Town of Sandwich
Climate Change Vulnerability Assessment and Adaptation Planning

MVP Action Grant – Final Presentation

Board of Selectmen Meeting (September 12, 2019)

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Vulnerability Assessment and Adaptation Planning

Acknowledgements

- MA EOEEA Municipal Vulnerability Preparedness Program
- Town of Sandwich
  - David DeConto, Natural Resources Director
  - Maribeth Chassey, GIS Technician
  - George Dunham, Town Manager
  - Ralph Vitacco, Director of Planning and Economic Development
  - Paul Tilton, Director of Public Works / Town Engineer
  - Peter Wack, Chief of Police
  - John Burke, Fire Chief
  - Guy Boucher, Recreation Director
  - Michael Dunning, Harbormaster
  - Joanne Lamothe, Director of Public Library
  - Mike Twoomey, Information Technology Director

Vulnerability Assessment and Adaptation Planning

Primary Objectives

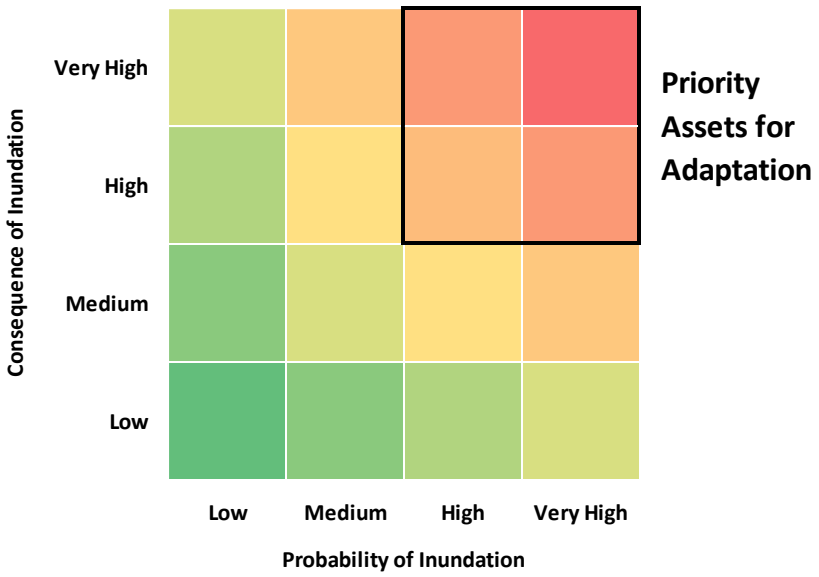
- Provide data on likely future flooding scenarios
- Identify potential flooding impacts to municipally-owned infrastructure
- Identify potential flooding impacts to natural resources
- Identify potential adaptation strategies to reduce risk
- Prioritize investments in adaptation strategies
- Produce high-quality maps/graphics
- Public outreach and education

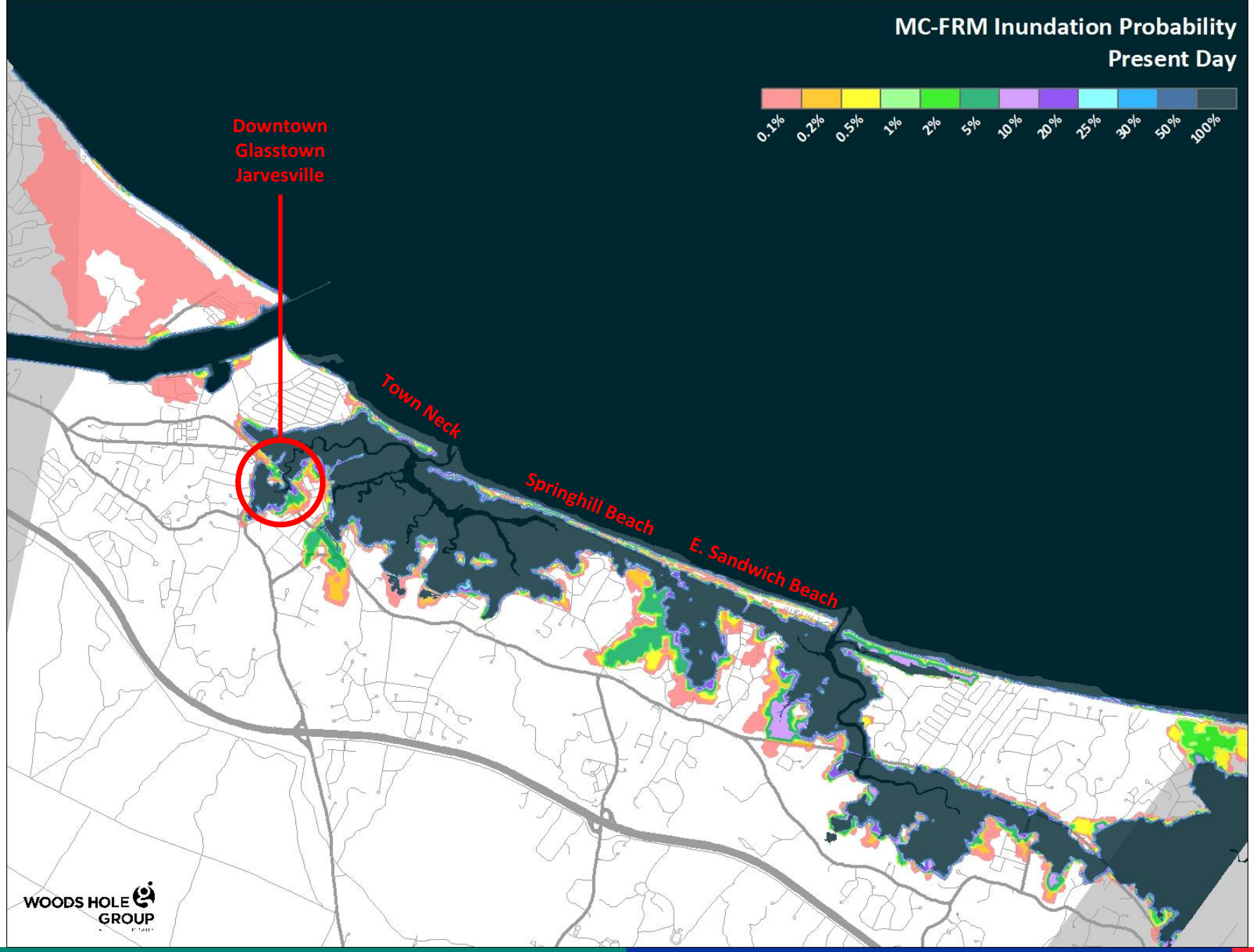
Vulnerability Assessment and Adaptation Planning

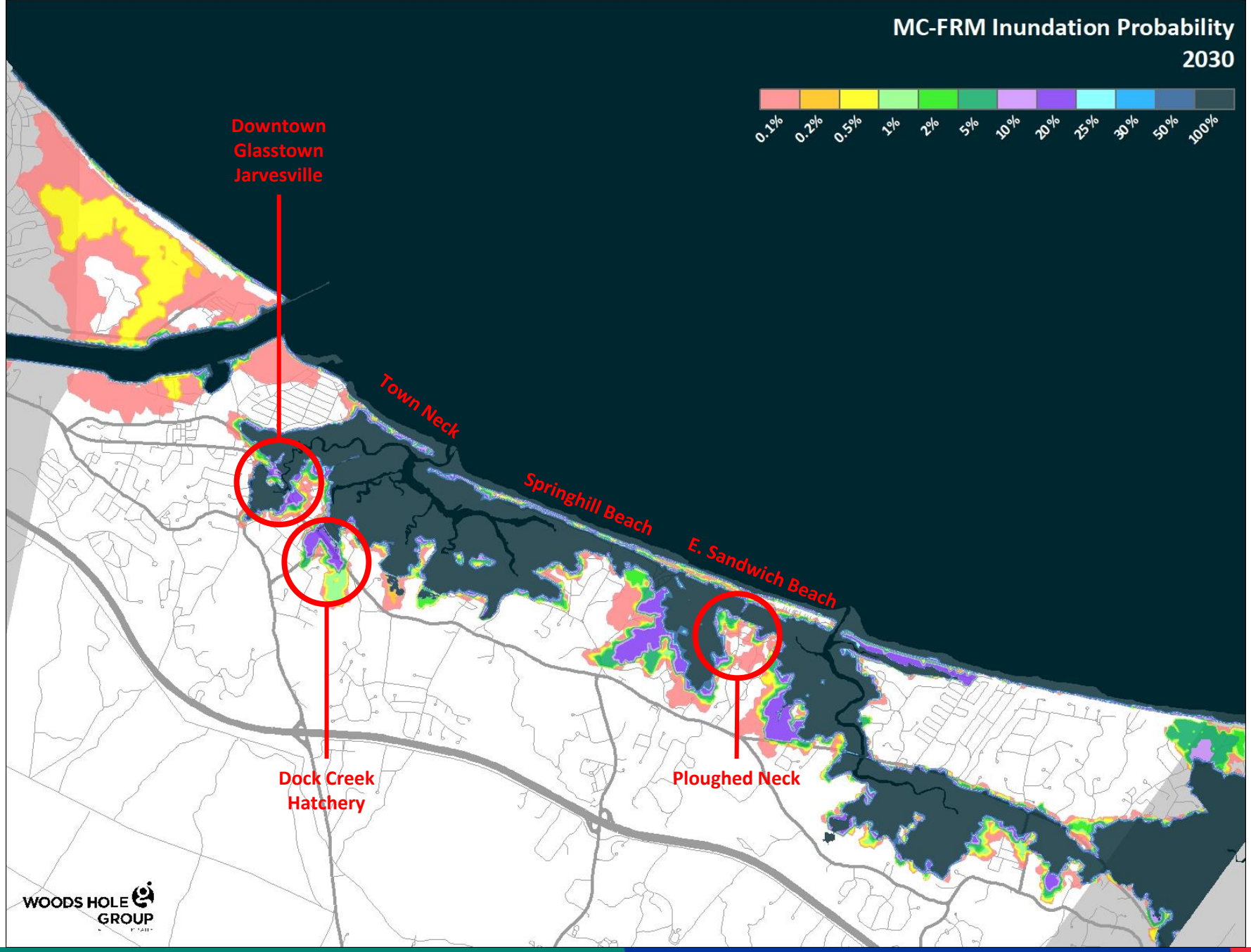
Project Approach

- Phase I
  - SLR / Storm Surge Projections
  - Scenario Development
  - Gather asset data
  - Determine Asset Critical Elevations
- Phase II
  - Score Asset Inundation Consequence
  - Map Inundation Probability
  - Vulnerability/Risk Assessment
    - *Risk = Probability * Consequence*
- Phase III
  - Prioritize High Risk Assets
  - Adaptation Strategies for Priority Assets
  - Resilience Recommendations for High Risk Areas

Rating	Area of Service Loss	Duration of Service Loss	Cost of Damage	Impact on Public Safety & Emergency Services	Impact on Important Economic Activity	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




