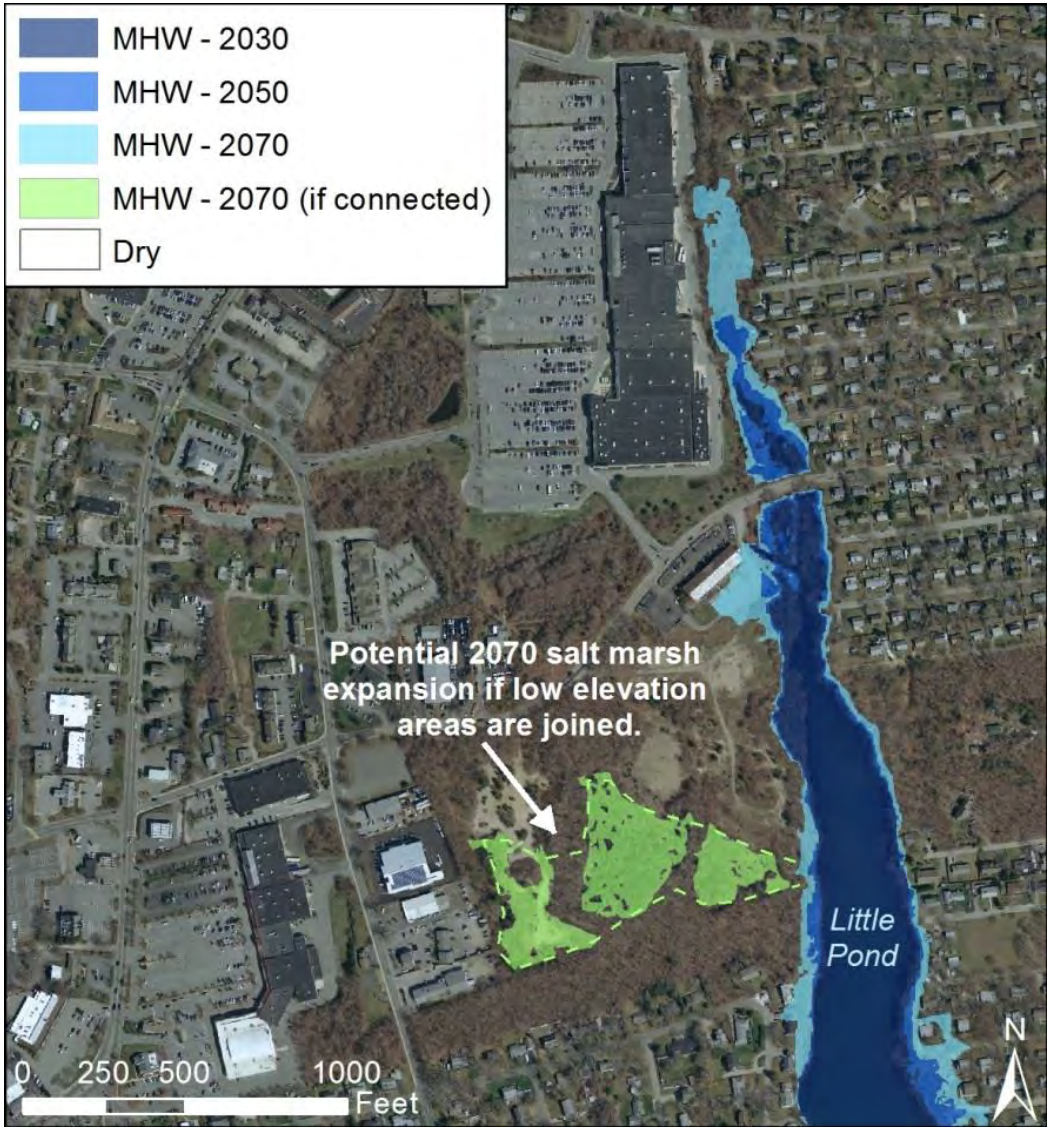
Develop Adaptation Strategies

Regional Strategy – Little Pond/Falmouth Mall



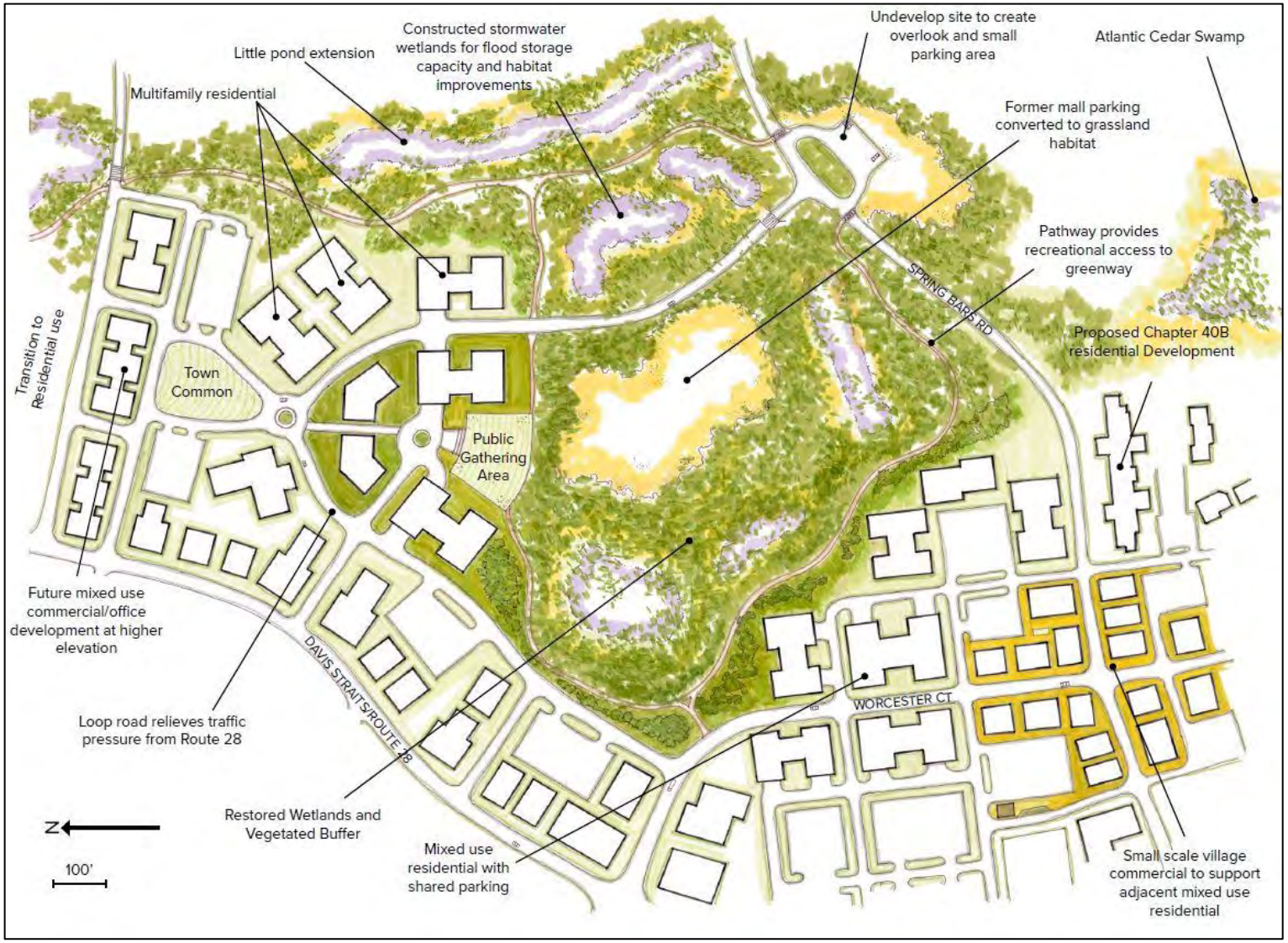
Develop Adaptation Strategies

Regional Strategy – Little Pond/Falmouth Mall



Develop Adaptation Strategies

Regional Strategy – Little Pond/Falmouth Mall



Develop Adaptation Strategies

Regional Strategy – Little Pond/Falmouth Mall

PRESENT DAY

Flood Risk:
The present day flood risk to the area west of Little Pond is relatively minor. The 1% chance event (i.e., the 100-year water levels) impact only the bowling alley property and the undeveloped parcel to the south.

Recommended Actions:
No direct action is needed at this time, but planning and fundraising should begin for 2030 and 2070 adaptation recommendations.

2030

Flood Risk:
The flood risk due to storm inundation in 2030 will impact a greater area. The 1% chance event will also impact various business at and around the Falmouth Mall, as well as Spring Bars Road and the Sewer Pump Station.

Recommended Actions:
1. Take steps to acquire and undevelop the large parcels highlighted in orange.
2. Construct first part of berm to protect newly constructed 40B Housing.
3. Consider raising or relocating sewer pump station.
4. Planning and fundraising should begin for 2070 adaptation recommendations.

