SOUTH SHORE CLIMATE CHANGE AND SEA LEVEL RISE SYMPOSIUM

December 1, 2016

LOCAL ADAPTATION CASE STUDY: HINGHAM, MA

Climate Change Vulnerability, Risk Assessment and Adaptation Study – June 2015

- Interest in identifying vulnerable municipal infrastructure and facilities that are likely to be affected by sea level rise and climate change.

WHAT PRECIPITATED STUDY?

- $44,461 Coastal Communities Resilience Grant from the Massachusetts Office of Coastal Zone Management ($60,000 total cost)
- Project Goal: to define degrees of impact in vulnerable areas, to develop recommended strategies to manage existing infrastructure, facilities and natural resources and to plan for future adaptation.

HOW WAS IT POSSIBLE?

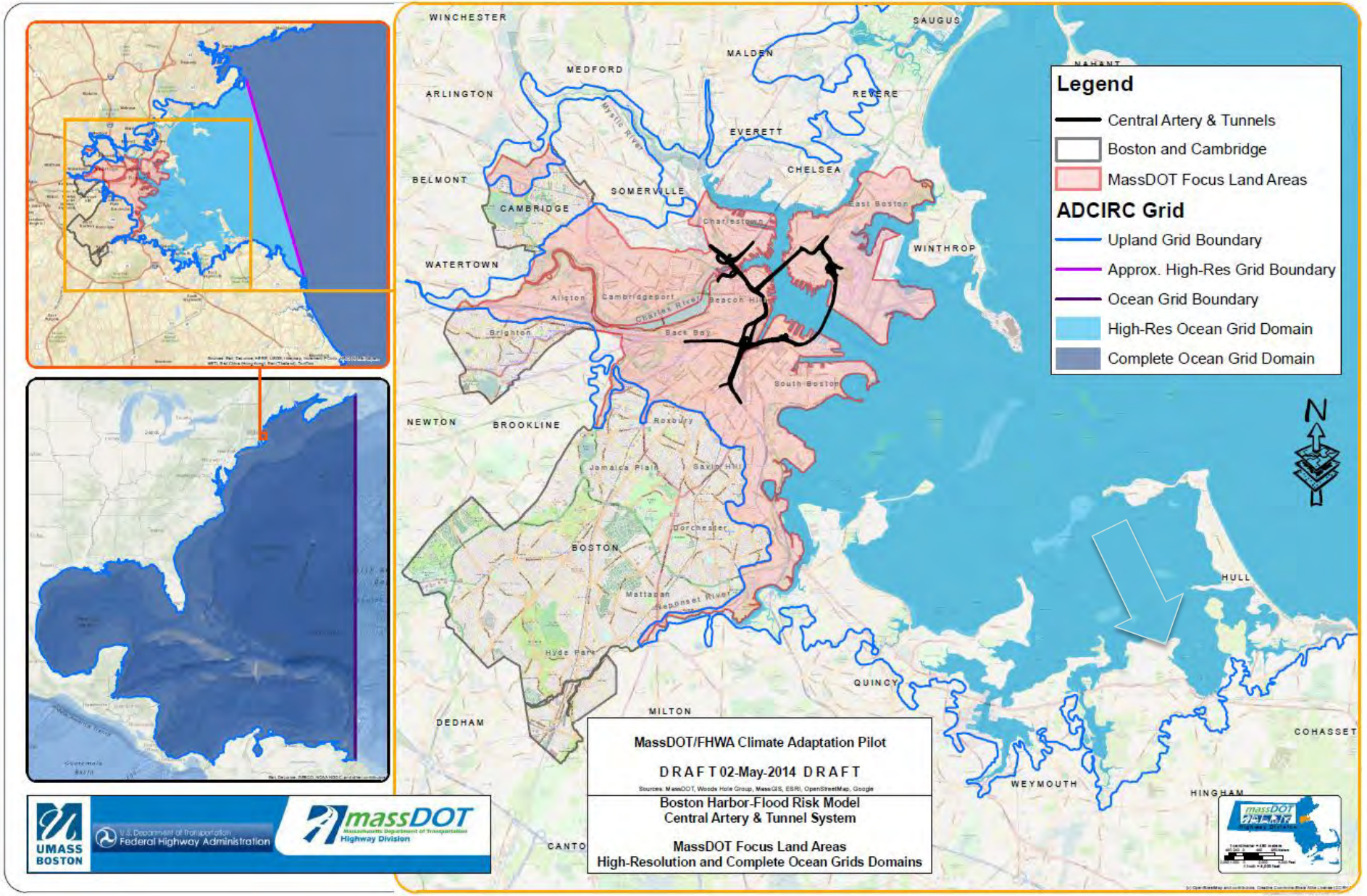
PROCESS

- Steering Committee formed to guide project and help establish study parameters
- Outreach:
  - Frequent presentations to elected officials (televised).
  - All materials on the town's website
  - Newspaper articles

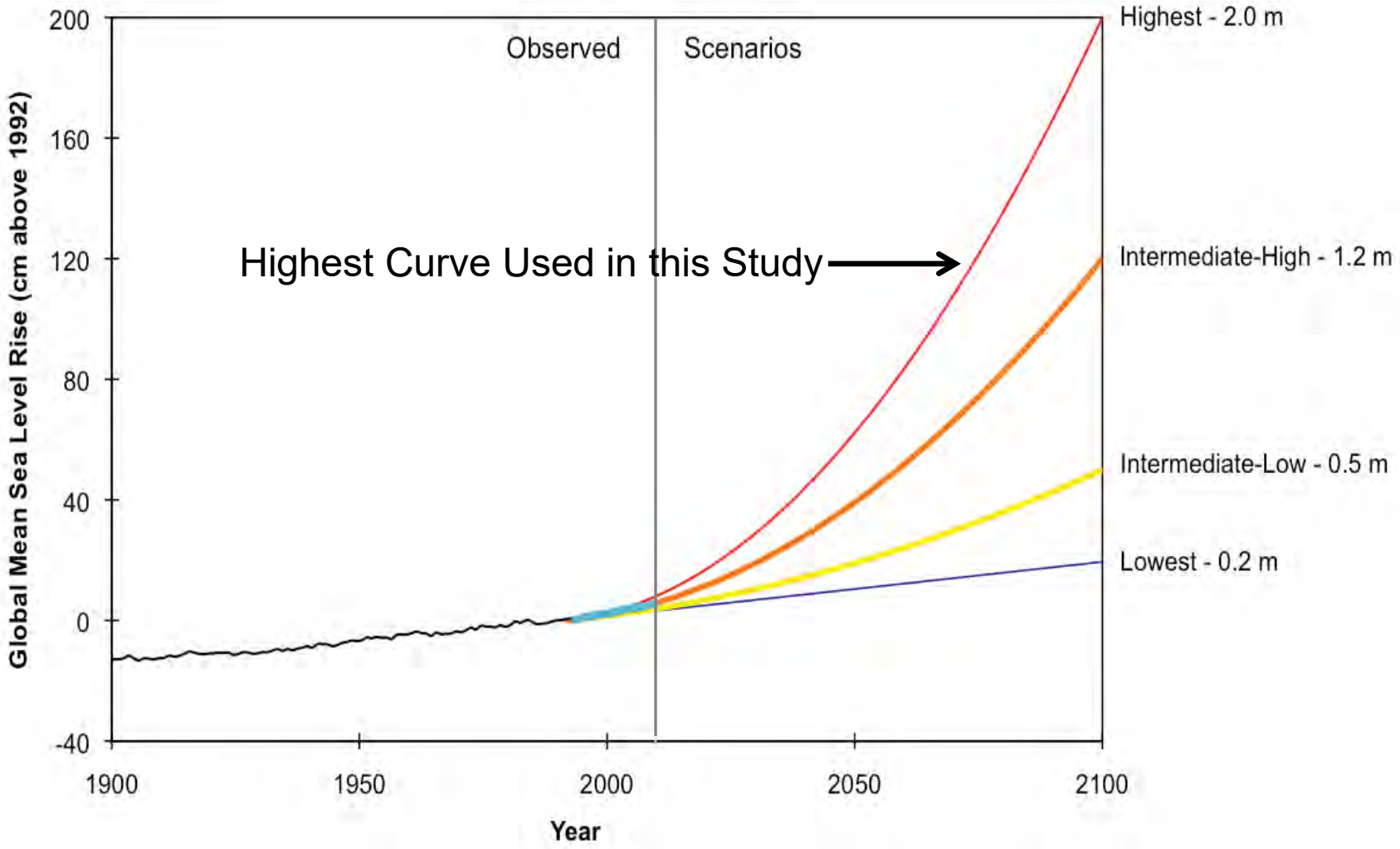
DESCRIPTION OF THE PARAMETERS, MODELING AND RESULTS

- The Sea Level Rise and Storm Surge Model used was the MassDOT Boston Harbor Flood Risk Model which takes into account sea level rise and storm surge impacts
- Better than other models because it takes into account waves and winds, and, can determine the volumetric flux of water accessing areas.

A Detailed Water Surface Model



Global Mean Sea Level Rise Projections



NOAA Technical Report *Global Sea Level Rise Scenarios for the United States National Climate Assessment*, December 2012

- We selected the highest projected sea level rise model and adjusted it by the local land subsidence rate for a Relative Sea Level Rise value
- We identified critical infrastructure and their critical elevations as possible

Planning Horizons

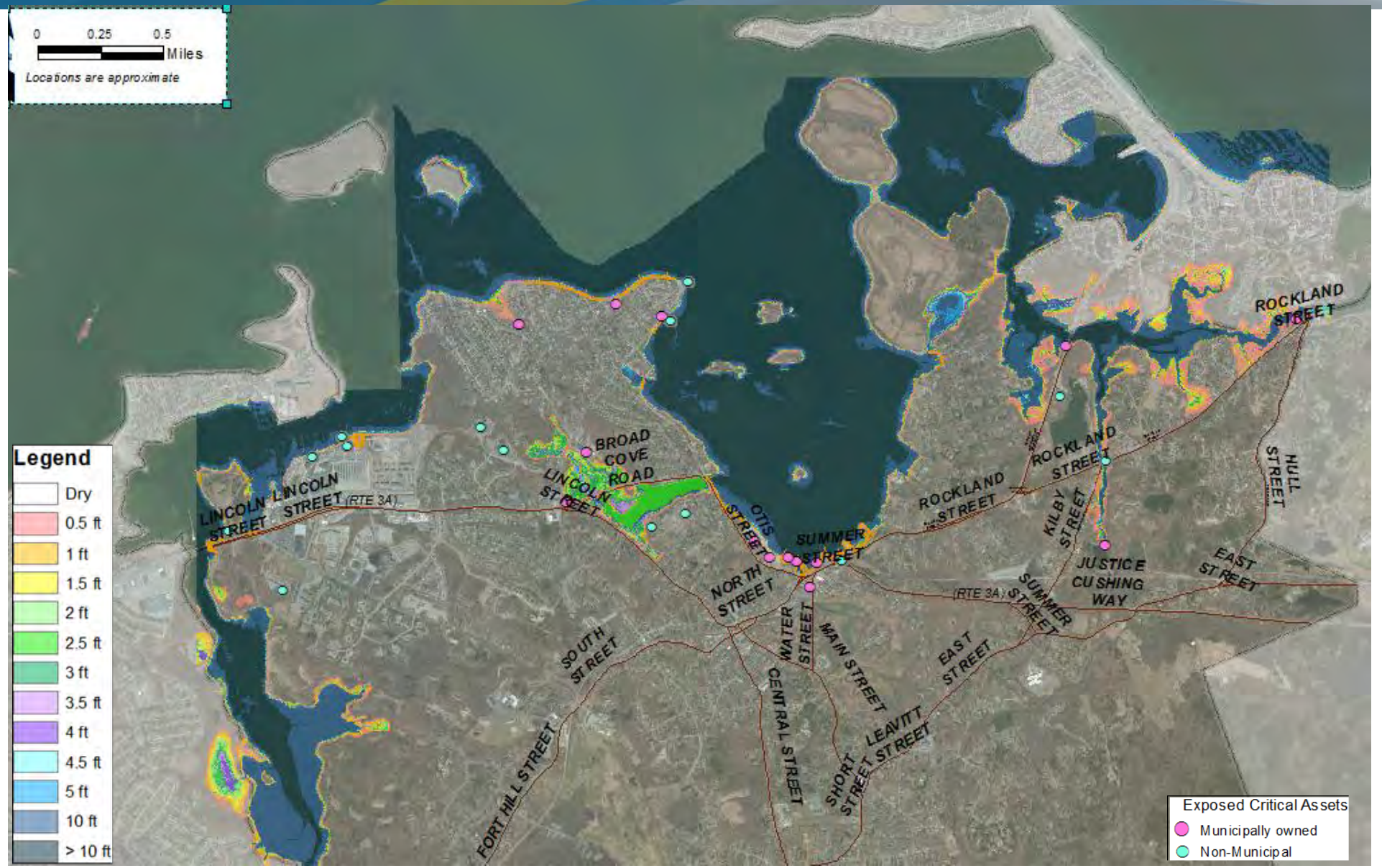
- 2015 - Present
- 2030 – 15 years out – Near term
- 2070 – 55 years out – Long term