MC-FRM Inundation Probability
Present Day
0.1%
0.2%
0.5%
1%
2%
5%
10%
20%
25%
30%
50%
100%
Downtown
Glasstown
Jarvesville
Town Neck
Springhill Beach
E. Sandwich Beach
WOODS HOLE GROUP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0.2%
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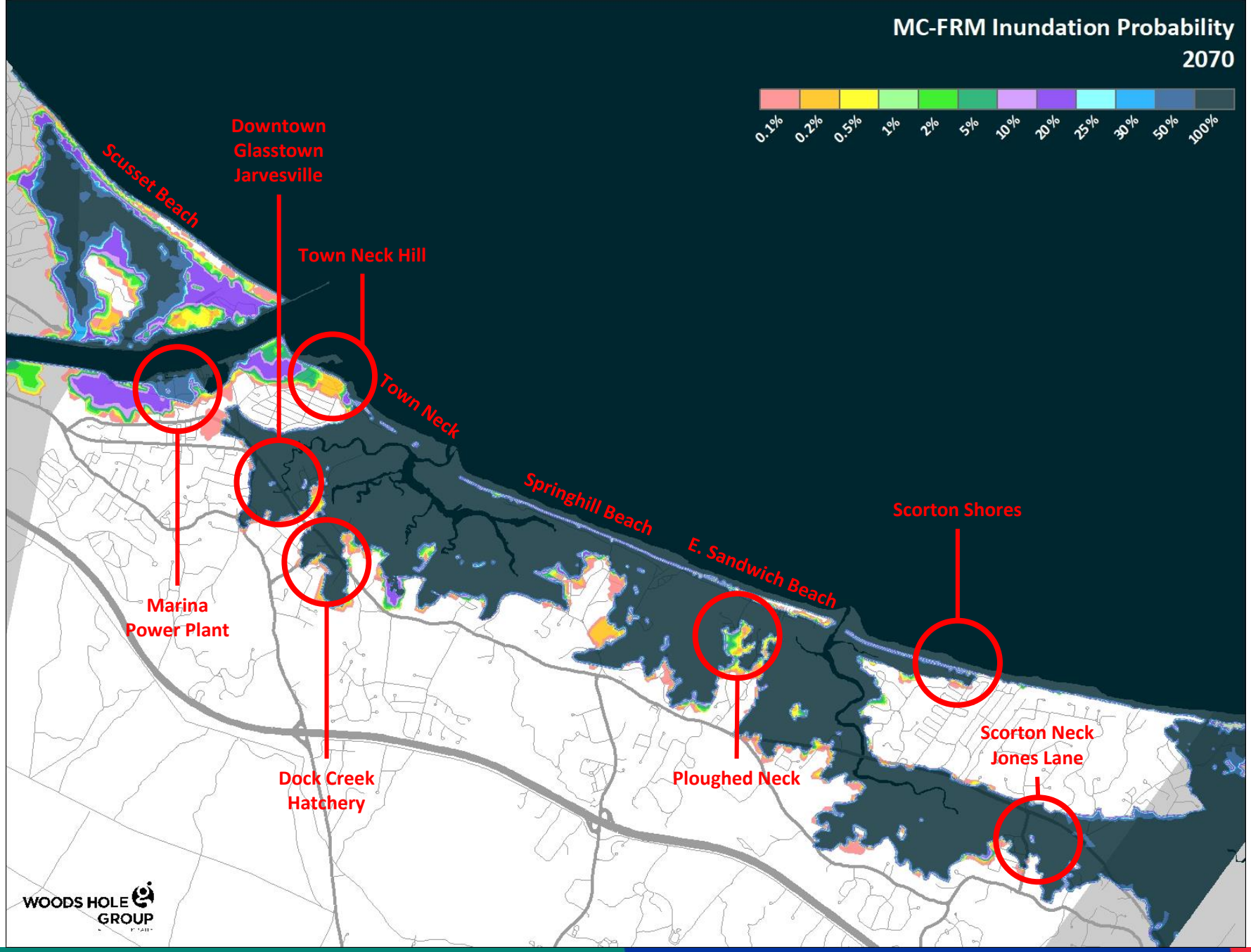
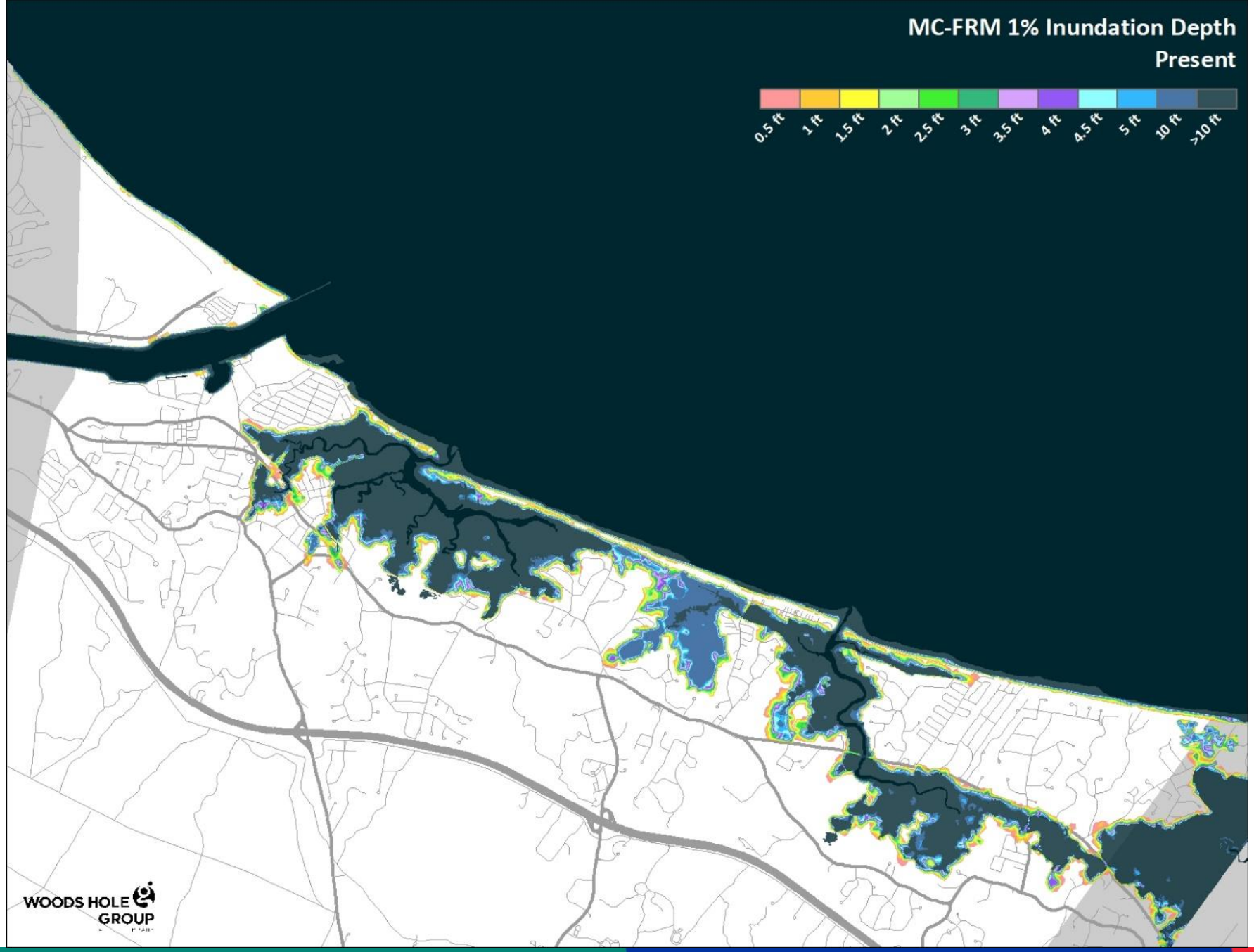
30%
50%
100%
Downtown
Glasstown
Jarvesville
Town Neck
Springhill Beach
E. Sandwich Beach
Dock Creek
Hatchery
Ploughed Neck
WOODS HOLE GROUP


MC-FRM Inundation Probability
2070
0.1%
0.2%
0.5%
1%
2%
5%
10%
20%
25%
30%
50%
100%
Scusset Beach
Downtown
Glasstown
Jarvesville
Town Neck Hill
Town Neck
Springhill Beach
E. Sandwich Beach
Scorton Shores
Marina
Power Plant
Dock Creek
Hatchery
Ploughed Neck
Scorton Neck
Jones Lane
WOODS HOLE GROUP