2070

Flood Risk:
The flood risk in 2070 will impact a greater area. The 1% chance event would impact various businesses along Worcester Ct, as well as homes along Maravista Ave.

Recommended Actions:
1. Extend flood protection berm to protect adjacent businesses and development.
2. Undevelop properties (orange in above map) to create a large parkland with trails.
3. Install new culvert or bridge on Maravista to re-connect Teaticket Park to Little Pond.
4. Optional: Remove high elevation areas to facilitate salt marsh expansion in the southwestern corner.

WOODS HOLE GROUP
A CLE COMPANY

Probability of Inundation
- Dry
- 0.1%
- 1%

- Proposed Trails
- Proposed Berm
- Proposed Parcel Acquisition
- Sewer Lift Station
- Proposed Culvert or Bridge on Maravista
- Potential Salt Marsh Creation
- Proposed Parkland/Wetlands

N

0 875 1,750 3,500 Feet

Develop Adaptation Strategies

Recommendations for regional adaptations:

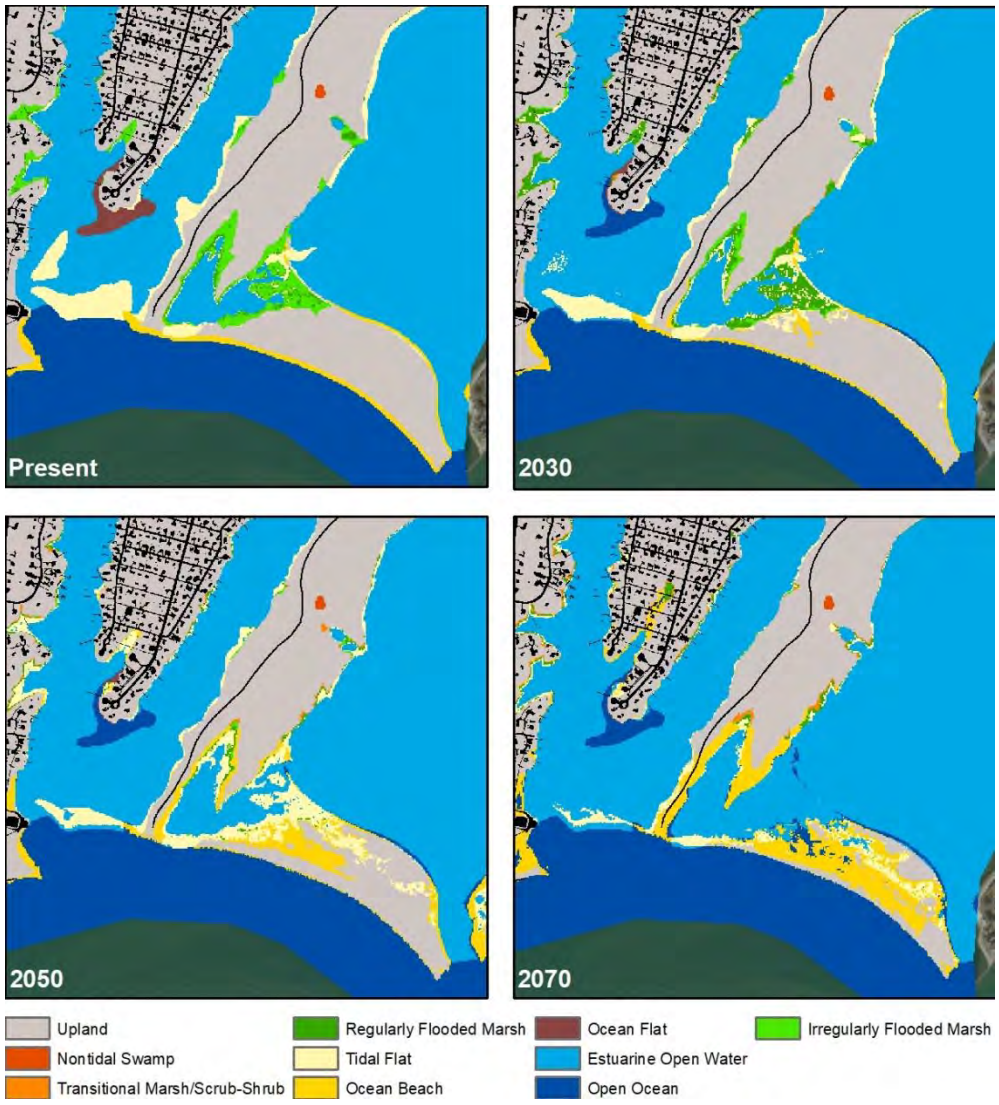
1. Main Street/Top of Falmouth Inner Harbor
2. Woods Hole/Water Street
3. Top of Little Pond/Falmouth Mall