Flood Modeling Results

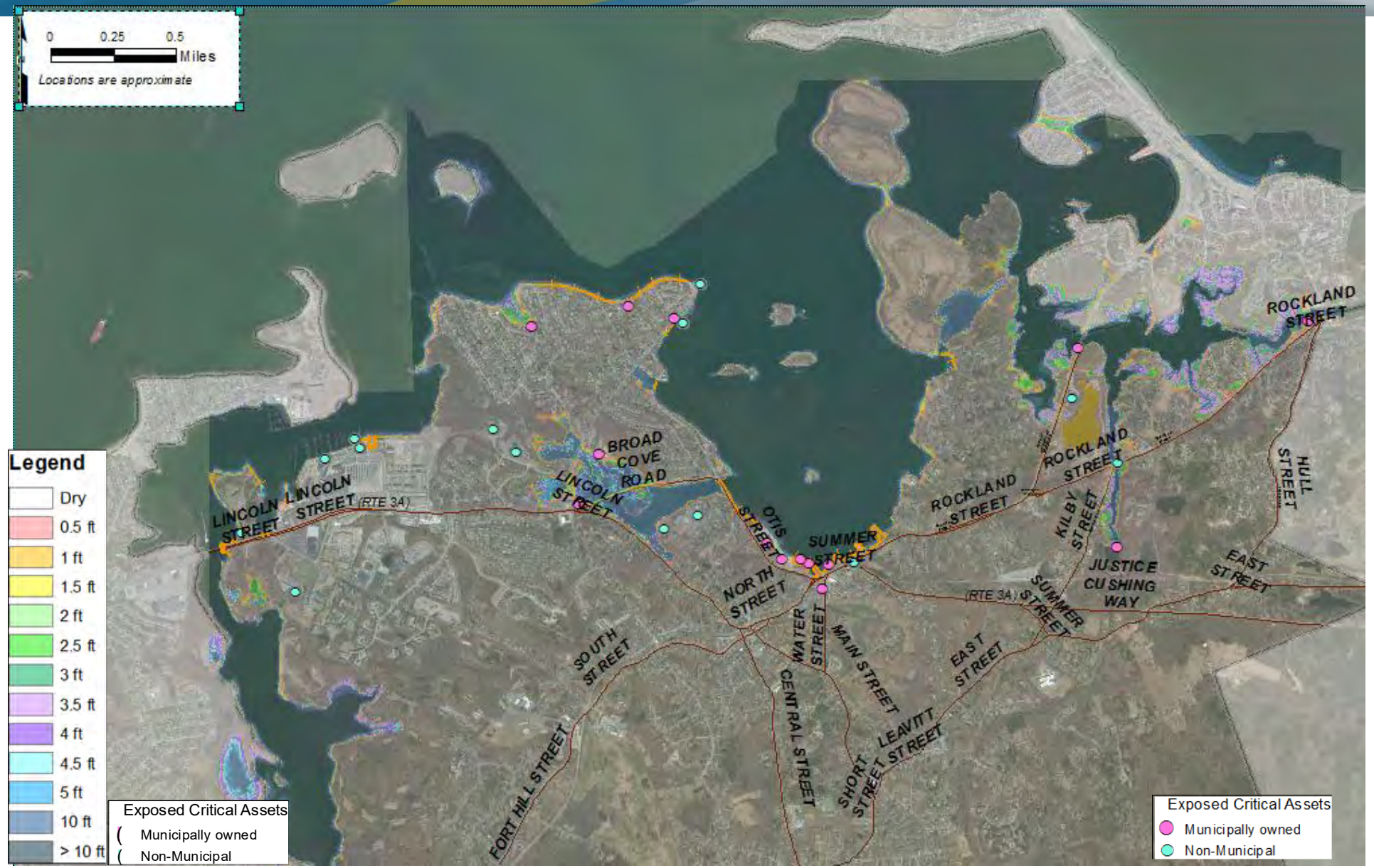
2030 – Risk of Flooding Map

2070 – Risk of Flooding Map

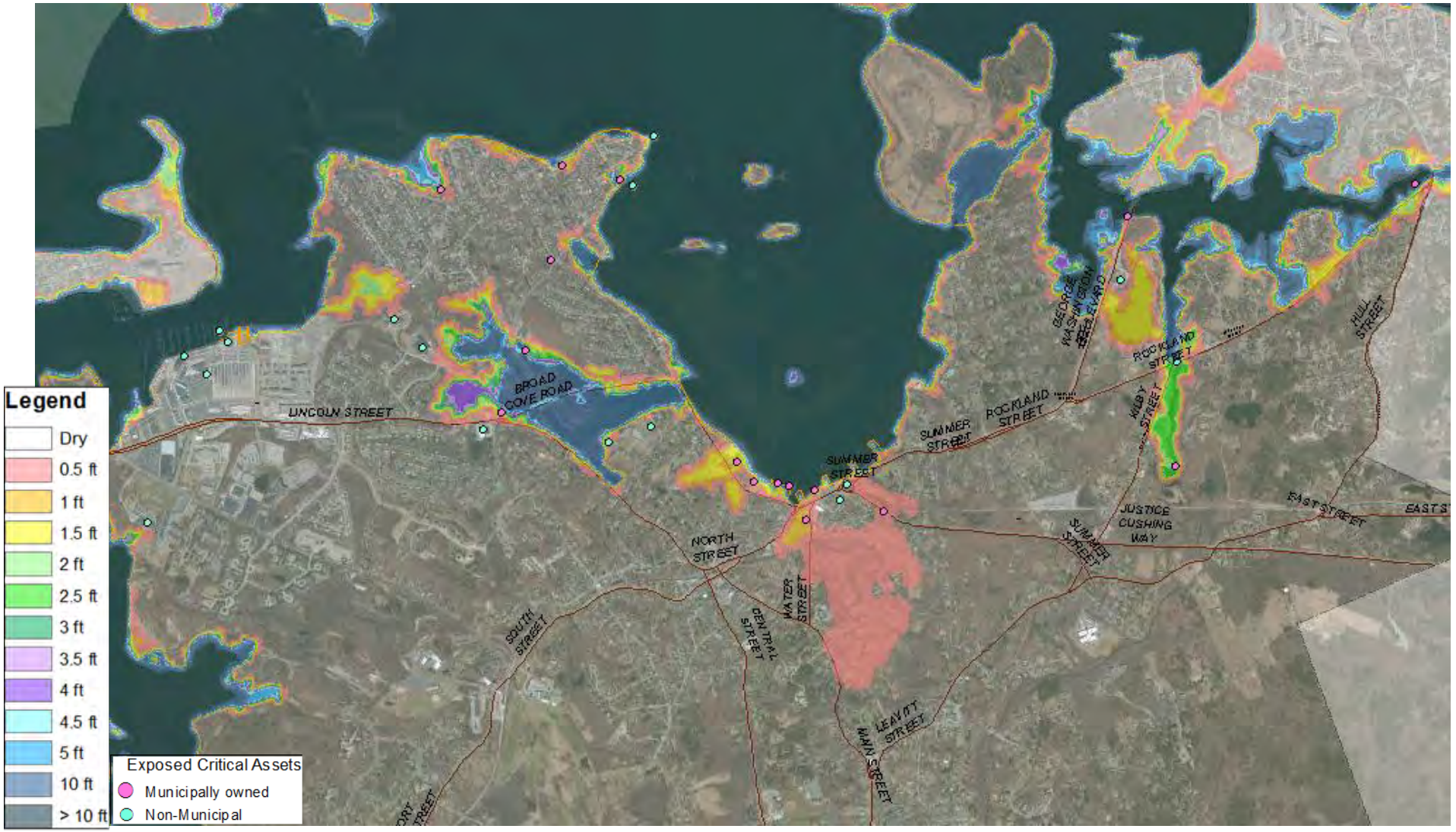
Sea Level Rise - 2030



Sea Level Rise - 2070

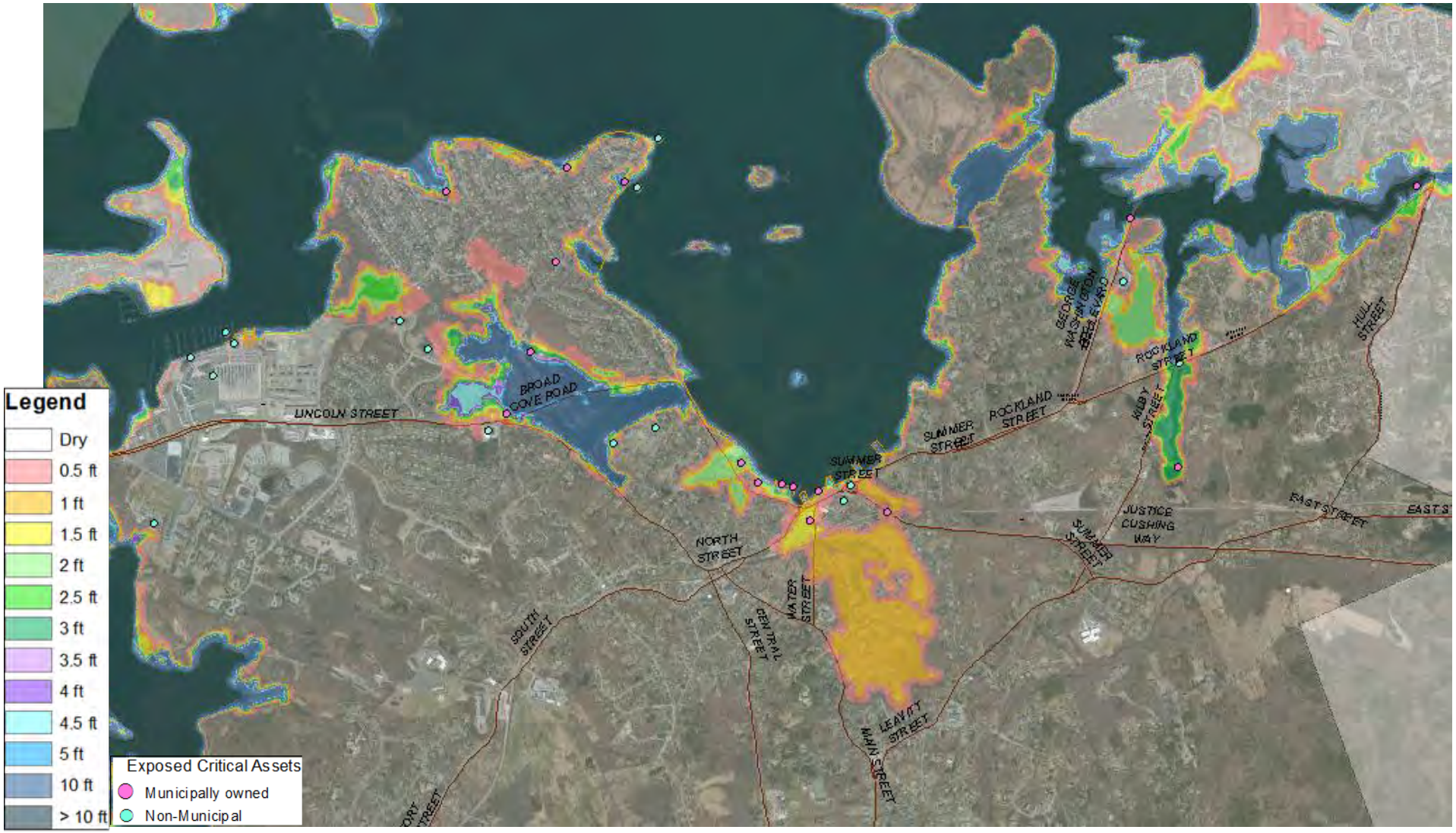


2030: 1% Annual Probability (≈100 yr Recurrence)



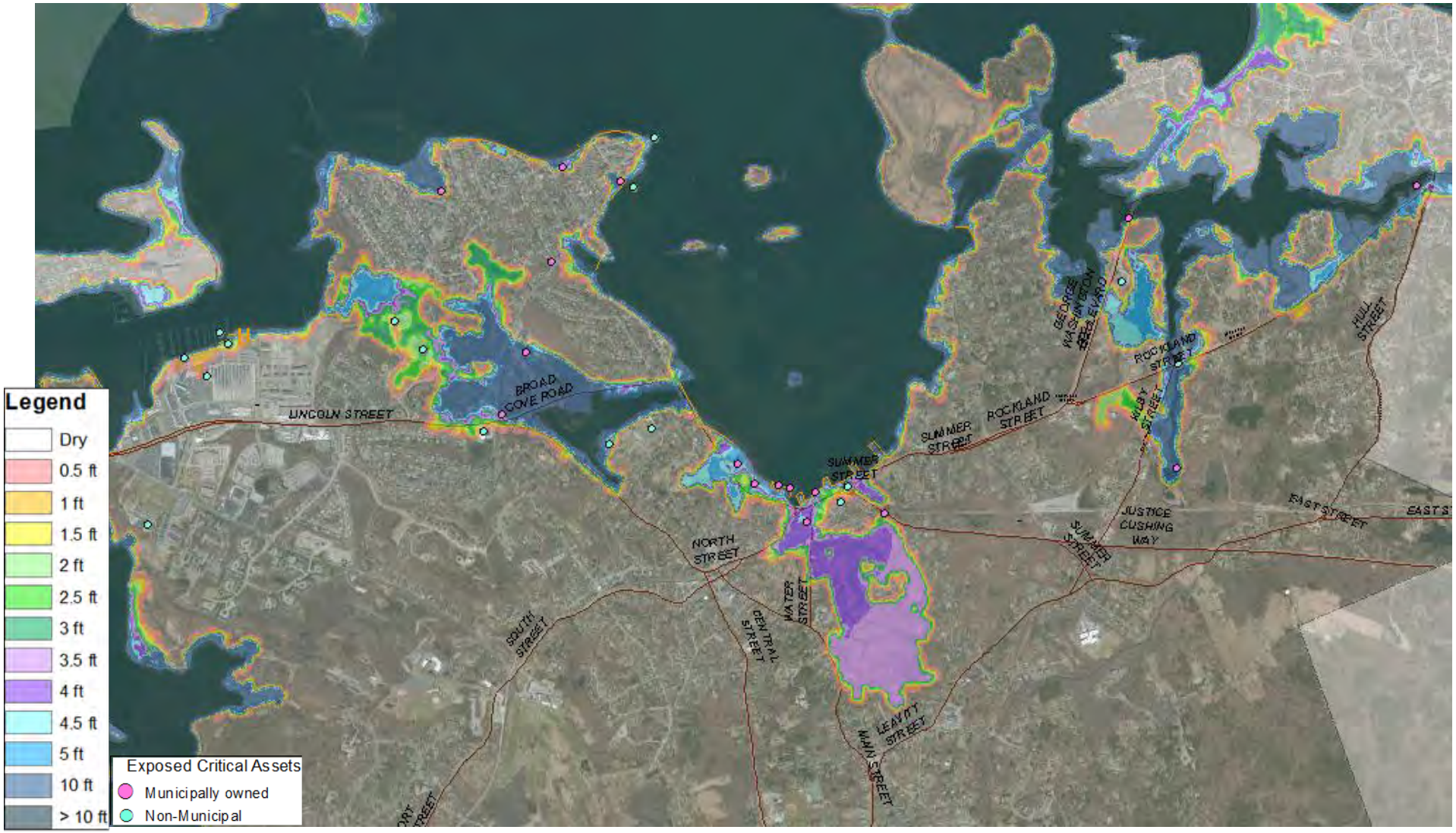
Depth of Flooding above Ground

2030: 0.2% Annual Probability (≈500 yr Recurrence)