MC-FRM 1% Inundation Depth
Present
0.5 ft
1 ft
1.5 ft
2 ft
2.5 ft
3 ft
3.5 ft
4 ft
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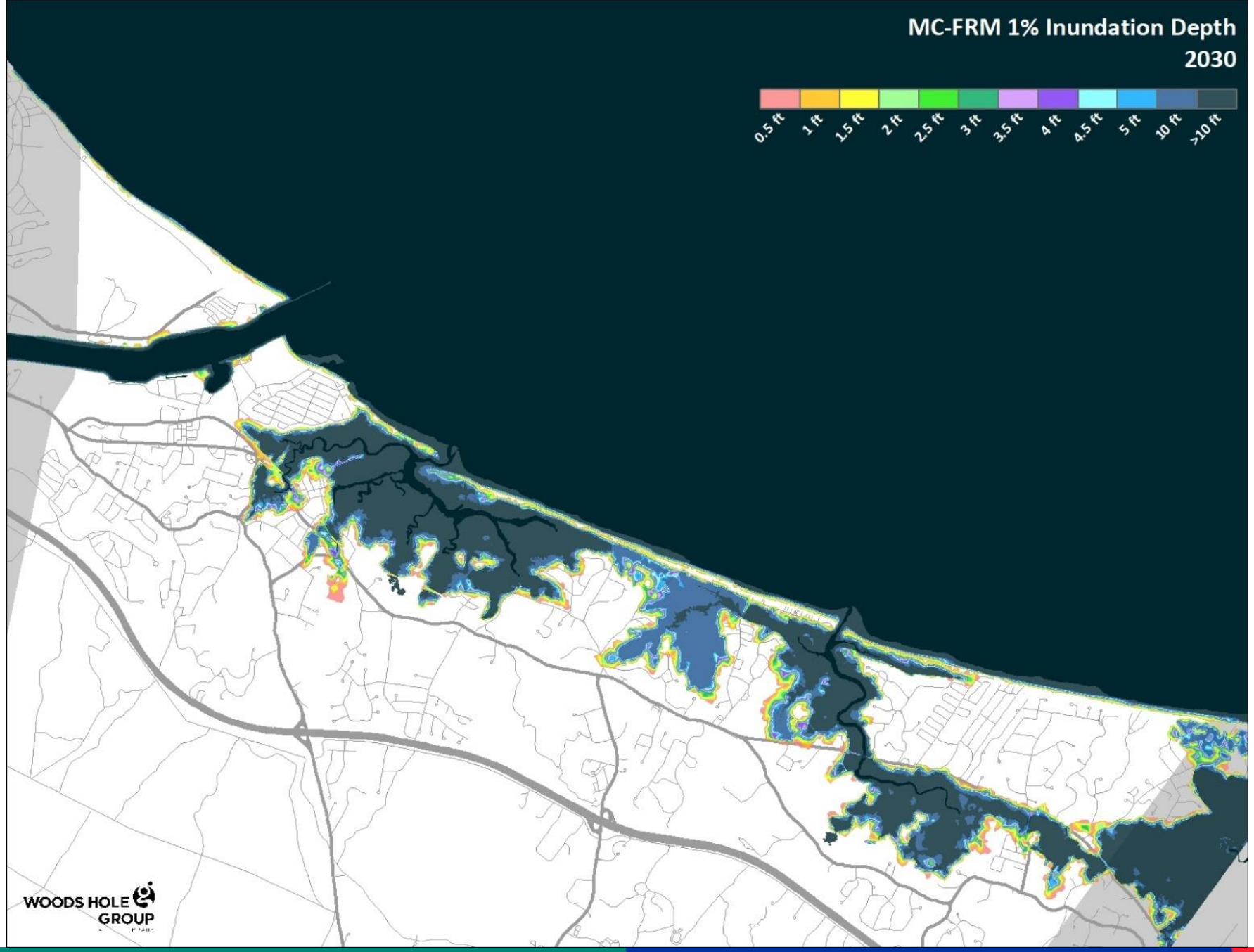
5 ft
10 ft
>10 ft
WOODS HOLE GROUP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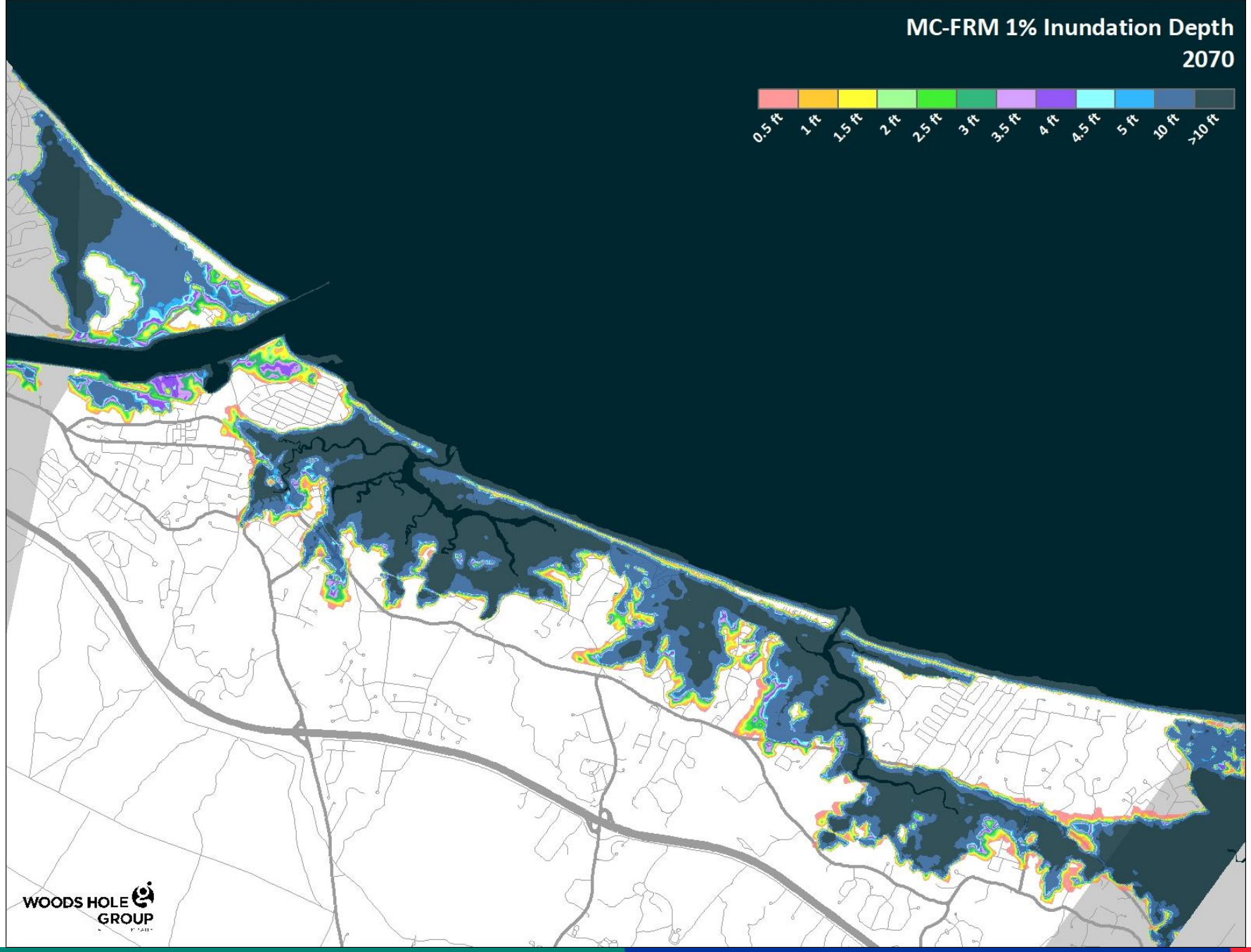
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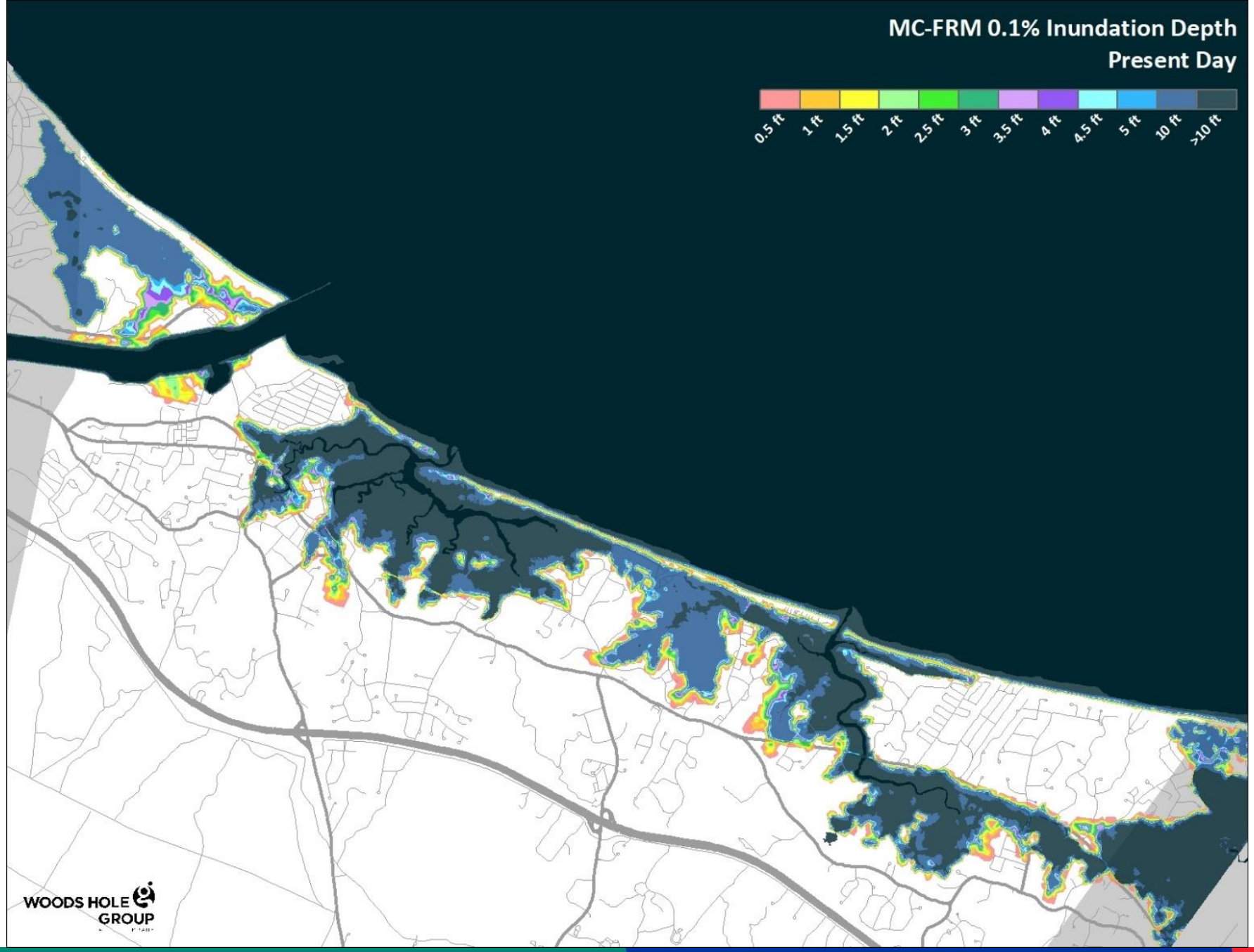
WOODS HOLE GROUP