Recommendations for natural resources adaptations:

1. Washburn Island
2. Great Sippewissett Marsh
3. Chapoquoit Road Barrier

Develop Adaptation Strategies

Washburn Island



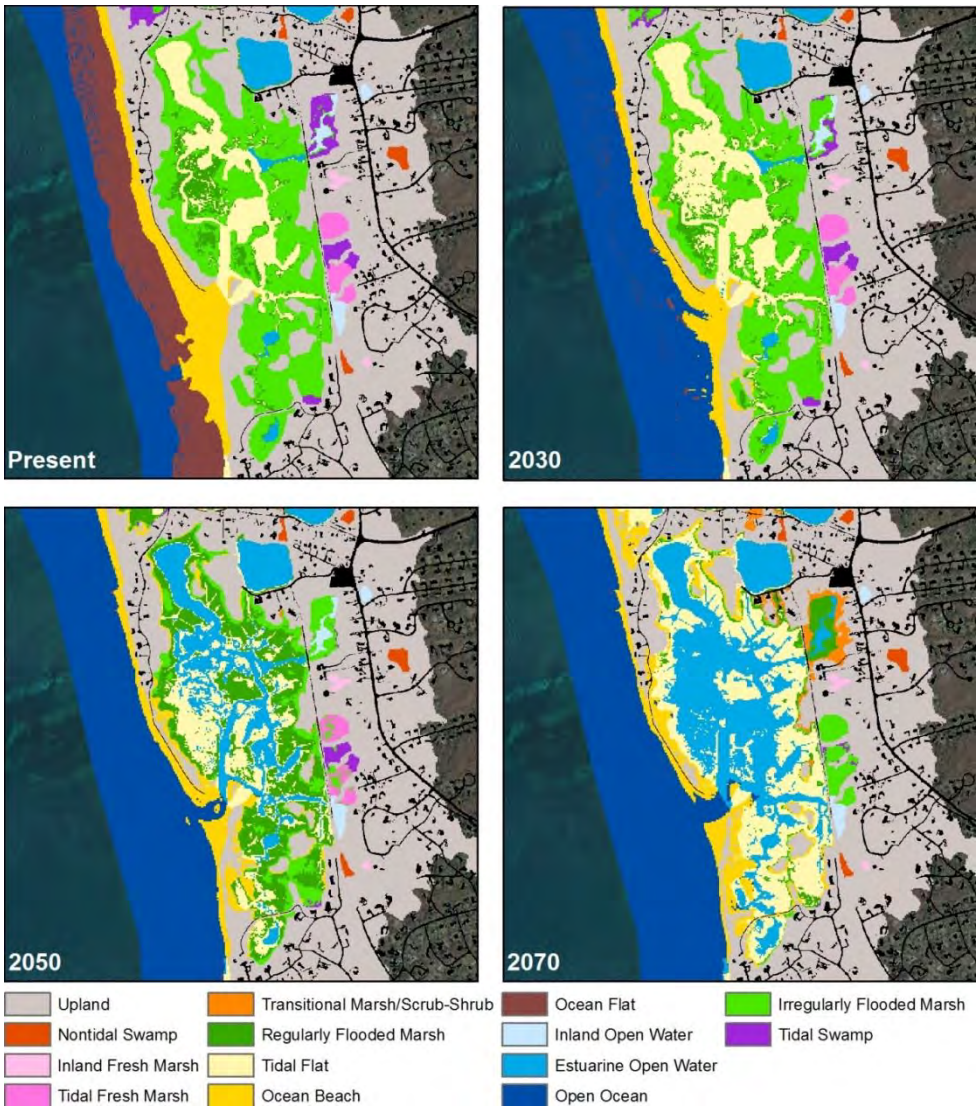
Goal: Reinforce and increase the coastal resiliency of the barrier beach, thus ensuring a stable Waquoit Bay system

Recommendations:

- Short term: the Town should engage the state, WBNERR, the Town of Mashpee, the Menauhant Yacht Club, Waquoit Bay Yacht Club, and other relevant stakeholders about this issue, to develop a long-term plan to manage Waquoit Bay and Washburn Island
- Long term: Dune and/or beach nourishment program on the south facing shoreline of Washburn Island.