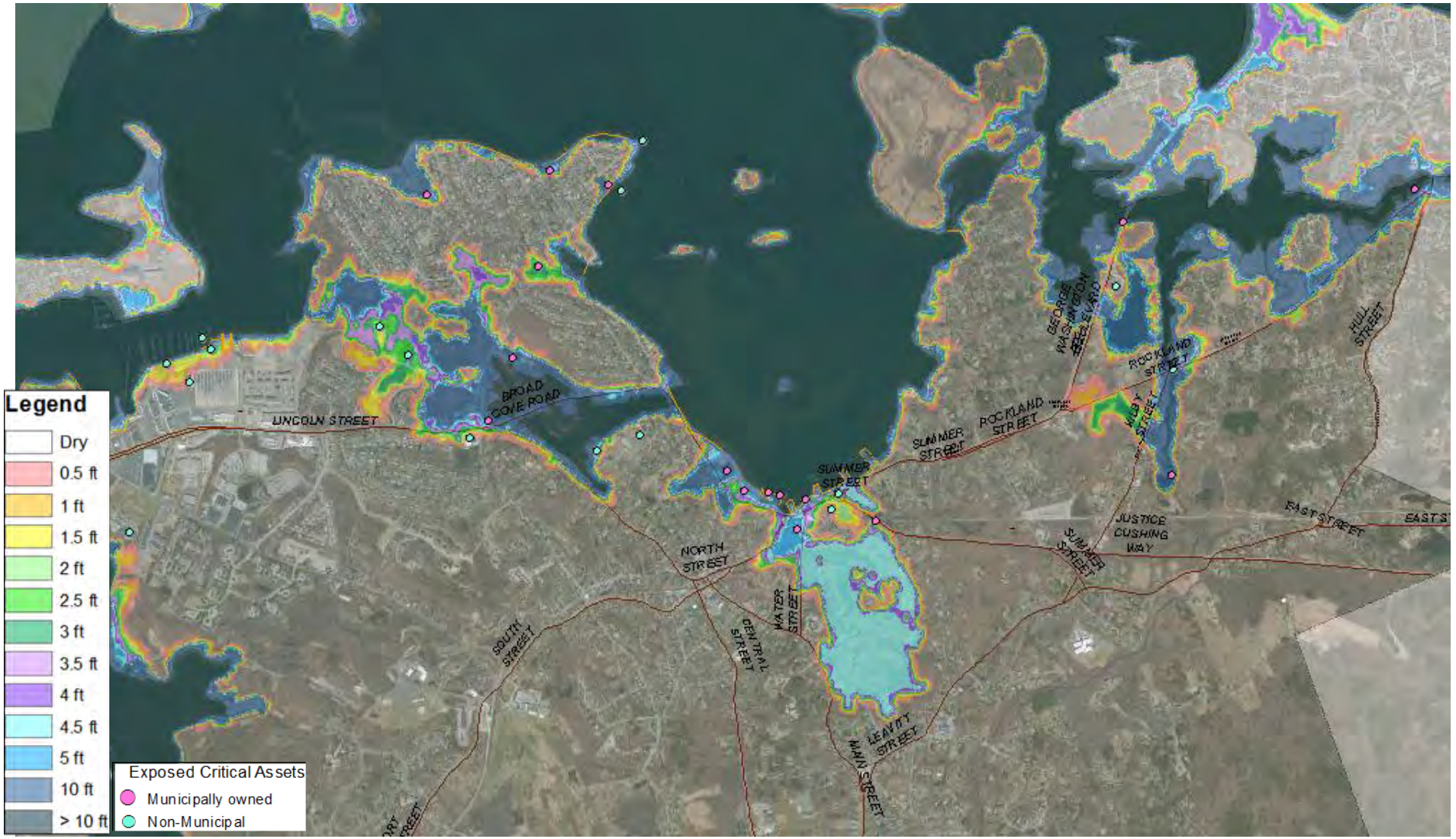
Depth of Flooding above Ground

2070: 1% Annual Probability (≈100 yr Recurrence)



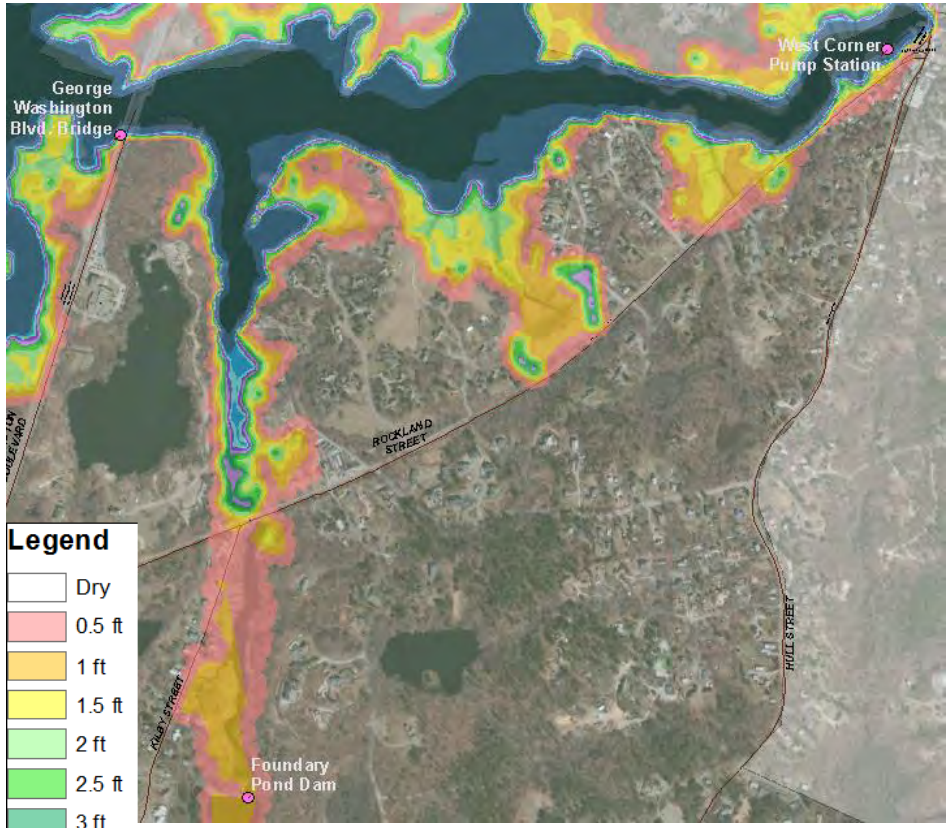
Depth of Flooding above Ground

2070: 0.2% Annual Probability (≈500 yr Recurrence)



Depth of Flooding above Ground

Present Inundation: Hingham-Hull Connectors

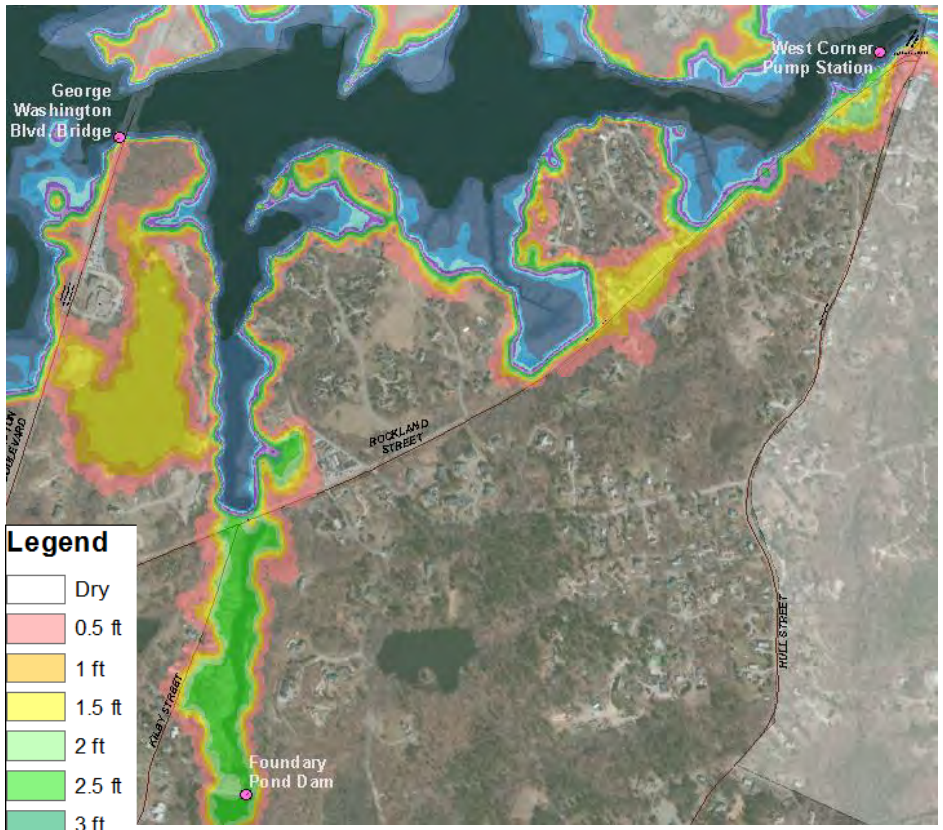


At 1% annual probability (≈100 yr recurrence)

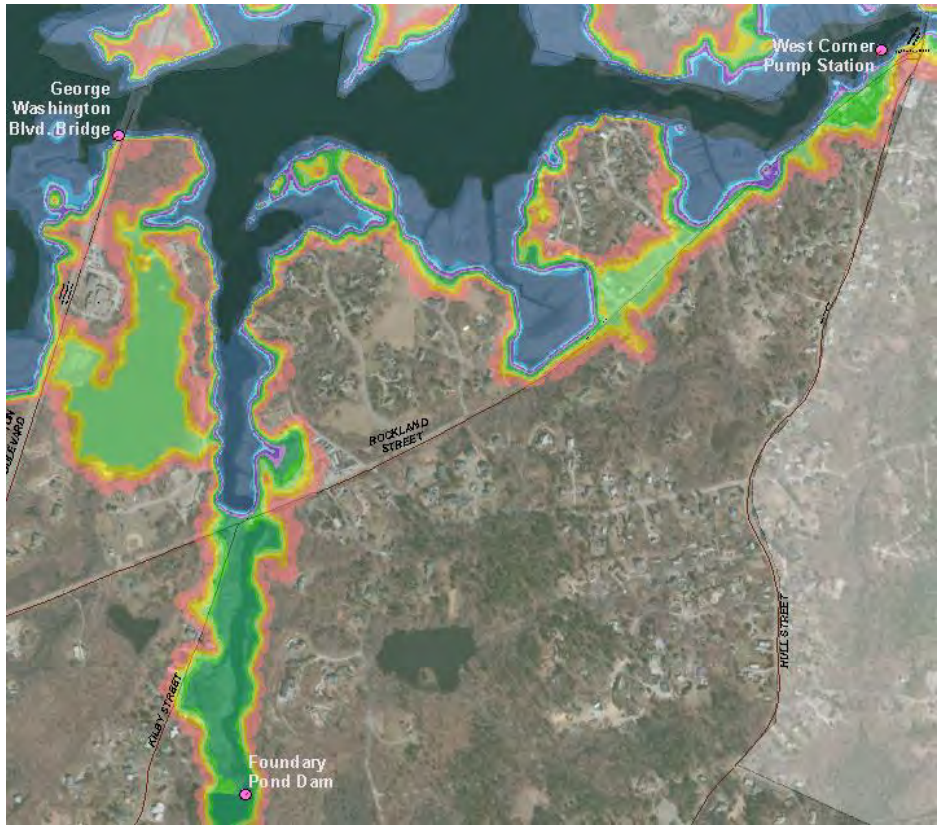
At 0.2 % annual probability (≈ 500 yr recurrence)

Depth of Flooding above Ground

2030 Inundation: Hingham-Hull Connectors



At 1% annual probability (≈100 yr recurrence)



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Depth of Flooding above Ground

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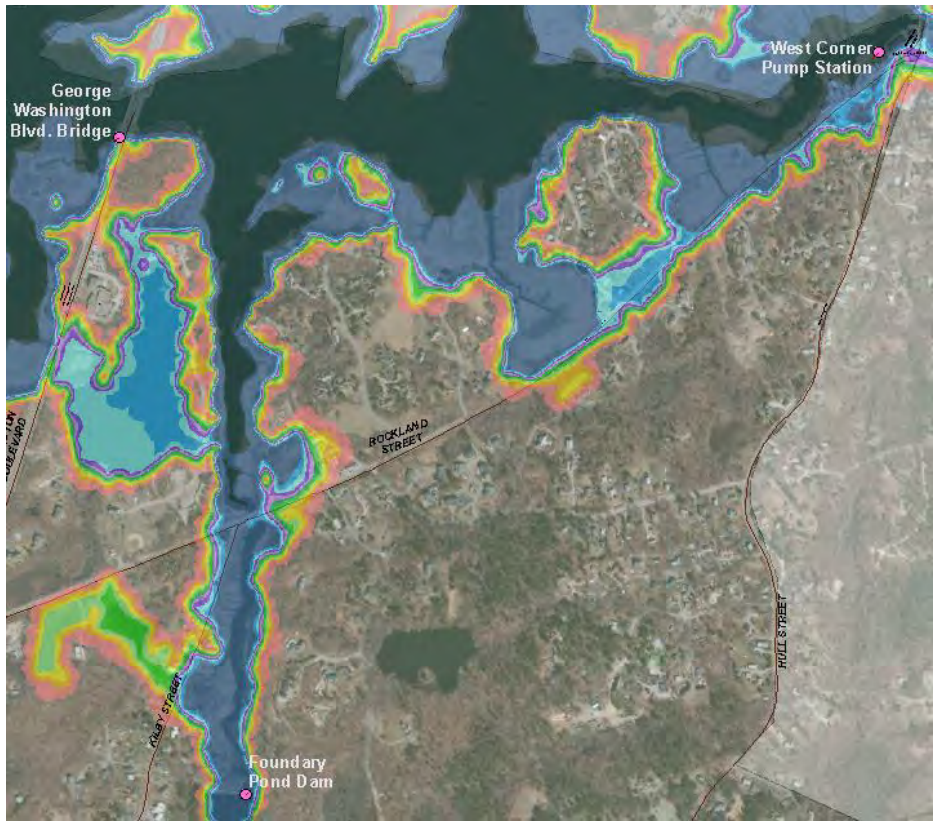