MC-FRM 0.1% Inundation Depth
Present Day
0.5 ft
1 ft
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2.5 ft
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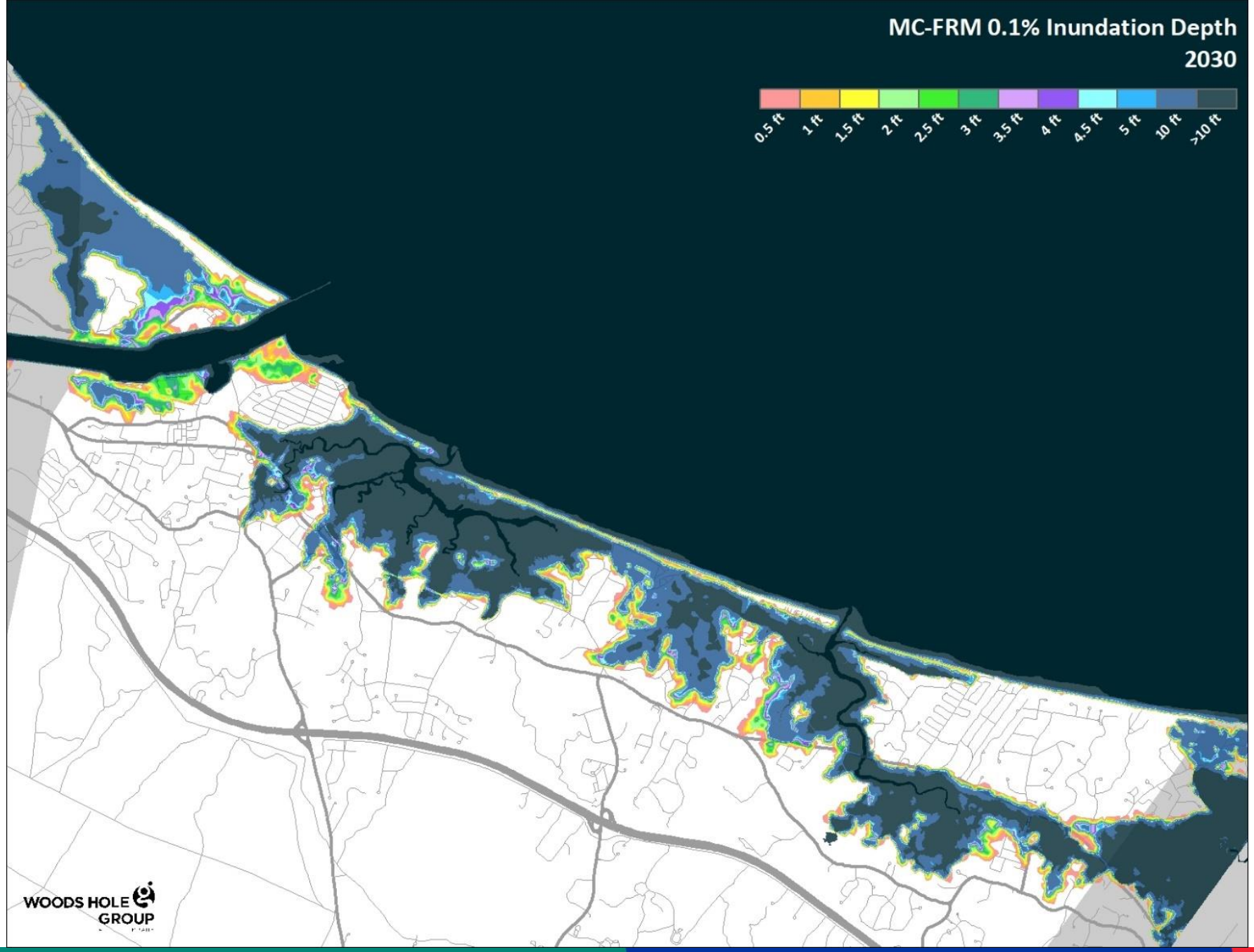
5 ft
10 ft
>10 ft
WOODS HOLE GROUP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2030
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4.5 ft
5 ft
10 ft
>10 ft
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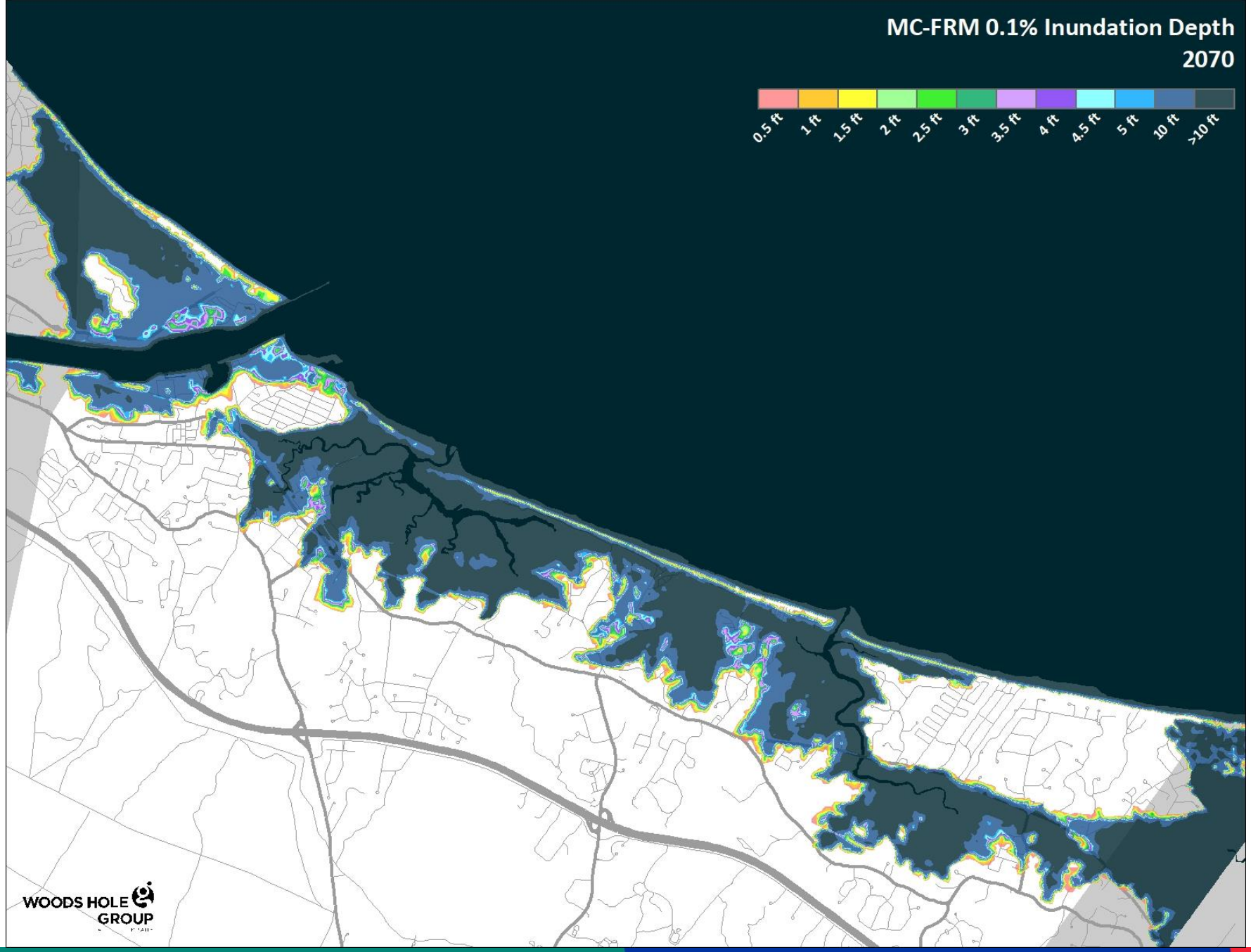
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2070
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1 ft
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2 ft
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5 ft
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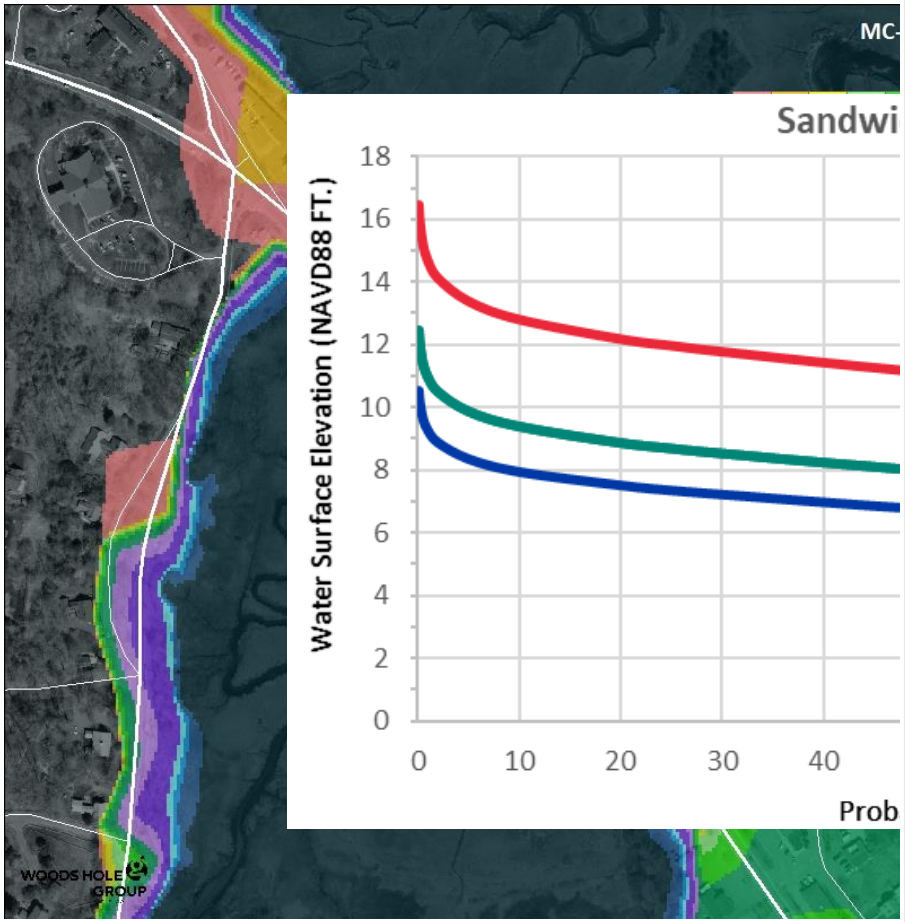
>10 ft
WOODS HOLE GROUP

Vulnerability Assessment and Adaptation Planning

Asset-specific Vulnerability Assessment Process



Sandwich Fire Station 1

Critical Elevation: 9.44 ft NAVD88
Threshold Description: First floor (slab)

Probability of Exceedance Summary Table

% Probability	Present		2030		2070	
	Flood Elevation	Depth Above Critical Elev.	Flood Elevation	Depth Above Critical Elev.	Flood Elevation	Depth Above Critical Elev.
0.1	10.52	1.08	12.44	3.00	16.44	7.00
0.2	10.14	0.70	11.99	2.55	15.90	6.46
0.5	9.63	0.19	11.39	1.95	15.19	5.75
1	9.25	Dry	10.94	1.50	14.65	5.21
2	8.87	Dry	10.48	1.04	14.11	4.67
5	8.35	Dry	9.86	0.42	13.38	3.94
10	7.94	Dry	9.38	Dry	12.80	3.36
20	7.51	Dry	8.86	Dry	12.18	2.74
25	7.35	Dry	8.68	Dry	11.97	2.53
30	7.22	Dry	8.52	Dry	11.78	2.34
50	6.75	Dry	7.97	Dry	11.12	1.68
100	5.75	Dry	6.78	Dry	9.71	0.27

Consequence of Exceedance

	Area of Service Loss	Duration of Service Loss	Cost of Damage	Impacts to Public Safety	Impacts to Economic Activities	Impacts to Public Health & Environ.	Consequence Score
Scores	4	4	4	4	4	4	24

Risk of Exceedance

Time horizon	Probability of Exceedance	Composite Consequence Score	Risk Score	Weight	Composite Risk Score	Composite Risk Rank
Present	0.5%	100	50	0.5	2175	#9* #29
2030	5%	100	500	0.3		
2070	100%	100	10000	0.2		