Develop Adaptation Strategies

Great Sippewissett Marsh



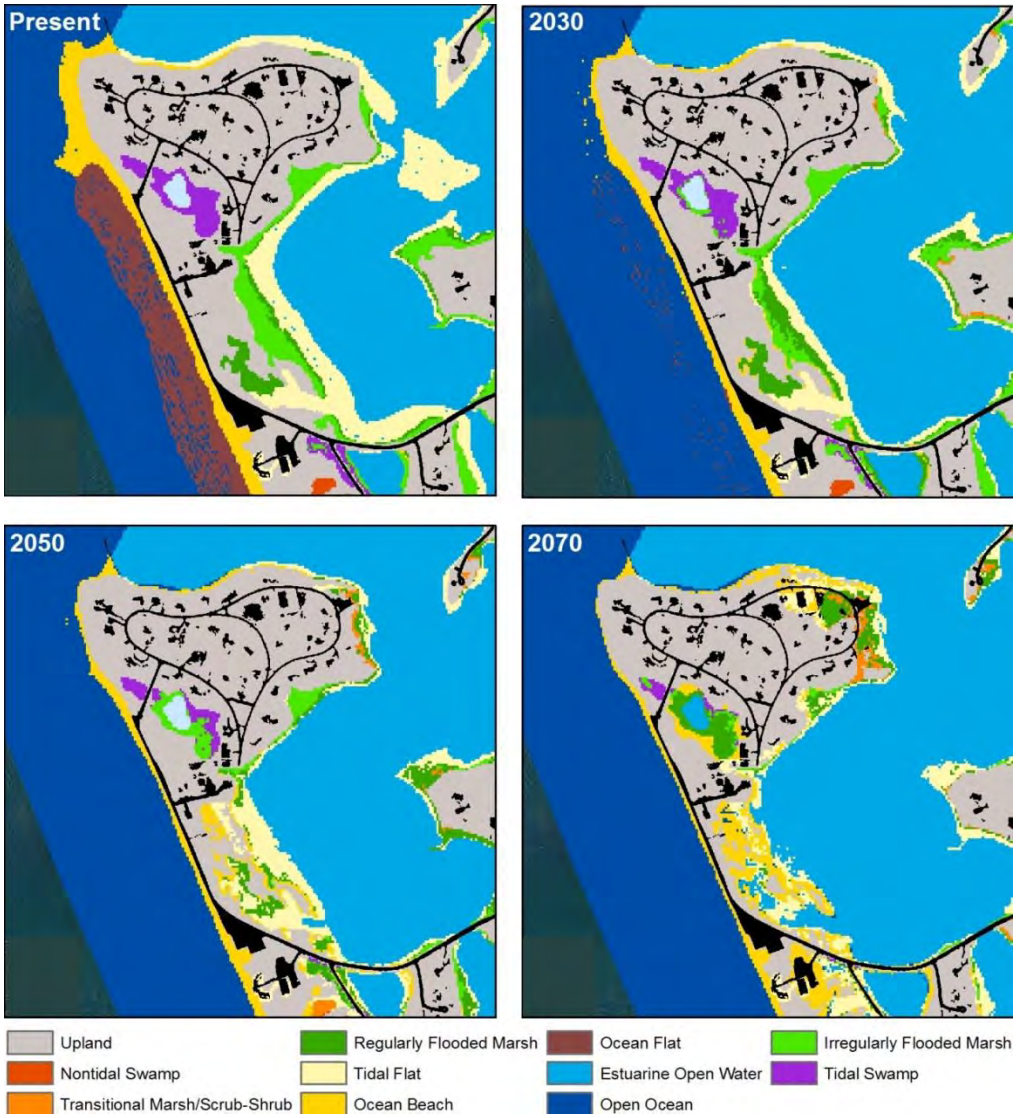
Goal: Maximize health of the salt marsh

Recommendations:

- Enhance and increase the coastal resilience of the main salt marsh area. Elevation enhancement (e.g., thin layer deposition) will be necessary to maintain suitable salt marsh elevations.
- Expansion of salt marsh east of the bike path. Prior to 2070, portions of the bike path to be replaced with elevated pile-supported path.

Develop Adaptation Strategies

Chapoquoit Road Wetlands



Goal: Reinforce and enhance coastal resiliency for the barrier beach system and salt marsh enhancement.

Recommendations:

- Beach nourishment on the outer coast should be pursued if possible, but need to look at barrier holistically.
- Address salt marsh loss and erosion on the West Falmouth Harbor side as well.
  - Consider living shoreline designs, salt marsh restoration and/or enhancement; establishment of oyster beds
  - Elevation enhancement
- Expansion of salt marsh into existing tidal swamp. Prior to 2050, evaluate the tidal creek and repair/replace any existing culverts as necessary to ensure that daily tides can enter.

Questions?