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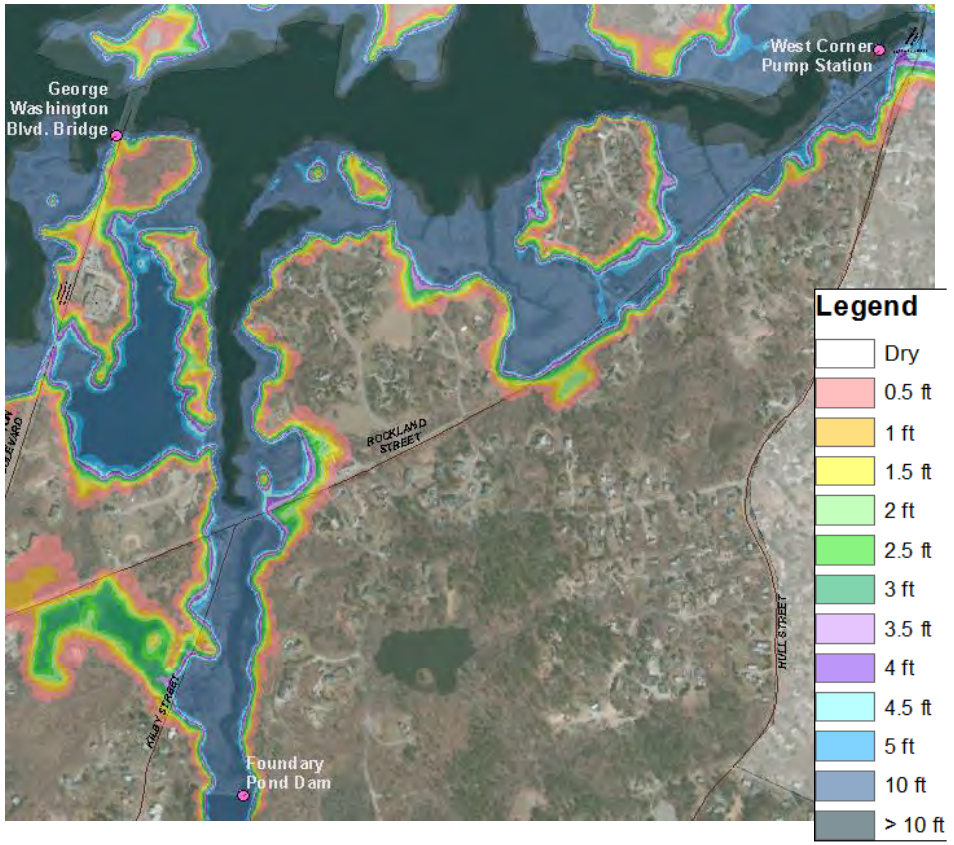
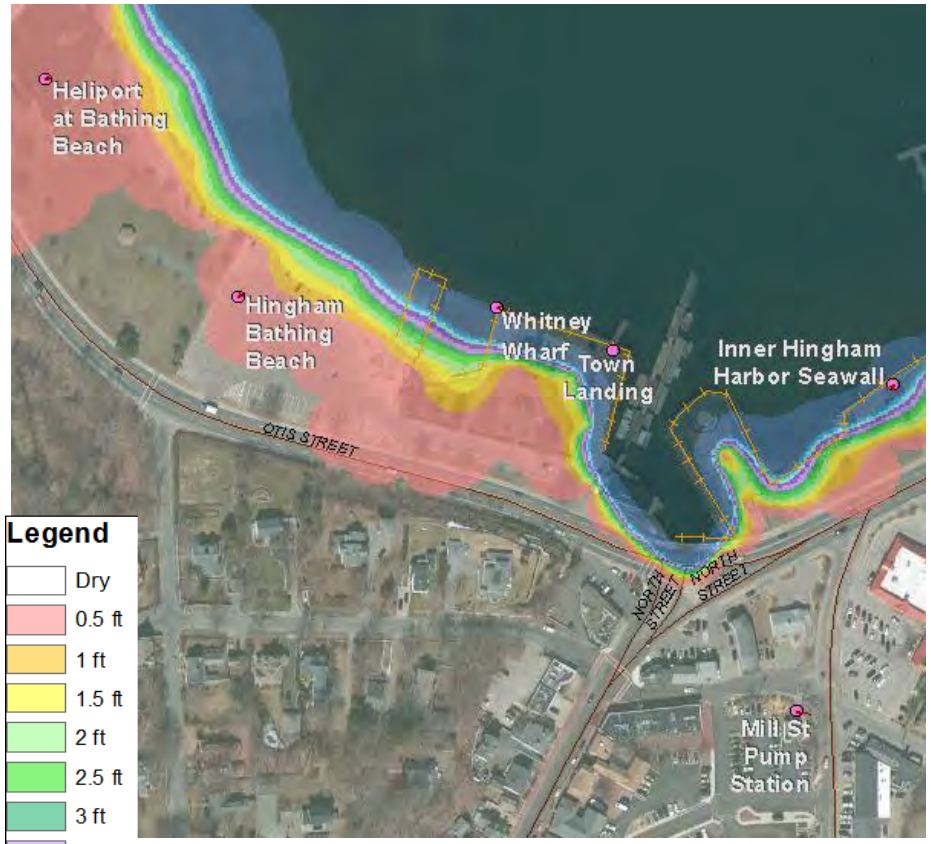


At 0.2 % annual probability (≈ 500 yr recurrence)

Depth of Flooding above Ground

Present Inundation: Inner Hingham Harbor

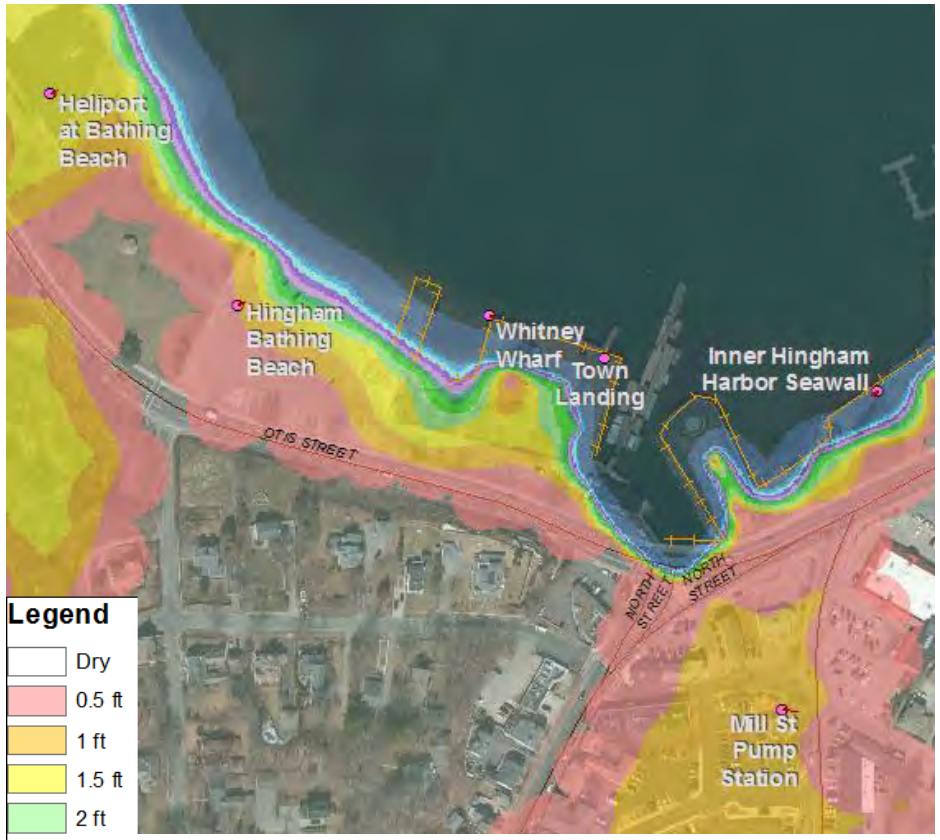


At 1% annual probability (≈100 yr recurrence)

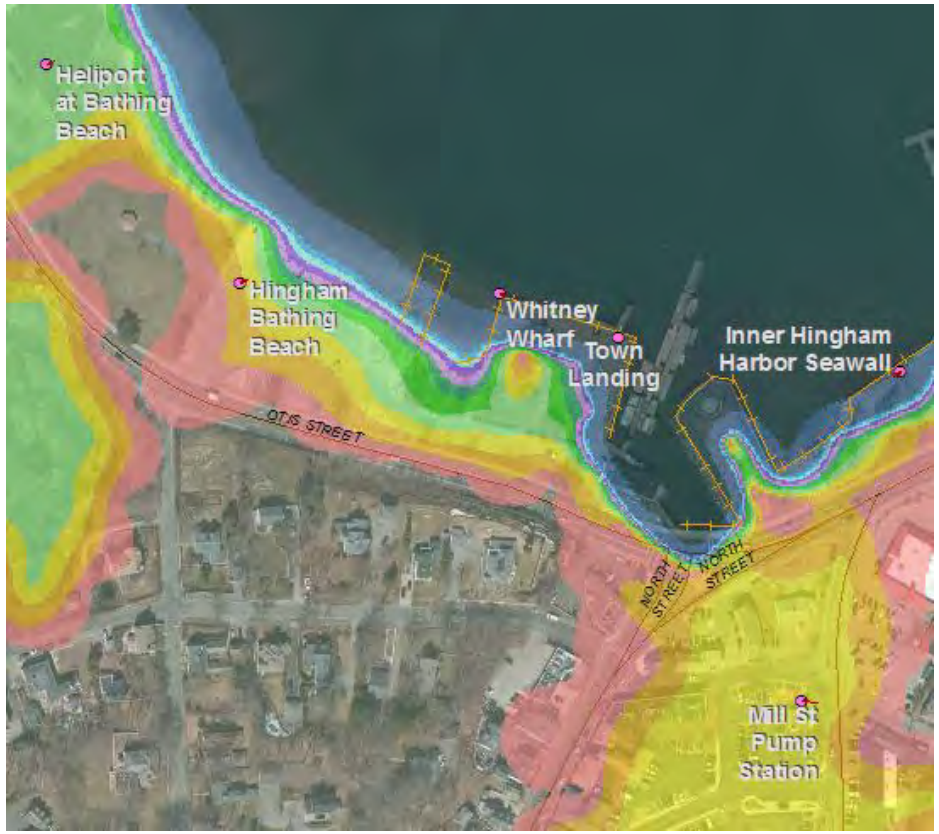
At 0.2 % annual probability (≈ 500 yr recurrence)

Depth of Flooding above Ground

2030 Inundation: Inner Hingham Harbor



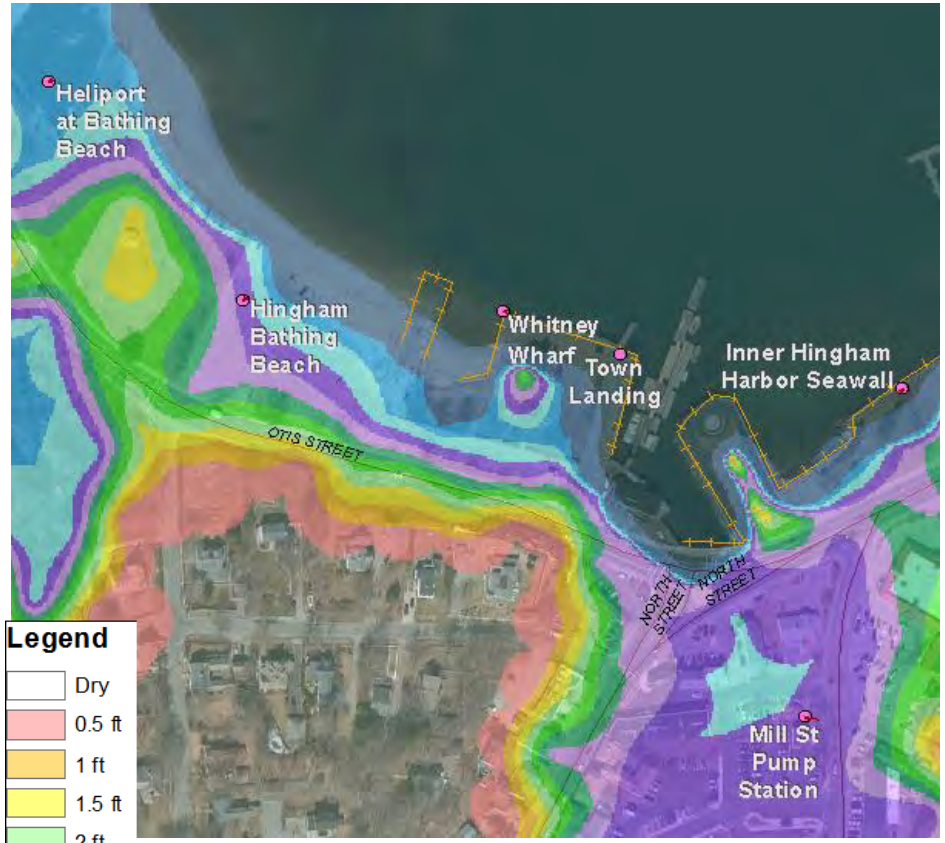
At 1% annual probability (≈100 yr recurrence)



At 0.2 % annual probability (≈ 500 yr recurrence)