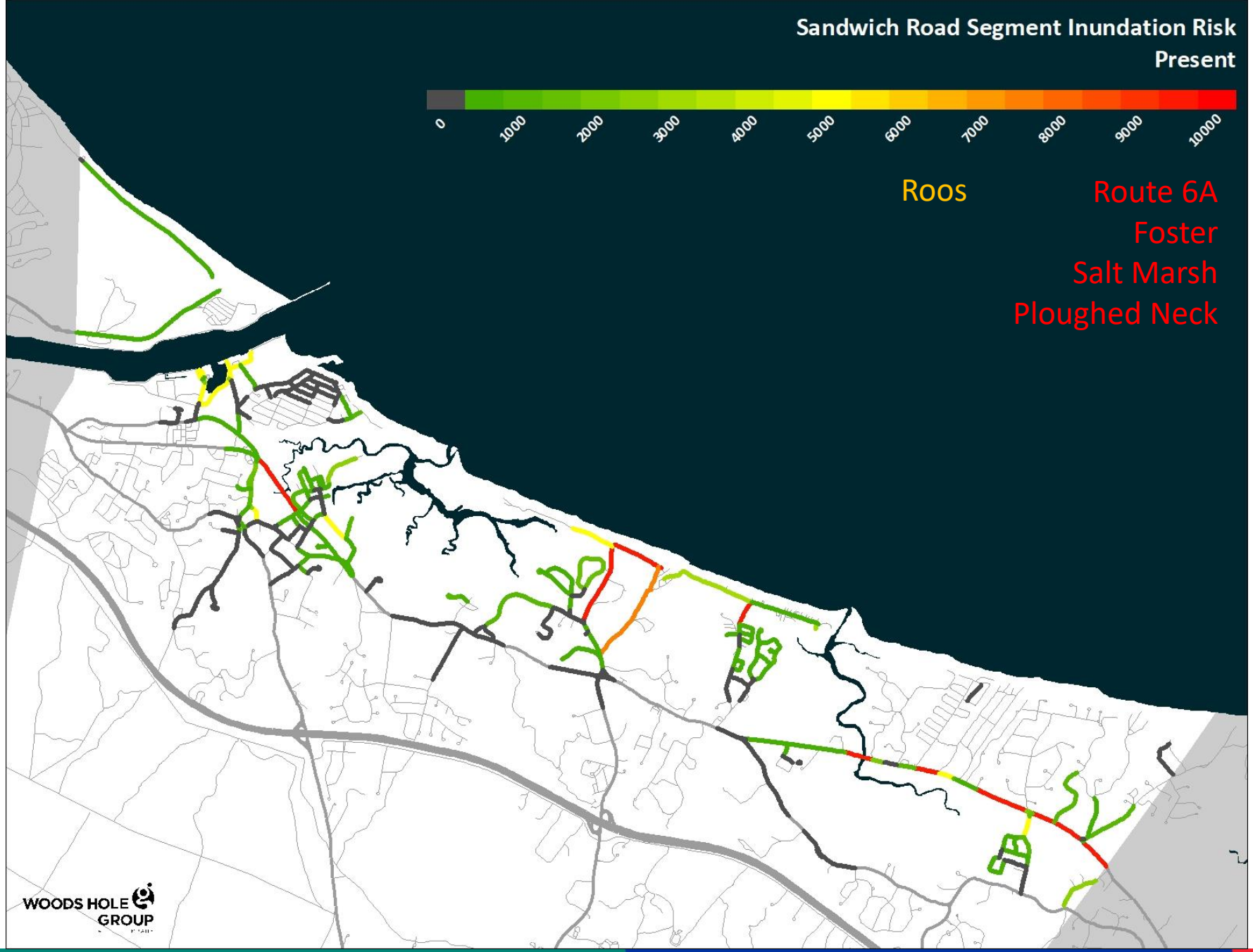
a. Risk ranking excluding road segments and fire hydrants

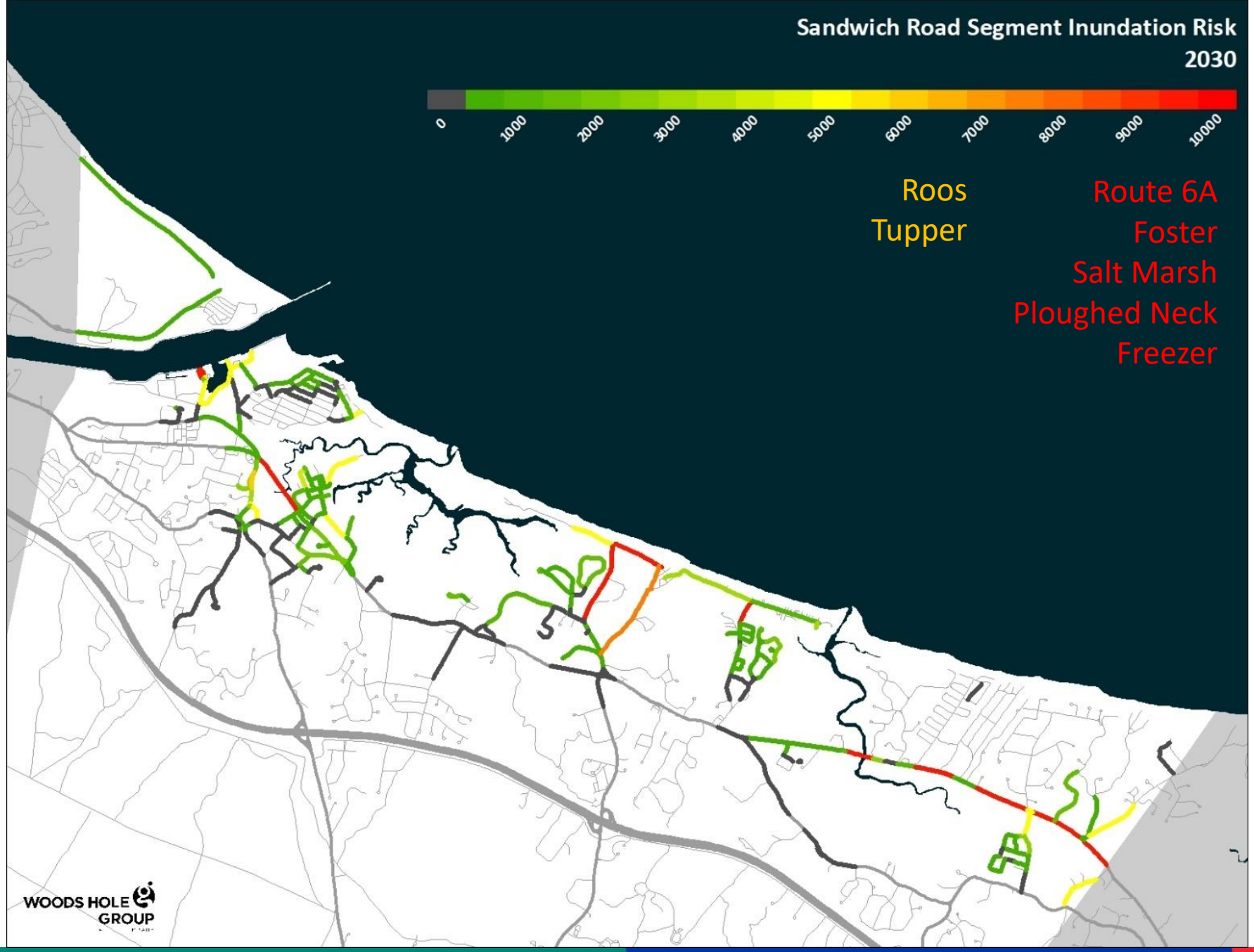
Vulnerability Assessment and Adaptation Planning

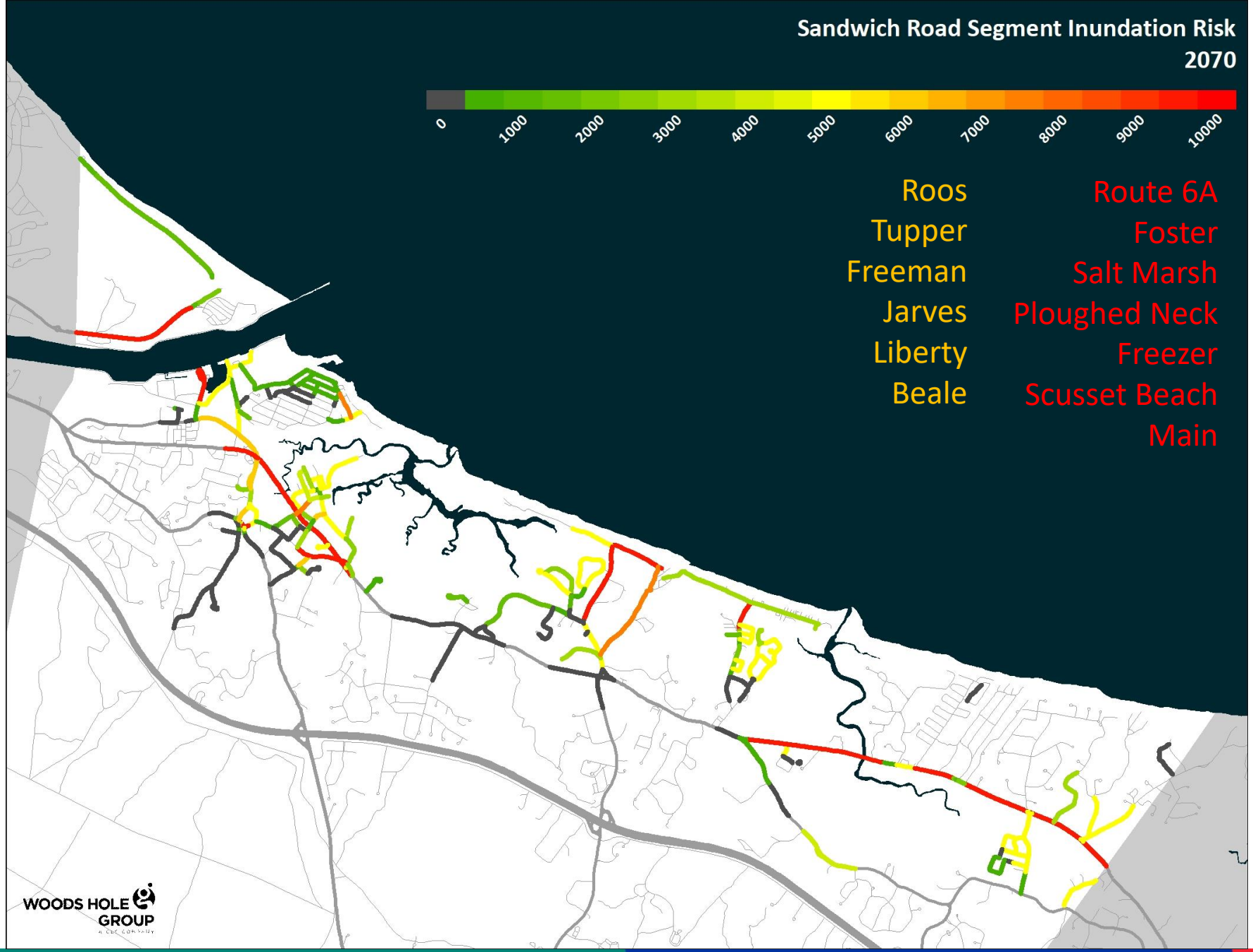
Consequence * Probability = Risk

Category	Asset	Consequence Score	Critical Elev. (NAVD88 ft.)	Probability Present	Probability 2030	Probability 2070	Risk Present	Risk 2030	Risk 2070	Composite Risk
Boardwalk	Boardwalk	79.2	6.577	50.0%	100.0%	100.0%	3958	7917	7917	5938
Marina Infrastructure	Fuel Ball Valves (monitoring)	70.8	5.804	50.0%	100.0%	100.0%	3542	7083	7083	5313
Docks	Observation Dock	45.8	6.19	50.0%	100.0%	100.0%	2292	4583	4583	3438
Parking	Boardwalk Road Parking Lot	58.3	Ground	33.8%	60.6%	82.5%	1970	3533	4815	3008
Marina Infrastructure	Fuel Monitoring Well - Middle	70.8	Ground	10.0%	50.0%	100.0%	708	3542	7083	2833
Marina Infrastructure	Coast Guard Fuel Tank	83.3	8.148	2.0%	30.0%	100.0%	167	2500	8333	2500
Docks	Commercial Unloading Pier	83.3	8.27	2.0%	25.0%	100.0%	167	2083	8333	2375
Parking	Town Neck Beach Parking Lot	58.3	Ground	23.4%	37.8%	75.6%	1365	2203	4409	2225
Facilities	Fire Station	100.0	9.44	0.5%	5.0%	100.0%	50	500	10000	2175
Parking	Sandwich Police and Fire Headquarters Parking Lot	66.7	Ground	3.3%	9.8%	75.1%	220	656	5005	1308
Parking	Sandwich Police and Fire Headquarters Parking Lot	66.7	Ground	4.5%	8.0%	73.2%	302	534	4880	1287
Docks	Commerial Fishing Dock - F	58.3	9.32	0.5%	5.0%	100.0%	29	292	5833	1269
Parking	Sandwich Police and Fire Headquarters Parking Lot	66.7	Ground	1.2%	4.1%	74.7%	82	270	4979	1118
Parking	East Sandwich Fire Station Parking Lot	66.7	Ground	0.1%	0.3%	73.3%	4	21	4887	986
Septic	Police Station	37.5	Ground	5.0%	10.0%	100.0%	188	375	3750	956
Marina Infrastructure	1500 Gallon Pumpout Tank	79.2	Ground	0.0%	0.5%	50.0%	0	40	3958	804
Septic	Firestation	37.5	Ground	0.1%	2.0%	100.0%	4	75	3750	774
Facilities	Fire Station Outbuilding	33.3	9.49	0.5%	5.0%	100.0%	17	167	3333	725
Septic	East Sandwich Firestation	33.3	Ground	0.1%	0.1%	100.0%	3	3	3333	669
Open Space	Marina Playground	33.3	Ground	2.5%	6.9%	75.6%	84	231	2520	615
Parking	Town Hall Annex Parking Lot	50.0	Ground	1.3%	2.2%	52.4%	66	110	2619	590
Facilities	Fire Station Propane Tank	25.0	9.68	0.5%	5.0%	100.0%	13	125	2500	544
Docks	Public Slips - B	45.8	10.13	0.1%	1.0%	50.0%	5	46	2292	474
Septic	Seasonal Bathrooms	33.3	Ground	1.0%	5.0%	50.0%	33	167	1667	400
Facilities	Old Police Station	91.7	12.17	0.0%	0.1%	20.0%	0	9	1833	369

Composite Risk Score = (50% Present) + (30% 2030) + (20% 2070)

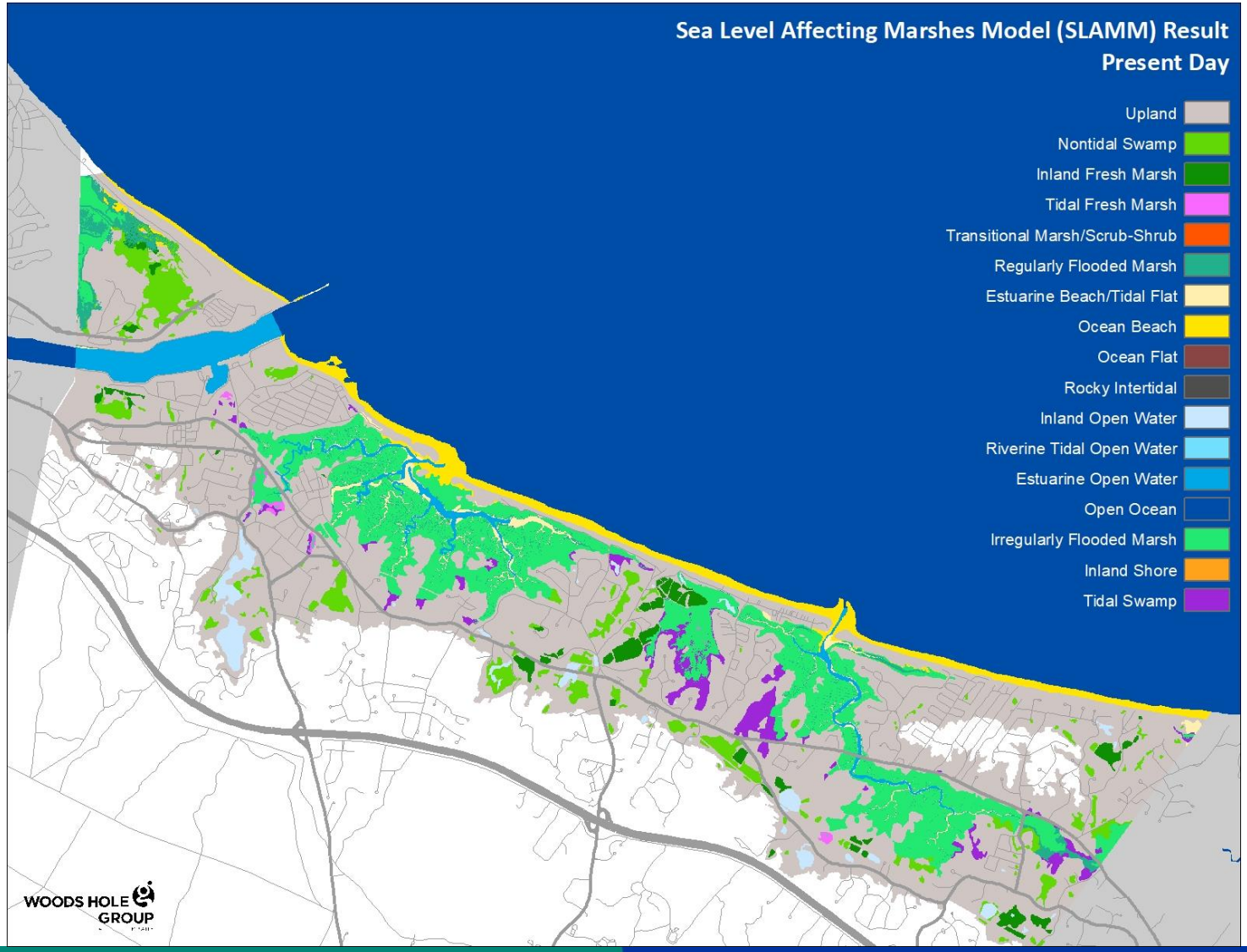

Sandwich Road Segment Inundation Risk
Present
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
Roos
Route 6A
Foster
Salt Marsh
Ploughed Neck
WOODS HOLE GROUP


Sandwich Road Segment Inundation Risk
2030
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
Roos
Tupper
Route 6A
Foster
Salt Marsh
Ploughed Neck
Freezer
WOODS HOLE GROUP


Sandwich Road Segment Inundation Risk
2070
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
Roos
Tupper
Freeman
Jarves
Liberty
Beale
Route 6A
Foster
Salt Marsh
Ploughed Neck
Freezer
Scusset Beach
Main
WOODS HOLE GROUP

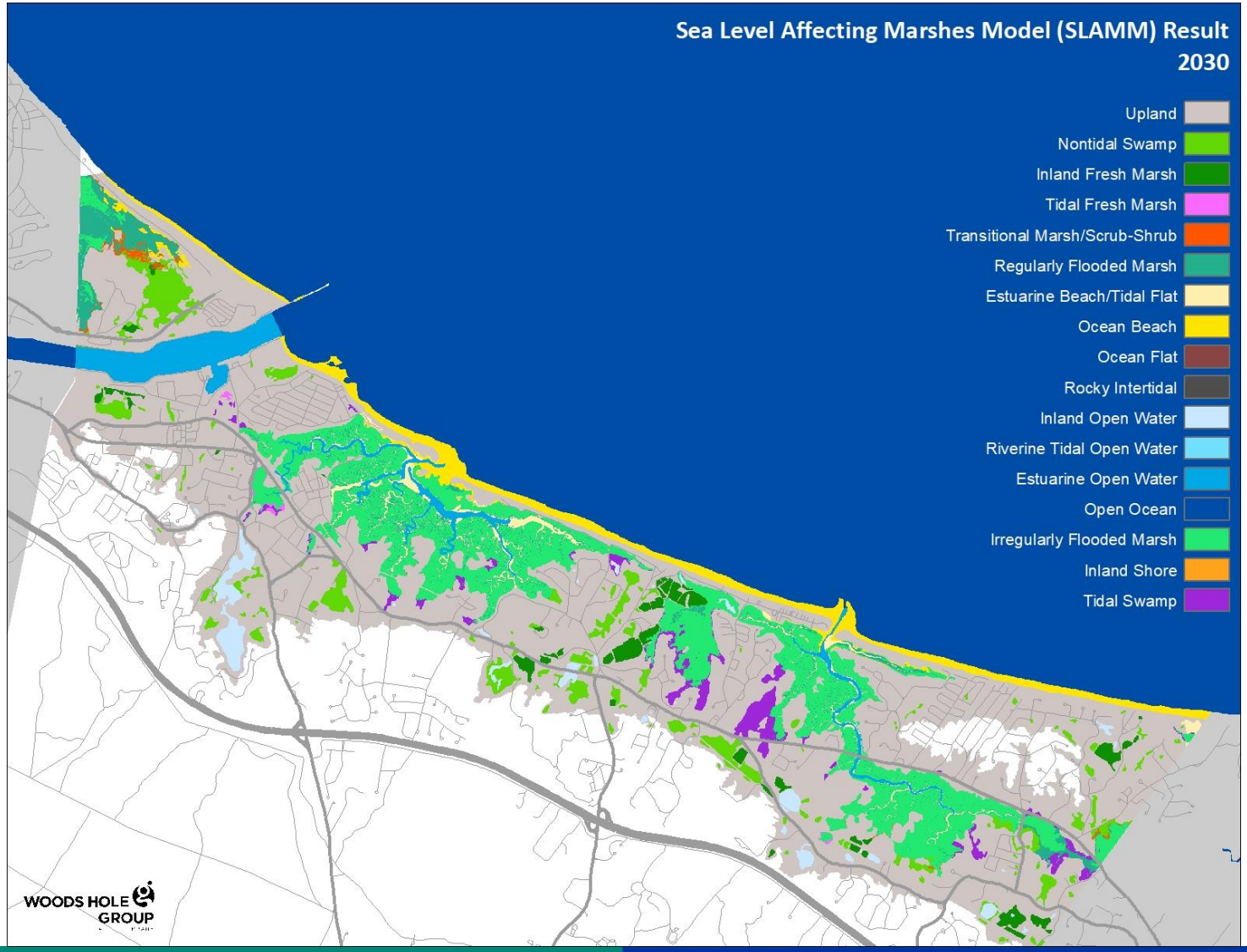
Vulnerability Assessment and Adaptation Planning