Depth of Flooding above Ground

2070 Inundation: Inner Hingham Harbor

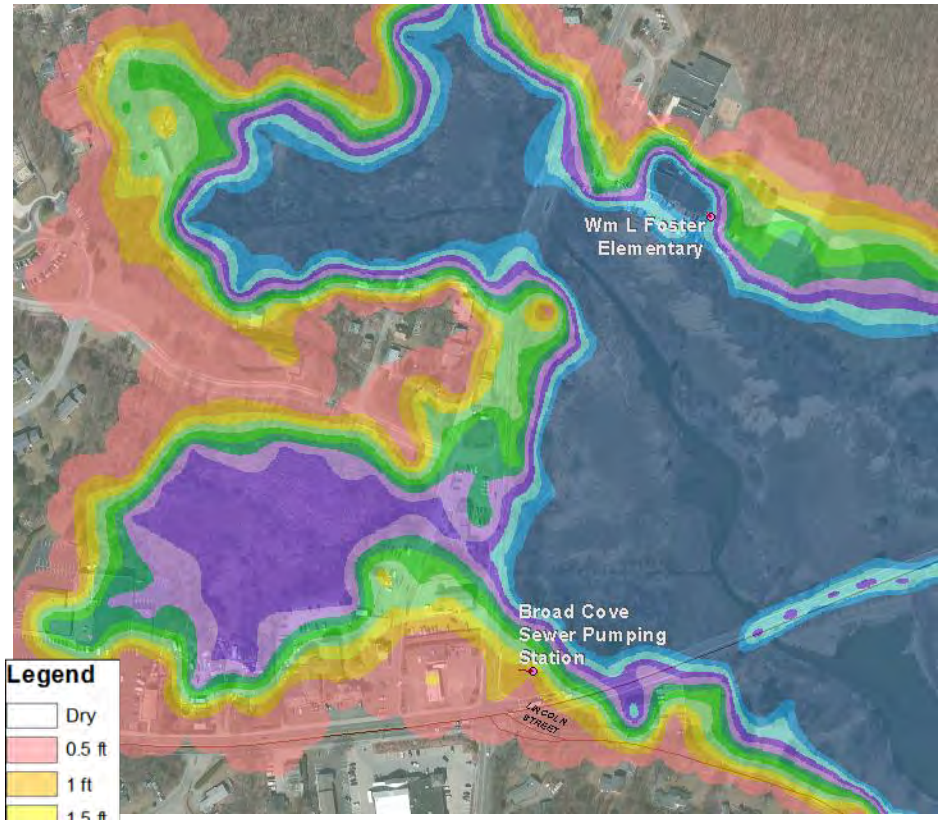


At 1% annual probability (≈100 yr recurrence)

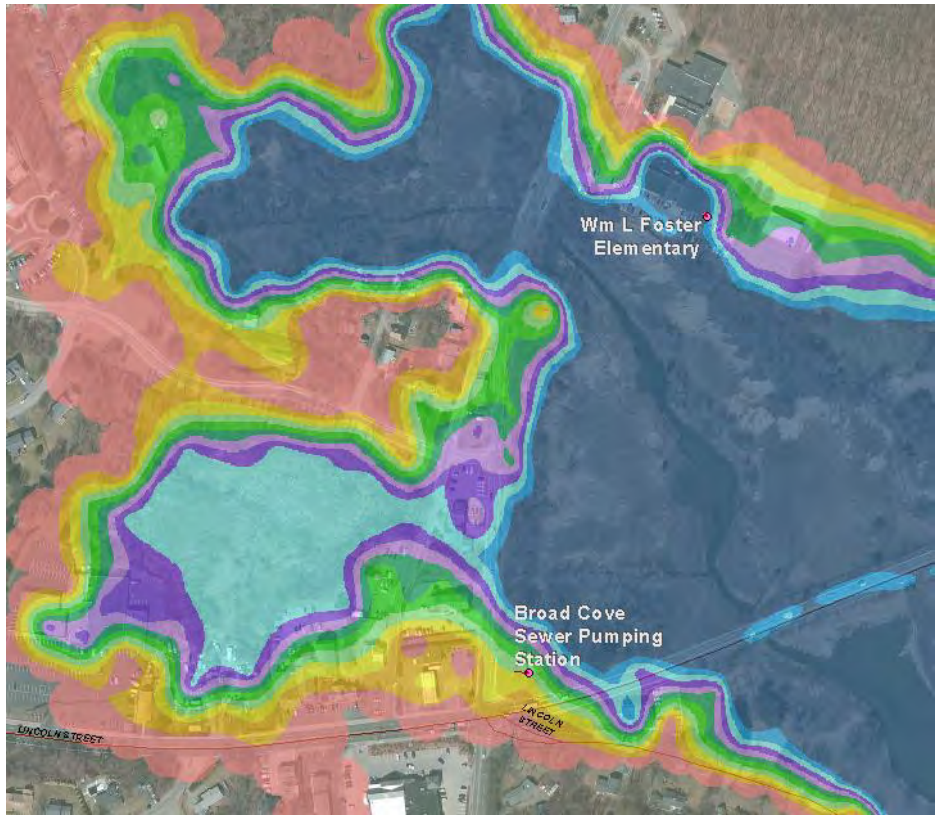
At 0.2 % annual probability (≈ 500 yr recurrence)

Depth of Flooding above Ground

2030 Inundation: Foster Elementary and Broad Cove PS



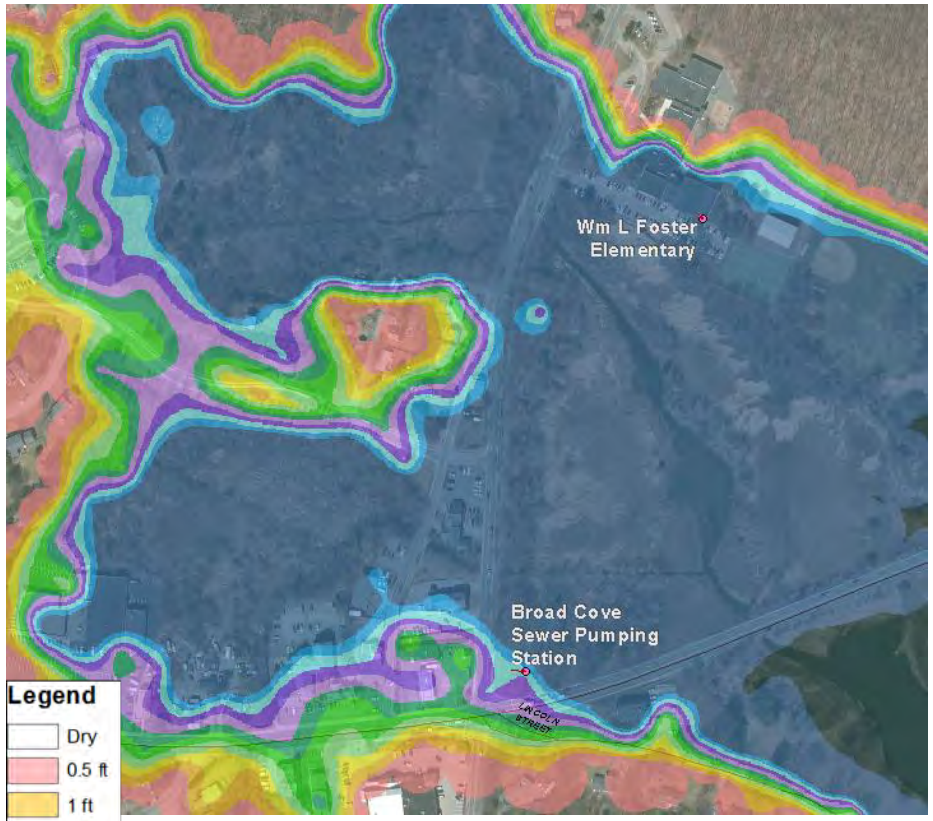
At 1% annual probability (≈100 yr recurrence)



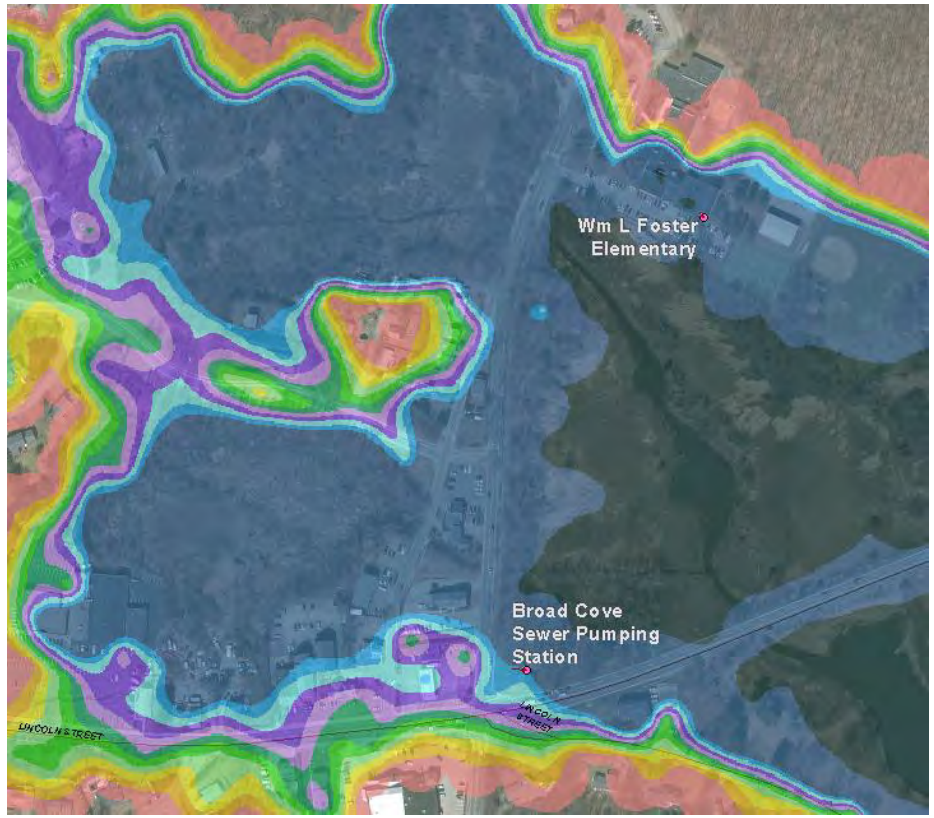
At 0.2 % annual probability (≈ 500 yr recurrence)

Depth of Flooding above Ground

2070 Inundation: Foster Elementary and Broad Cove PS



At 1% annual probability (≈100 yr recurrence)



At 0.2 % annual probability (≈ 500 yr recurrence)

Depth of Flooding above Ground

Risk Based Vulnerability Assessment

Risk Based Vulnerability Assessment

For each infrastructure asset, assess:

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

R = P X C

Probability of Exceedence Data

Mill Street Pump Station

Critical Elevation Threshold = **8.69 ft. NAVD88**

	Present		2030		2070	
% Probability	Flood elevation	Depth above critical elev.	Flood elevation	Depth above critical elev.	Flood elevation	Depth above critical elev.
0.1	dry	0	11.8	3.11	14.1	5.41
0.2	dry	0	11.5	2.81	14	5.31
0.5	dry	0	11	2.31	13.5	4.81
1	dry	0	10.3	1.61	12.8	4.11
2	dry	0	10	1.31	12.5	3.81
5	dry	0	9.3	0.61	12.1	3.41
10	dry	0	dry	0	11.5	2.81
20	dry	0	dry	0	11.1	2.41
25	dry	0	dry	0	10.9	2.21
30	dry	0	dry	0	10.8	2.11
50	dry	0	dry	0	9.3	0.61
100	dry	0	dry	0	dry	0

Consequence of Failure Score

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

Mill St. Pump Station

	Area of Service Loss	Duration of Service Loss	Cost of Damage	Impacts to Public Safety Services	Impacts to Economic Activities	Impacts to Public Health/ Environment	Consequence score
Rating	2	4	2	1	5	5	63

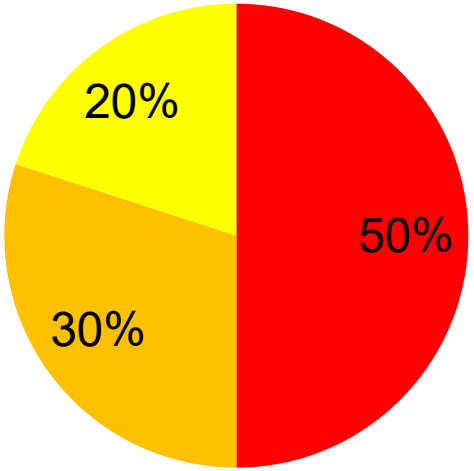
Calculate Risk Scores and Rankings

$$R_{tn} = P_{tn} \text{ X } C_{tn}$$

$$R_{composite} = R_{pres.}(W_{pres.}) + R_{2030}\,(W_{2030}) + R_{2070}\,(W_{2070})$$

Weighting (W)

- Present
- 2030
- 2070



Risk Scores and Rankings

Example - Mill Street Pump Station

	Probability of Exceedance	Consequence Score	Risk Score	Weight	Composite Risk Score
Present	0	63	0	0.5	728
2030	5	63	317	0.3	
2070	50	63	3167	0.2	