Present Day SLAMM Results



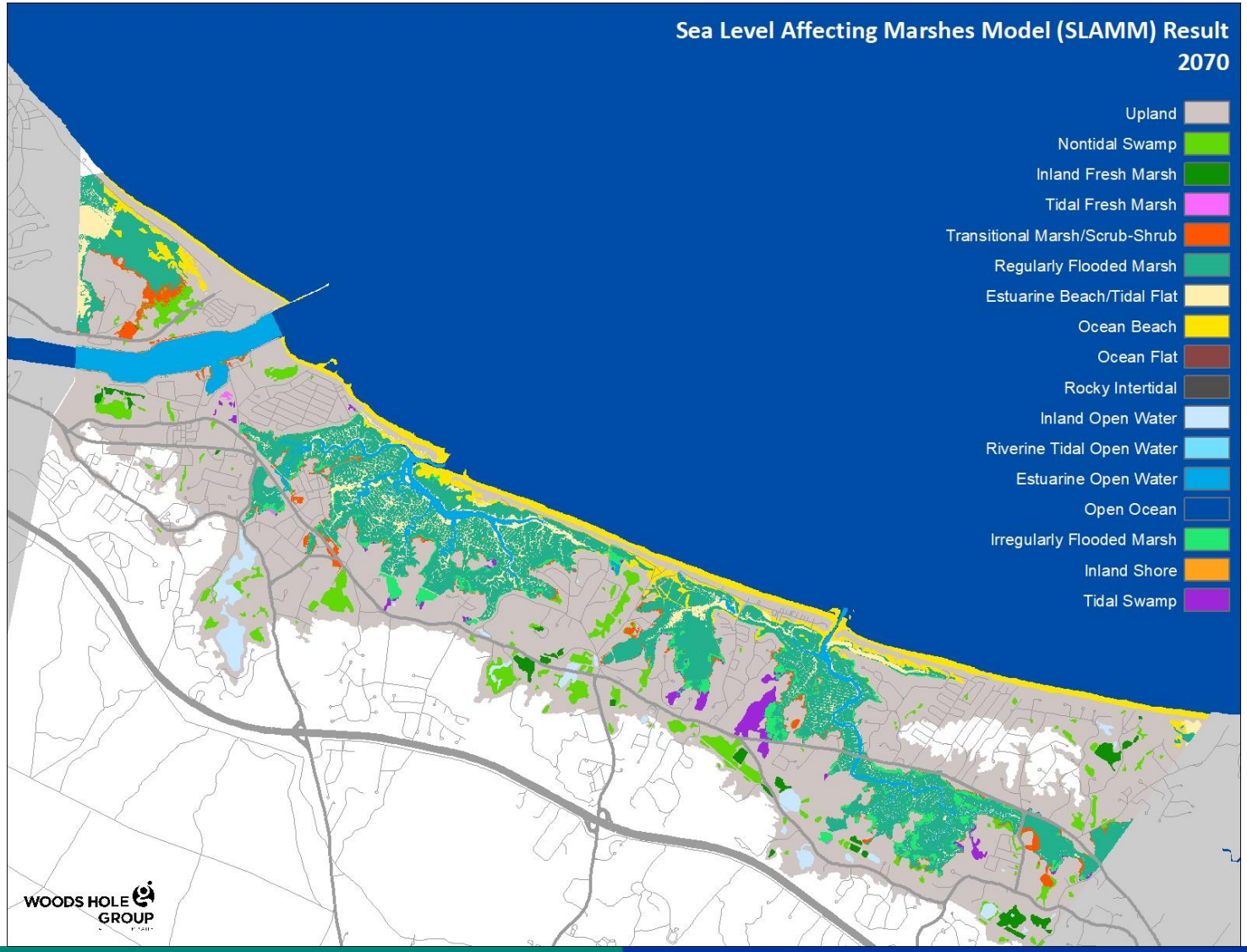
Vulnerability Assessment and Adaptation Planning

2030 SLAMM Results



Vulnerability Assessment and Adaptation Planning

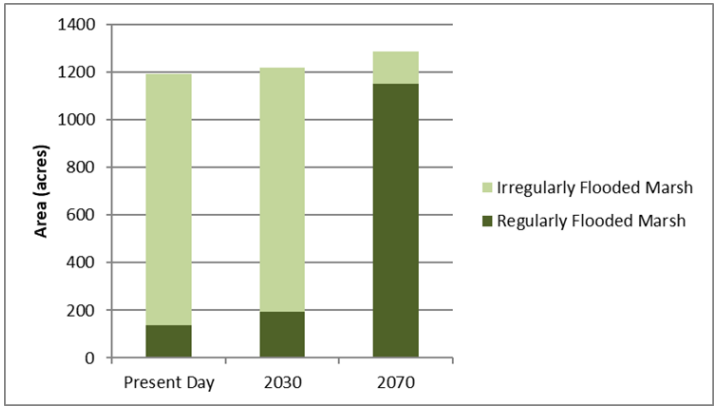
2070 SLAMM Results

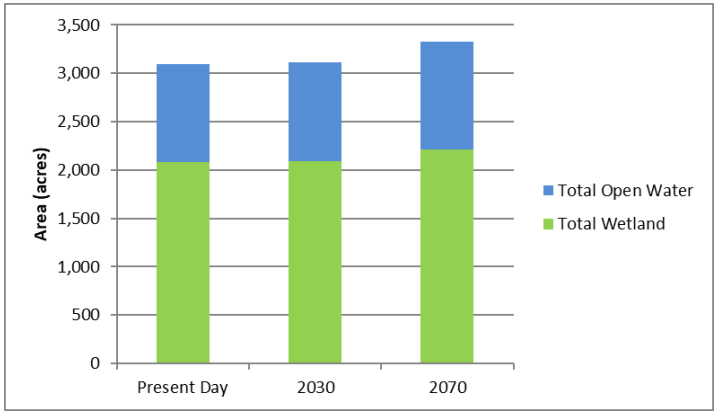


Vulnerability Assessment and Adaptation Planning

Natural Resources Assessment

Wetland Category	Area (acres)		
	Present	2030	2070
Upland	3891.7	3871.9	3662.1
Irregularly Flooded Marsh	1054.0	1024.9	136.3
Open Ocean	685.3	690.3	750.0
Nontidal Swamp	310.5	291.2	224.3
Ocean Beach	243.0	248.5	276.1
Estuarine Open Water	235.5	237.8	272.4
Regularly Flooded Marsh	137.9	193.4	1151.4
Tidal Swamp	129.6	109.6	54.0
Inland Fresh Marsh	111.3	106.7	60.3
Inland Open Water	98.6	98.6	94.1
Estuarine Beach/Tidal Flat	78.5	92.3	214.9
Tidal Fresh Marsh	12.3	5.9	2.5
Transitional Marsh/Scrub-Shrub	0.0	17.2	89.7





Vulnerability Assessment and Adaptation Planning

Visualization – Boardwalk in 2030 MHHW (6.52 ft. NAVD88)

Vulnerability Assessment and Adaptation Planning

Visualization – Scorton Creek Bridge in 2030 1% Chance Event

Vulnerability Assessment and Adaptation Planning

Visualization – Scorton Creek Bridge in 2070 1% Chance Event

Vulnerability Assessment and Adaptation Planning

Visualization – Fire Station in 2030 1% Chance Event (2070 dotted)

Vulnerability Assessment and Adaptation Planning

Adaptation Strategies – a Summary of Approaches (NCCCARF, 2019)

Avoid

Identify future 'no-build areas' and use planning tools to prevent new development in areas at risk now or in future

$

Accommodate

Continue to use the land but accommodate changes by building on piles, converting agriculture to fish farming or growing flood- or salt-tolerant crops

$$$

Protect

Use hard structures (eg sea walls) or soft solutions (eg dunes and vegetation) to protect land from the sea. May be prohibitively expensive, especially in the long term

$$$

Retreat

Withdraw, relocate or abandon assets that are at risk; ecosystems are allowed to retreat landward as sea levels rise

$$

Key Considerations:

Cost of response

$ $$$

Low – high

Potential cost to government and regulators

Length of protection

Short- to long-term protection

Vulnerability Assessment and Adaptation Planning

Recommendations: Avoidance

Permitted uses

Fishing, cultivation, and harvesting of shellfish (including excavation of areas for cultivation and harvesting of marine foods); various horticulture activities

Outdoor recreation activities, provided that related structures do not destroy beneficial character of district

Floats

Maintenance of existing raised roadways

Installation of utilities

Agriculture

Government dredging of navigation channels

Construction and maintenance of town landings and public boat launching ramps; nourishment of town beaches

Mosquito control by Cape Cod Mosquito Control Project

Maintenance of existing channels and marine facilities

Special permit uses

Construction of certain structures, including catwalks, piers, ramps, stairs, boat shelters, tennis courts

Construction of structures or buildings used in conjunction with a marina or boatyard

Construction and maintenance of driveways or roadways of minimum legal length and width

Construction and maintenance of private boat launches and beaches

Installation of submerged pipes or cables used for swimming pools or commercial fishing operations

Prohibited uses

Filling of land

Draining of land

Discharging of hazardous substances, treated sewage, or thermal effluent

Construction of residential units or use of houseboats or barges as dwellings

Building of any structure in V and V1-30 Zones

Construction of pipelines to carry crude oil or unprocessed natural gas

Actions that destroy natural vegetation, alter existing tidal flow, or otherwise alter the character of the land

Destruction of natural growth that prevents erosion or storm damage

Draining, damming, or relocating water courses except for aquaculture, agriculture, or flood or mosquito control