Top 20 Assets Subject to Flooding Ranked by Composite Risk Score

Asset Name	Type	Consequence Score	Present Probability (%)	2030 Probability (%)	2070 Probability (%)	Composite Risk Score
Walton Cove 034-027-000-059-100	Bulkhead/ Seawall	37	100	100	100	3667
Iron Horse Park Area 034-051-000-003-100	Bulkhead/ Seawall	60	25	50	100	2850
Iron Horse Park Area 034-051-000-005B-200	Bulkhead/ Seawall	57	30	50	100	2833
Bridge Street 034-045-000-002-100	Revetment	50	30	50	100	2500
Iron Horse Park Area 034-051-000-059-100	Bulkhead/ Seawall	33	50	50	100	2000
Iron Horse Park Area 034-051-000-001-200	Bulkhead/ Seawall	60	5	30	100	1890
Bridge Street 034-045-000-002-200	Bulkhead/ Seawall	50	10	30	100	1700
Bridge Street 034-045-000-002-300	Revetment	50	10	30	100	1700
William L. Foster Elementary School	Facility	63	0	10	100	1457
Iron Horse Park Area 034-051-000-004-100	Bulkhead/ Seawall	60	2	10	100	1440
Iron Horse Park Area 034-050-000-050-200	Bulkhead/ Seawall	40	10	30	100	1360
Rockland St and Kilby St	Roadway	30	10	50	100	1200
Otis St (Rt 3A) at Hingham Bathing Beach	Roadway	50	1	10	100	1175
Martin's Well 034-030-000-011-100	Revetment	23	30	50	100	1167
Bridge Street 034-045-000-002-400	Groin/ Jetty	23	30	50	100	1167
Iron Horse Park Area 034-051-000-005-100	Bulkhead/ Seawall	50	1	10	100	1163
Broad Cove Entrance 034-039-000-009-100	Revetment	47	2	10	100	1120
West Corner Pump Station	Facility	50	1	5	100	1088
Broad Cove Rd (Rt 3A)	Roadway	47	0	10	100	1073
Beach Rd and Beach Ln	Roadway	33	5	25	100	1000

Photo Renderings

Rt. 3A at Broad Cove
2030 1% (100 YR)

Rt. 3A at Broad Cove
2070 1% (100 YR)

Rt. 3A - North St. to Water St.
2030 1% (100 YR)

Rt. 3A - North St. to Water St.
2070 1% (100 YR)

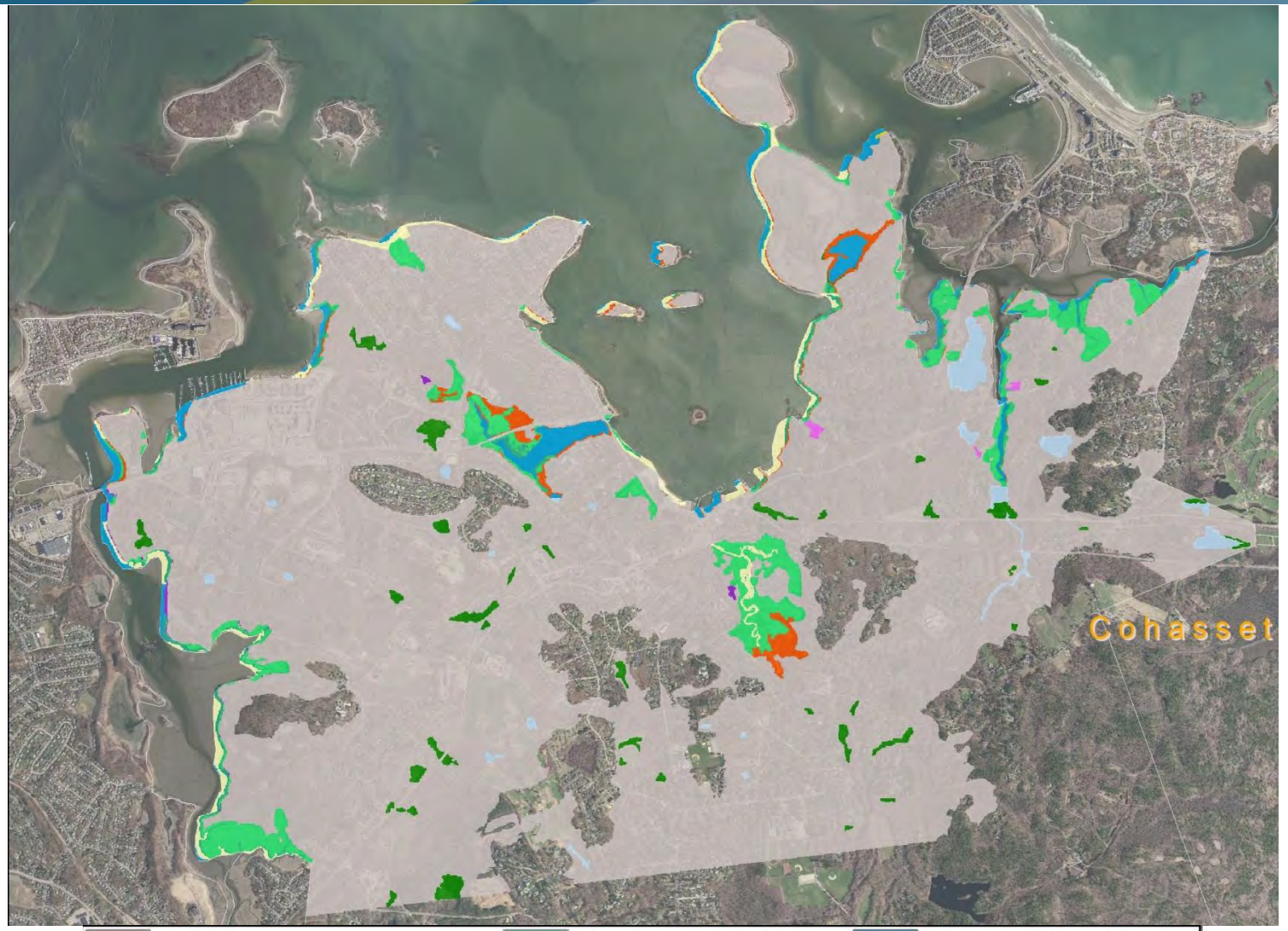
George Washington Blvd.
2070 1% (100 YR)

Natural Resources Evolution

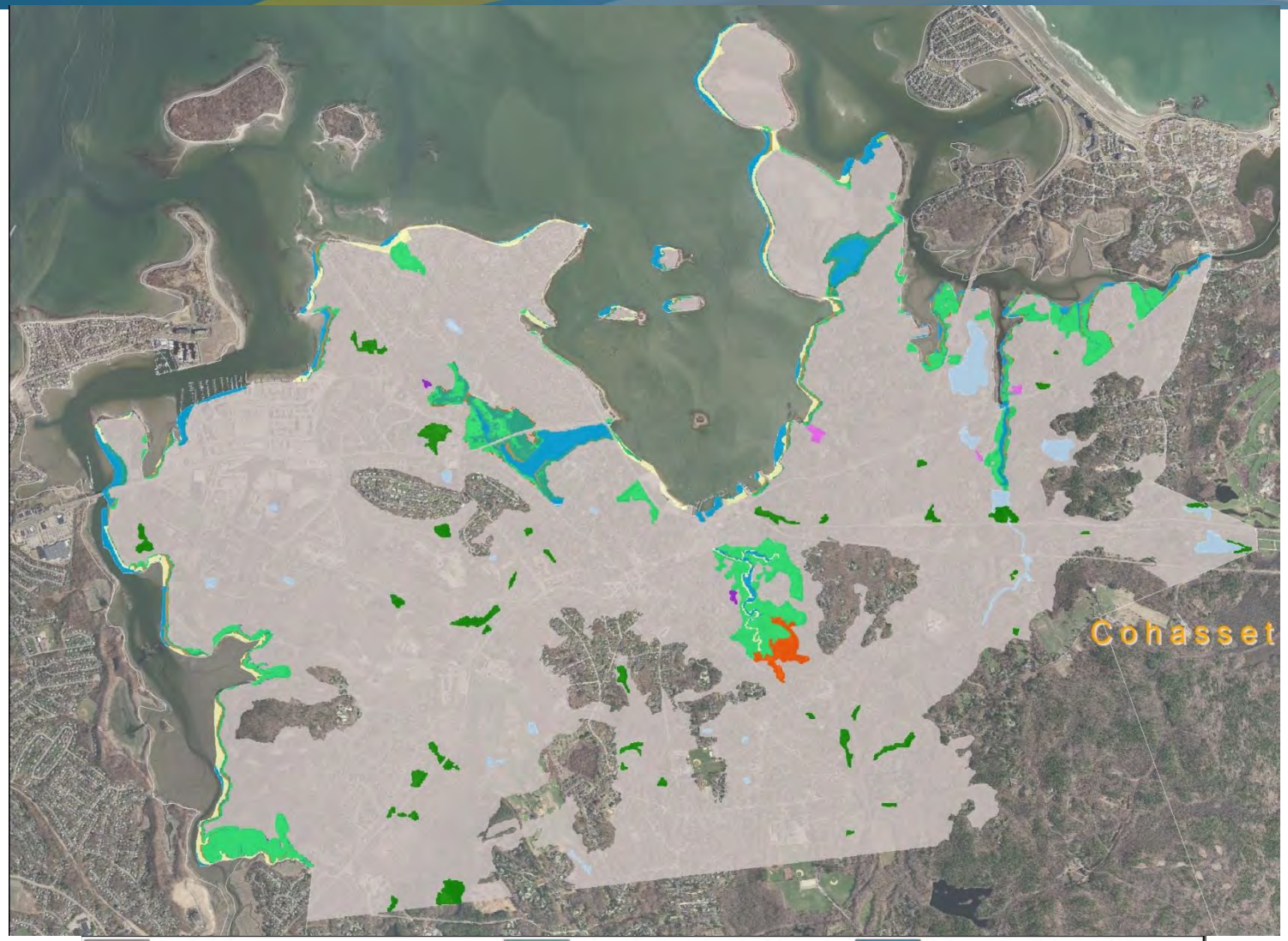
Natural Resources Evolution

- Evolution of natural resources modeled using Sea Level Affecting Marsh Migration (SLAMM) software
- Topography based on 2011 USGS LiDAR from Mass GIS
- 2011 wetland layer classified by National Wetland Inventory (NWI) used as base line
- Model inputs include:
  - Accretion rates (marsh, beach, etc.)
  - Tidal range and attenuation
  - Freshwater parameters
  - Impervious surfaces
  - Storm surge not included

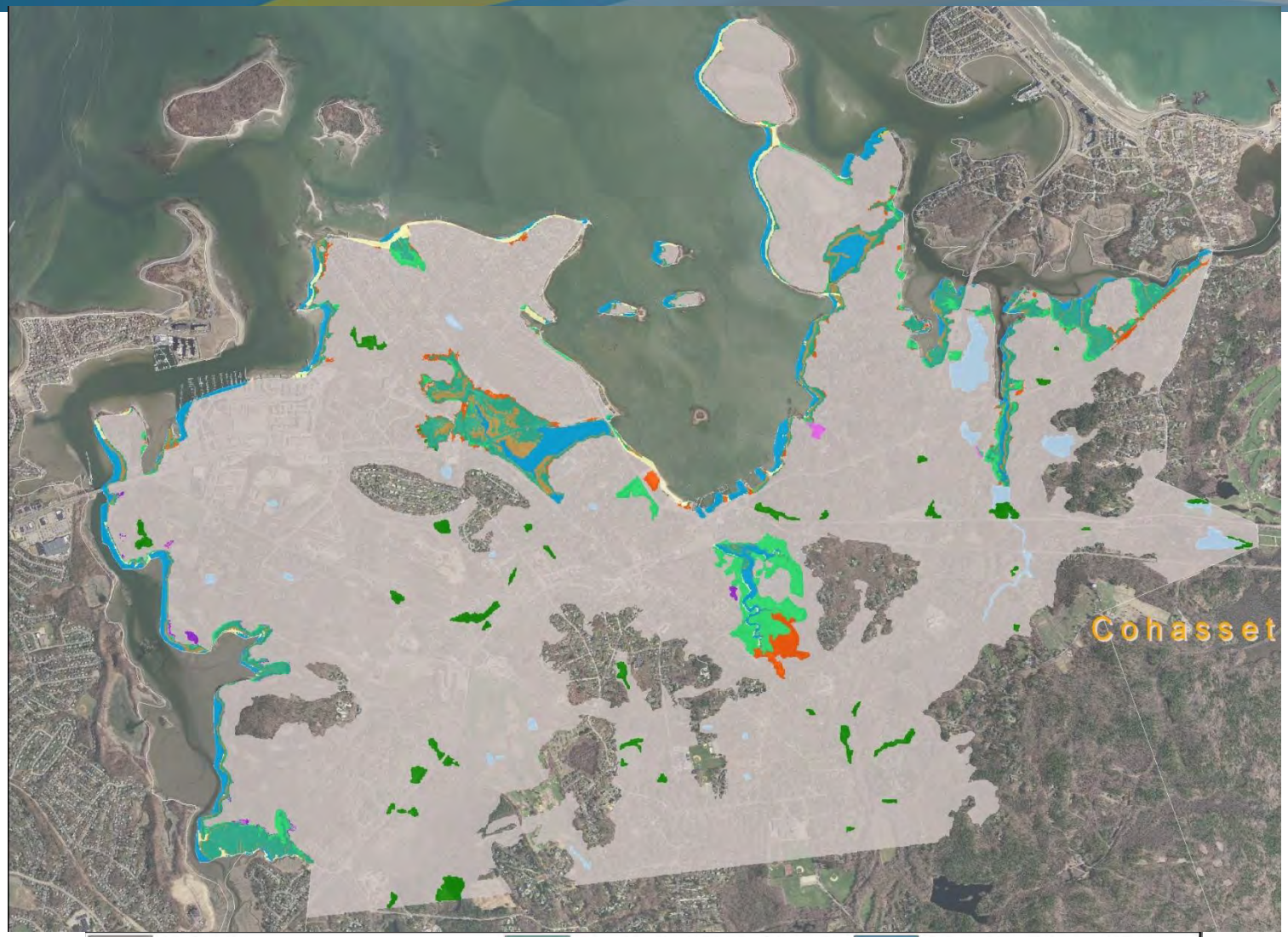
Natural Resources Evolution - 2011



Natural Resources Evolution - 2030



Natural Resources Evolution - 2070



Upland	Regularly Flooded Marsh	Estuarine Open Water
Inland Fresh Marsh	Estuarine Beach	Irregularly Flooded Marsh
Tidal Fresh Marsh	Ocean Beach	Tidal Swamp
Transitional Marsh/Scrub-Shrub	Inland Open Water	

Natural Resources Evolution - Summary

Town-wide Changes

2011 - 2030

- Loss of approximately 13 acres of high marsh (to low marsh – not necessarily a problem)
- Loss of approximately 10 – 30 acres of upland area
- Loss of approximately 28 acres of transitional marsh to high marsh
- Gain of approximately 28 acres of low marsh
- Gain of approximately 25 acres of tidal flats

Natural Resources Evolution - Summary

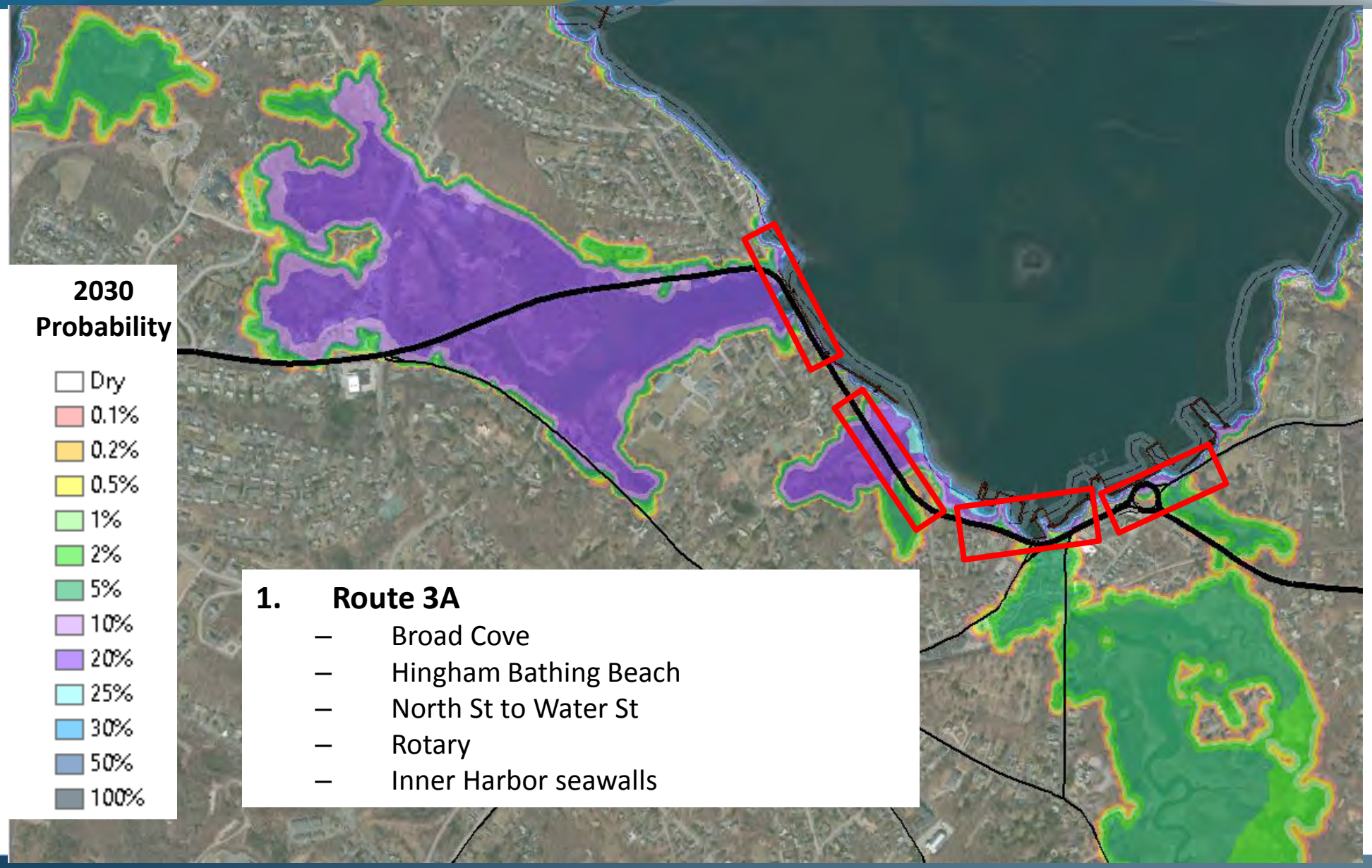
Town-wide Changes

2030 - 2070

- Loss of approximately 98 acres of high marsh (to low marsh)
- Loss of approximately 70 – 100 additional acres of upland area along edges of water bodies
- Loss of approximately 26 acres of estuarine beach along edges of estuaries – increase in tidal creeks
- Gain of approximately 100 acres of low marsh
- Gain of approximately 32 additional acres of tidal flats, especially in Broad Cove area
- Gain of approximately 38 acres of tidal creeks

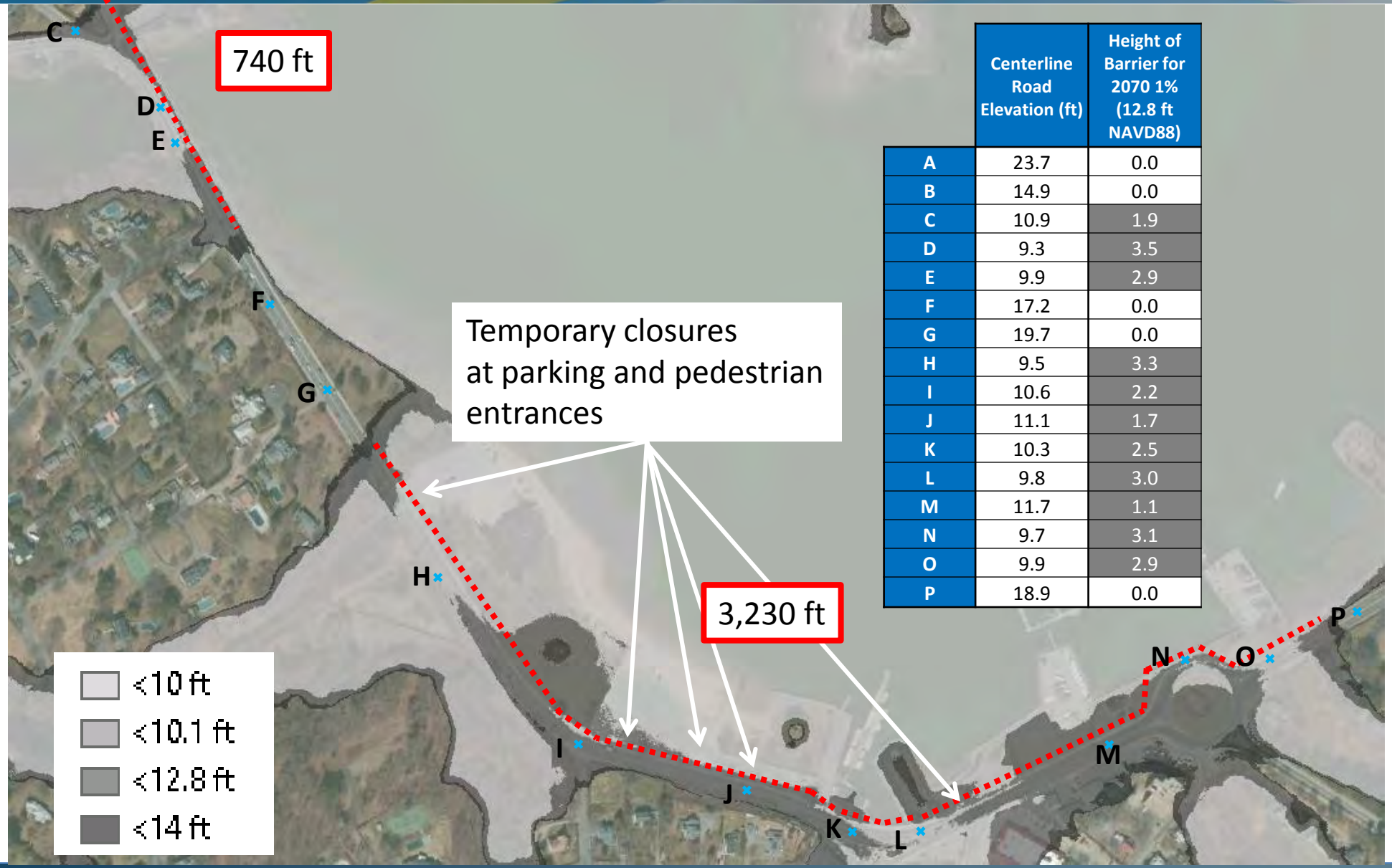
Adaptation Strategies

Route 3A (Broad Cove-Inner Harbor)



1. **Route 3A**
   - Broad Cove
   - Hingham Bathing Beach
   - North St to Water St
   - Rotary
   - Inner Harbor seawalls

Vulnerable Segments – Long Term



	Centerline Road Elevation (ft)	Height of Barrier for 2070 1% (12.8 ft NAVD88)
A	23.7	0.0
B	14.9	0.0
C	10.9	1.9
D	9.3	3.5
E	9.9	2.9
F	17.2	0.0
G	19.7	0.0
H	9.5	3.3
I	10.6	2.2
J	11.1	1.7
K	10.3	2.5
L	9.8	3.0
M	11.7	1.1
N	9.7	3.1
O	9.9	2.9
P	18.9	0.0

Adaptation

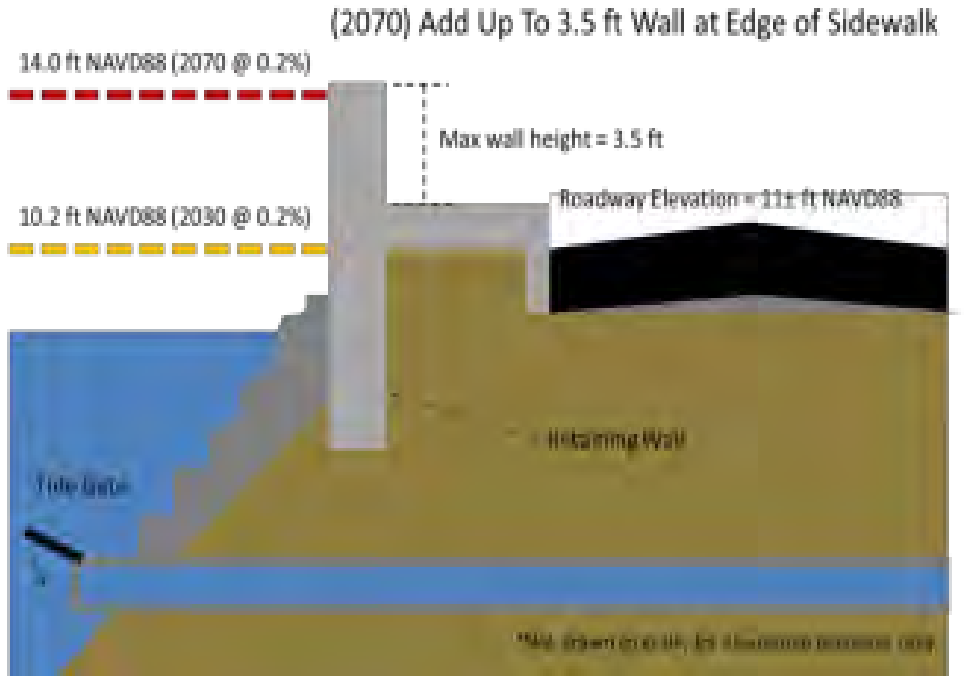
Route 3A / Inner Harbor:

- Raise 5,000 ft. of seawalls (excluding Kimball's Wharf) at unit cost ranging from $1,000 to $3,000/ft:
  - $5,000,000 - $15,000,000
- Raise 450 ft. Kimball's Wharf:
  - $450,000 - $1,350,000

Adaptation

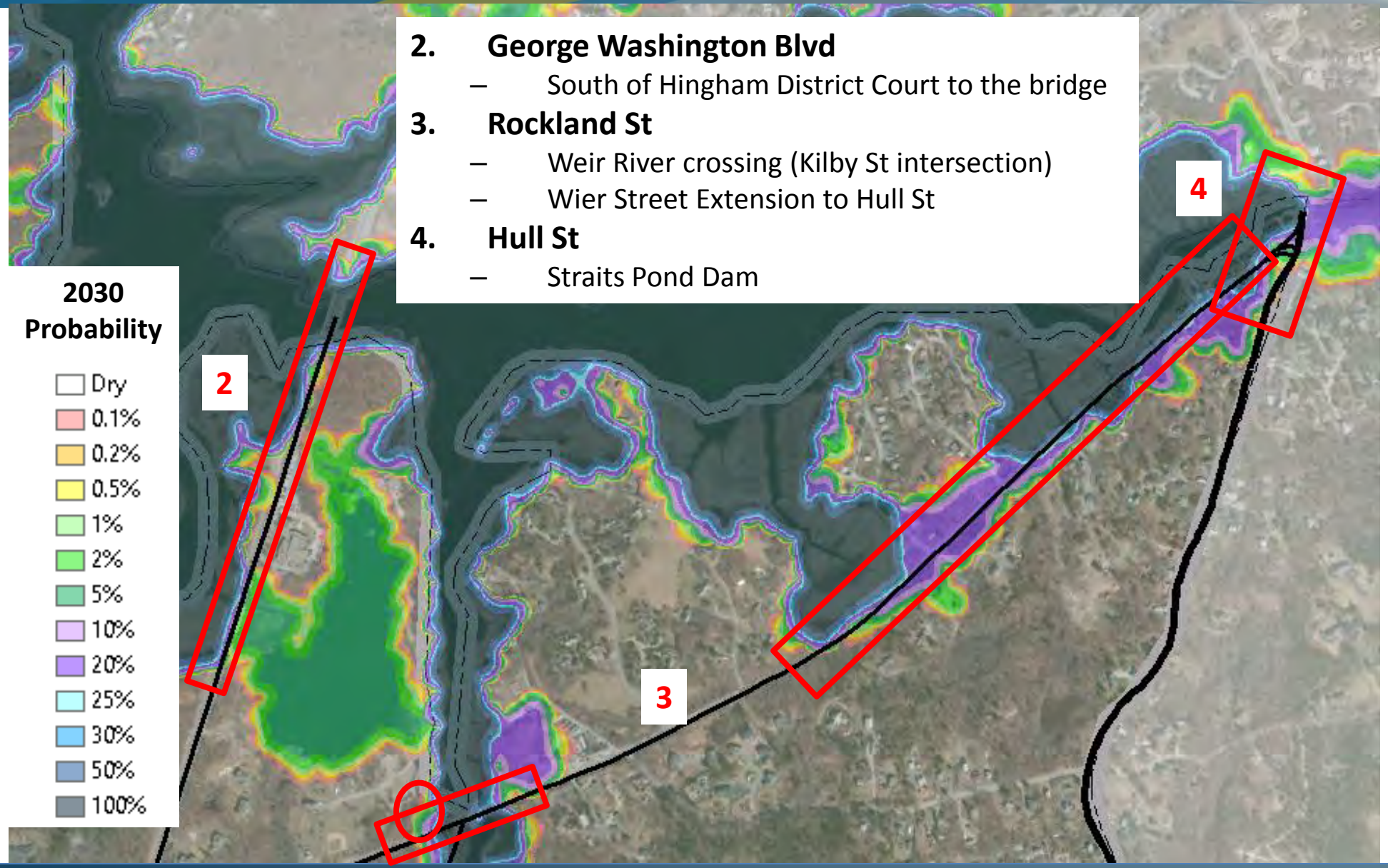
Route 3A / Inner Harbor:

- Raise 1,880 ft. Rt. 3A to El. 10.2 NAVD88
  - Construction $4,750,000
  - Design: $475,000
- Construct 4,250 ft. flood walls/berms from El. 10.2 to 14 NAVD88 @ $500/ft.
  - Construction $2,337,000



Examples of Flood Walls

Regional Connectors

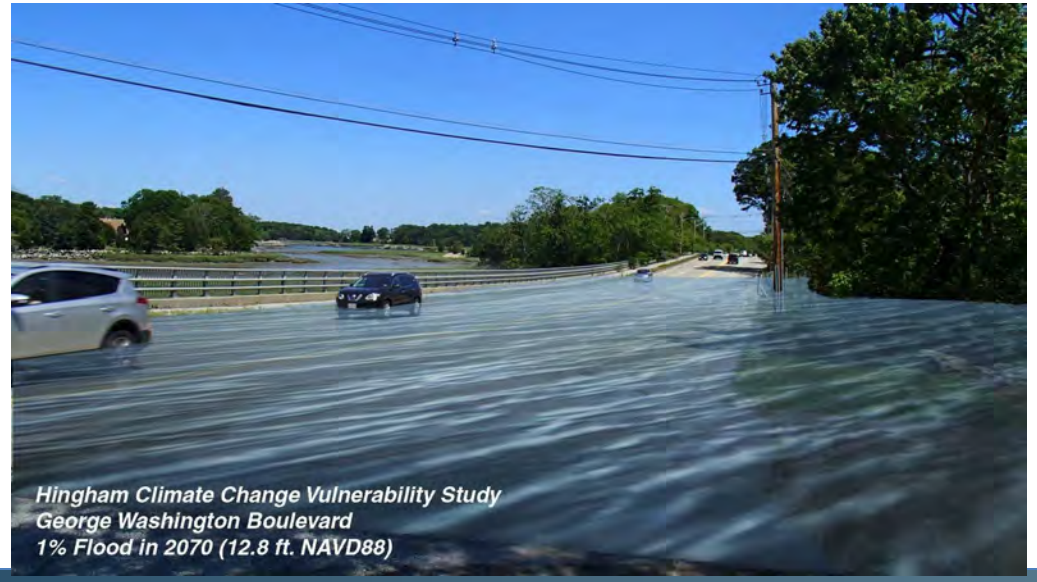


2. **George Washington Blvd**
   - South of Hingham District Court to the bridge
3. **Rockland St**
   - Weir River crossing (Kilby St intersection)
   - Wier Street Extension to Hull St
4. **Hull St**
   - Straits Pond Dam

Adaptation

George Washington Boulevard:

- Raise 850 ft. George Washington Blvd. to El. 10.2 NAVD88
  - Construction $2,225,000
  - Design: $223,000
- Construct 2,000 ft. flood walls/berms from El. 10.2 to 14 NAVD88 @ $500/ft.
  - Construction $1,100,000



Adaptation

Rockland Street to Hull Street:

- Raise 6,000 ft. Rockland St. to El. 10.2 NAVD88
  - Construction $15,169,000
  - Design: $1,517,000
- Construct 6,000 ft. flood walls/berms from El. 10.2 to 14 NAVD88 @ $500/ft.
  - Construction $3,300,000

Adaptation

Foster Elementary School:

2030

- High level water alarm and sump pump: $10,000
- Flood proof stairwell enclosure: $10,000
- Flood proof vents and doorways: $30,000
- Seal underground electrical conduits and install shut-off valves in drains/sewers: $5,000

2070

- Perimeter flood protection system (walls/berms): $820,000
- New School??

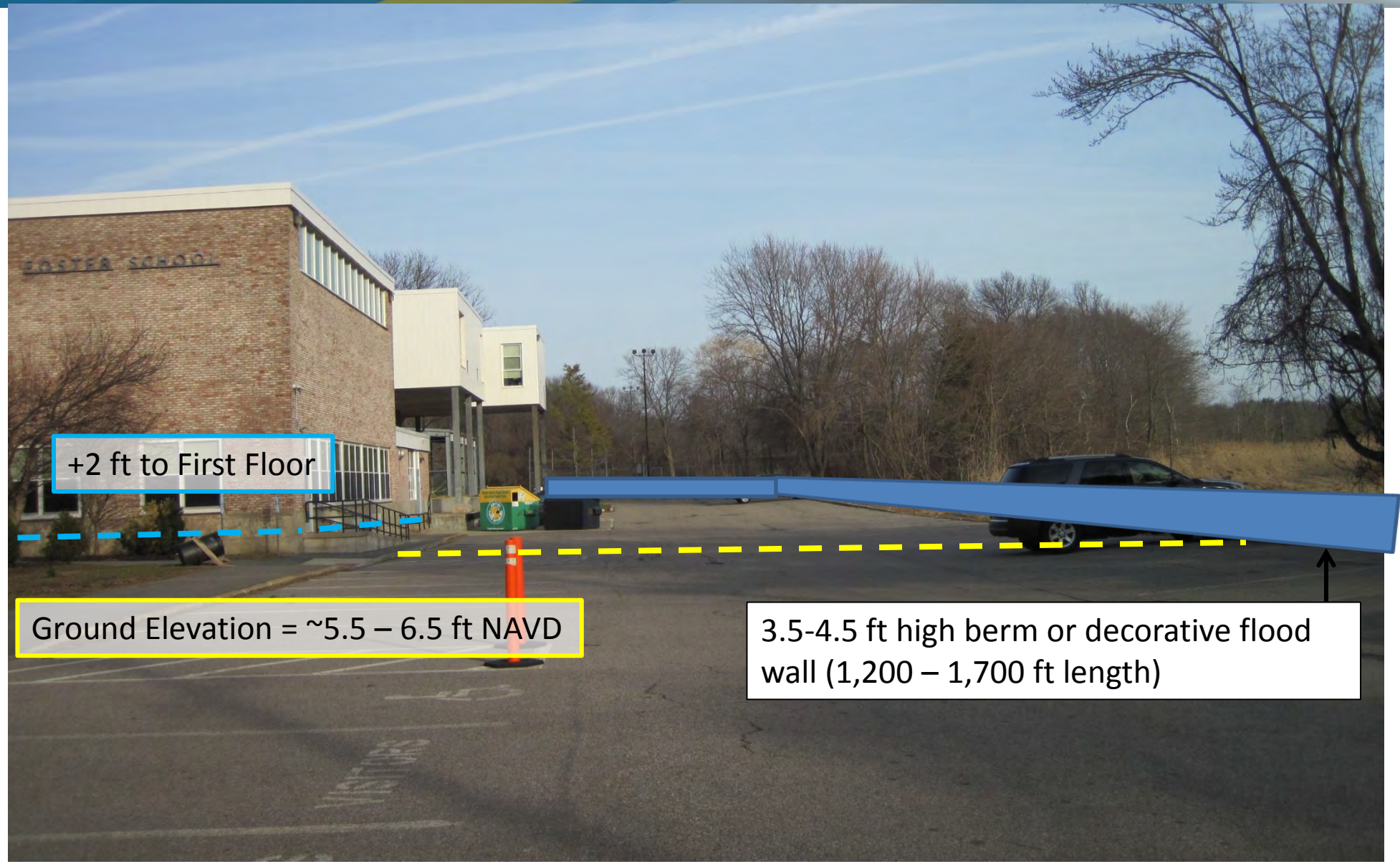
Foster Elementary School – Near Term

Foster Elementary School – Near Term

Figure 7-4. Low wall construction

Build small enclosures around louvers and crawl space entrance on vulnerable sides of School building

Foster Elementary School – Medium Term



Adaptation

Mill Street Pump Station:

2030

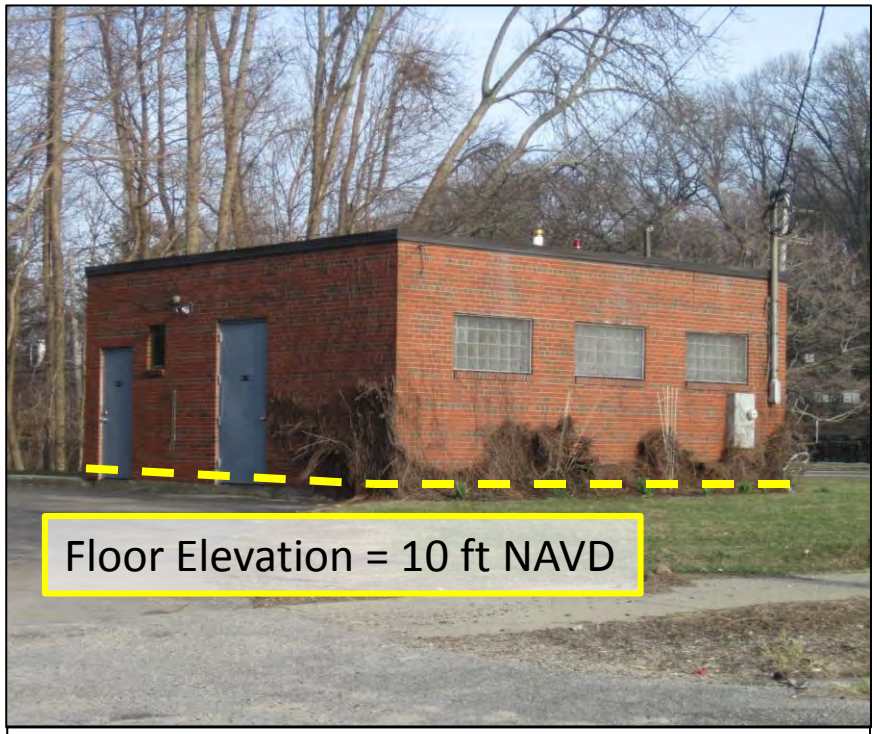
- Purchase and have ready to deploy 5 ft. high temporary flood barriers: $56,000
- Seal underground electrical conduits: $2,000
- Install high water alarm and sump pump: $10,000

Mill St Pump Station – Medium/Long Term

Well Elevation = 8.7 ft NAVD

Install 4 ft high 160 ft long temporary flood barrier around perimeter of pump station and generator

Sewer Pump Stations – Long Term



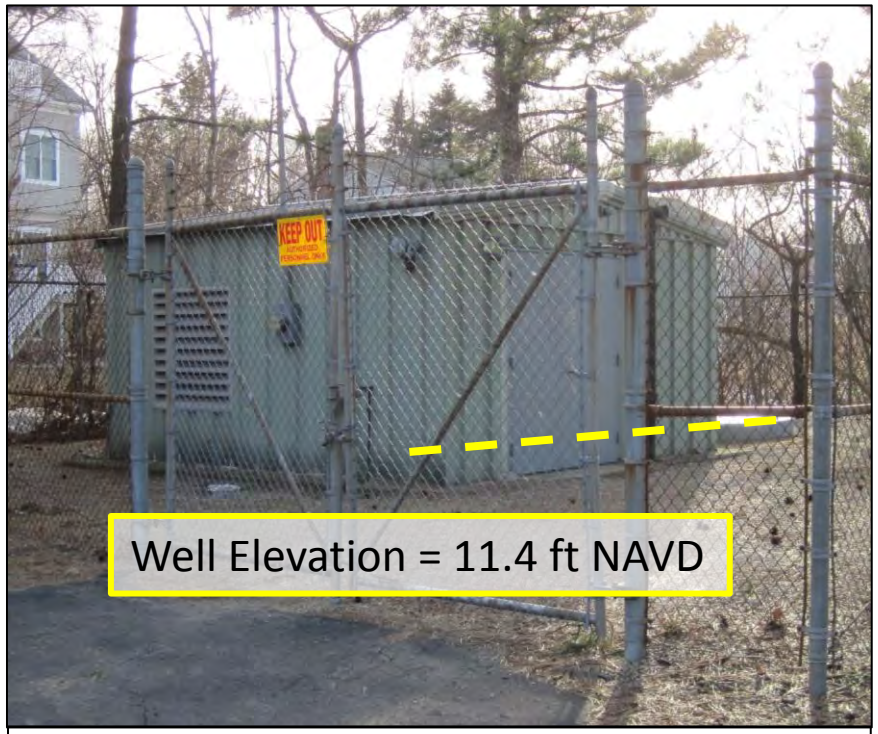
Broad Cove Pump Station

2070

- Dry – Floodproof: 13,000

or

- Temporary Barriers: $56,000



Bel Air Pump Station

2070

- Floodwall: $120,000
- Seal electrical conduits and pump system: $4,000

- Potential Wetlands Regulation, Zoning By-Law and Subdivision Regulation Changes
- Potential land acquisition strategies identified
- Adaptation recommendations provided
- Potential public policies and future planning needs identified

POLICIES & REGULATIONS

- The results are considered during planning Town Projects
- Some improvements are underway
- Public awareness of the implications of climate change is much higher (school)
- The relative priority of recommended improvements is useful in capital planning

POST STUDY

- Some of the concerns identified relate to infrastructure that crosses town lines, and/or, is multi-jurisdictional (Municipal/State)…
- A collaborative approach to coastal resiliency is needed because some of the action items are bigger than Hingham

NEXT STEPS – DISCUSSION