Vulnerability Assessment and Adaptation Planning

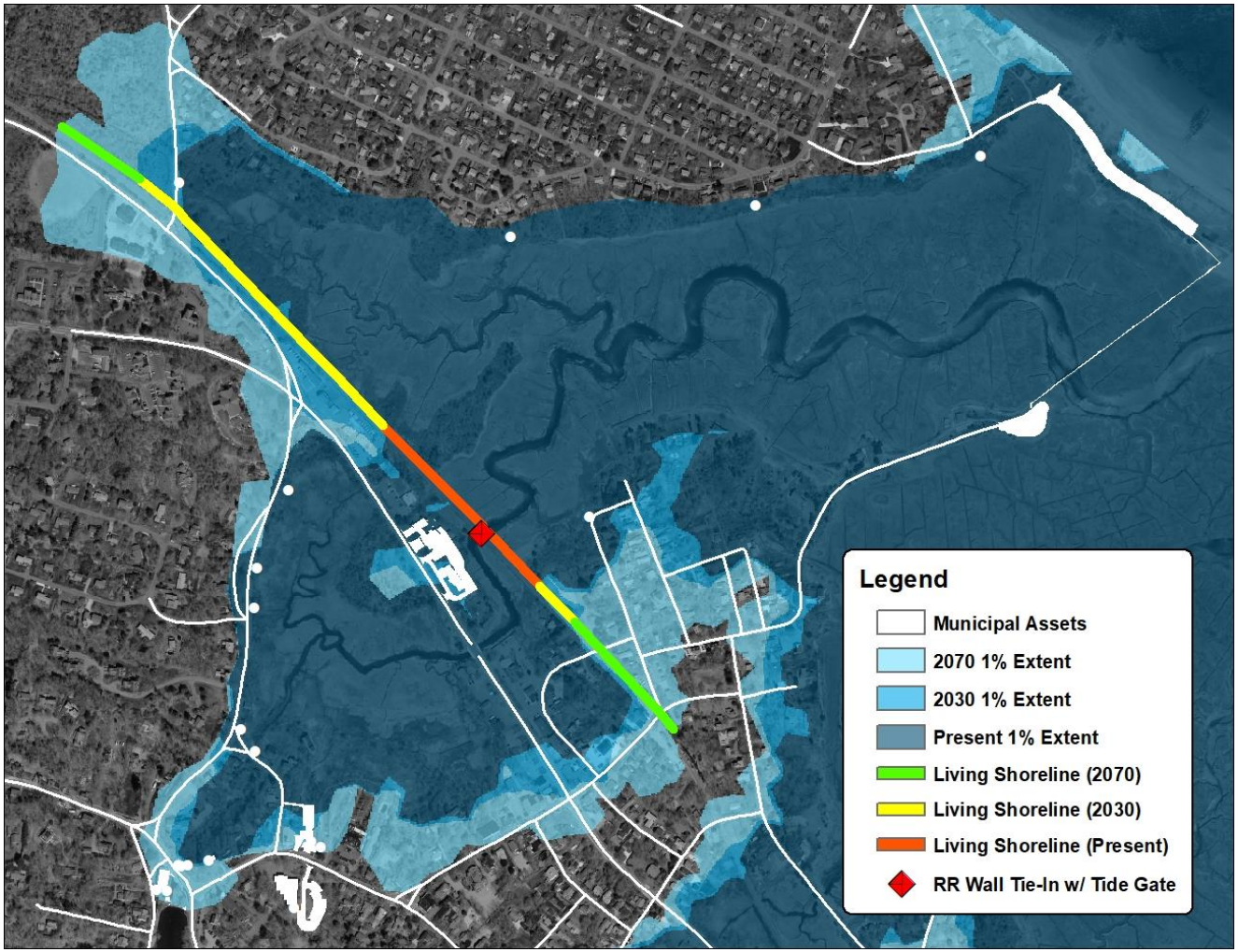
Recommendations: Accommodation

Type of Measure	Examples		
Physical	Construct an artificial floodway to convey flood water away from roadways and homes to a natural area or flood-tolerant green space that can store the water with limited damage.	Raise new and existing structures, for example on stilts or piles, above flood elevations with additional freeboard to provide a safety factor.	Implement wet floodproofing measures such as raising occupied spaces and utilities above flood elevations, building with flood damage resistant materials, or using flood-resilient structural design.
Operational	Improve flood evacuation and emergency planning by updating scenarios and plans, training first responders, or providing education and resources to residents and businesses in high flood risk areas.		
Regulatory	Strengthen building codes and zoning to require or encourage projects in high flood risk areas to implement increased setbacks, physical accommodation measures, onsite flood storage, or protection or enhancement of existing natural systems (e.g., dunes, wetlands).		

- Recommend adjustments to (already strong) regulations to take projected climate impacts into account (e.g. using the MC-FRM projected coastal flooding as reference to floodplain)
  - Integrate MC-FRM and prescriptive measures in Zoning and other Regulations
  - Create a “climate change resilience” overlay for prescriptive measures

Vulnerability Assessment and Adaptation Planning

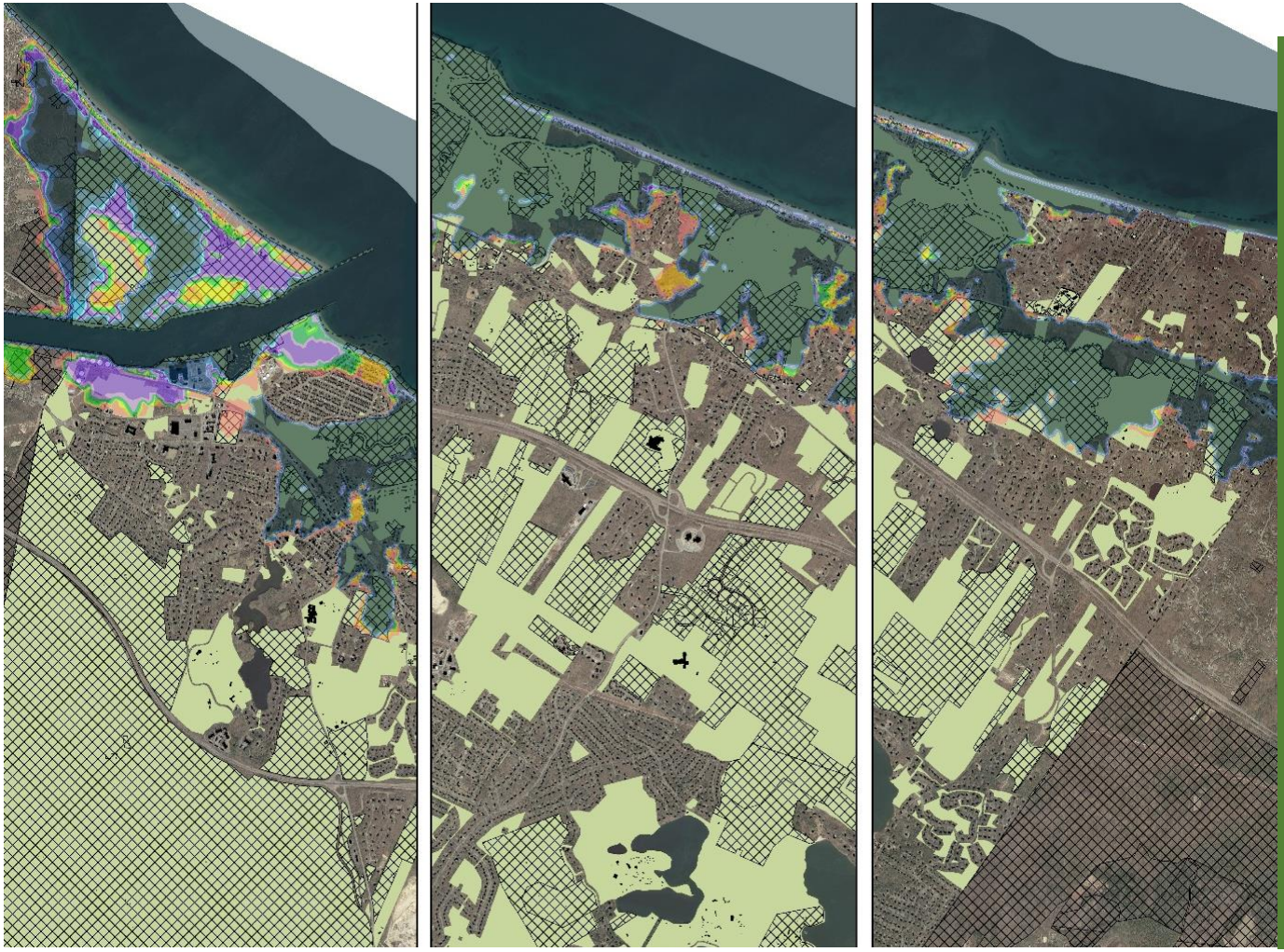
Recommendations: Protection



- Climate impact-protective, nature-based measures
- Preserve the ability of wetlands to buffer climate impacts… eliminate waiver for 50-foot “no build” wetland buffer

Vulnerability Assessment and Adaptation Planning

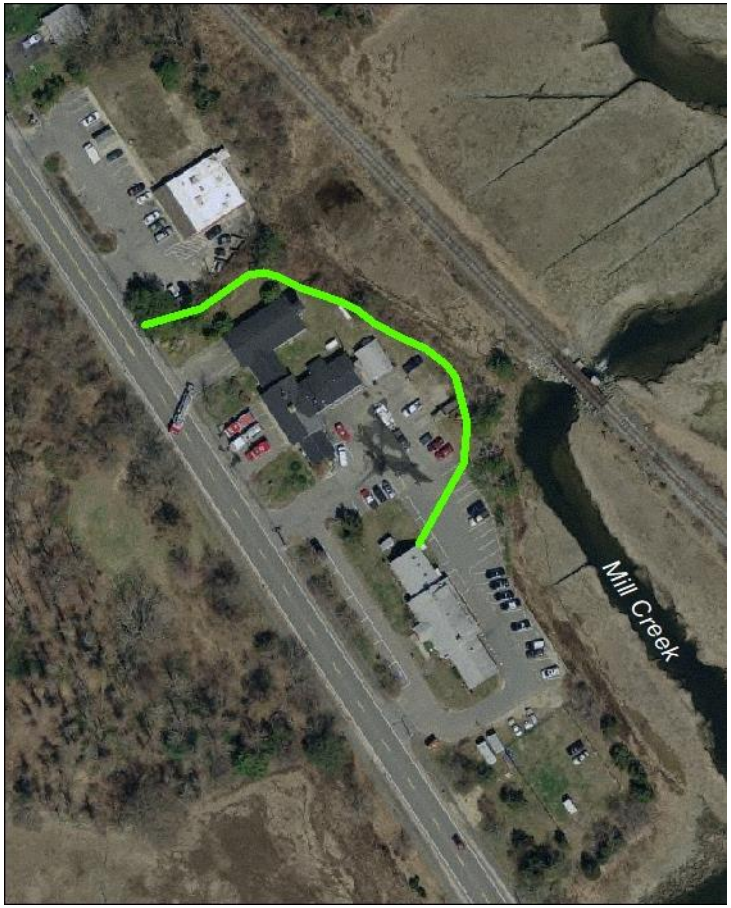
Recommendations: Retreat (Managed)



Examples of managed - and phased - retreat strategies include rolling easements, relocation of roads and infrastructure, implementation of new zoning or other regulations to limit reconstruction, or expansion of structures in high risk flood areas, property buyouts, and other policies and programs that steer development towards areas that are safe from flood risks.

Vulnerability Assessment and Adaptation Planning

Adaptation Strategies – Fire Station



- Option 1 ~ $265,000
  - Building floodproofing
  - Deployable barriers
- Option 2 ~ $300,000+
  - 3 ft. perimeter berm tied to Police and 6A (plus additional deployable barriers)
  - Protective of all 2030 storms, and up to 10% chance 2070 event
- Long-term outlook
  - Not a viable location by 2070 due to building and roadway vulnerabilities
  - Relocate

Vulnerability Assessment and Adaptation Planning

Adaptation Strategies – Ploughed Neck Road

- Option ~ $750,000
  - Causeway with 2 ft. roadbed elevation, with operable tide gate
  - Protective to 0.2% chance 2030 event, and reduces flooding for high probability 2070 events
- Long-term outlook
  - Potential for future salt marsh restoration of Long Creek

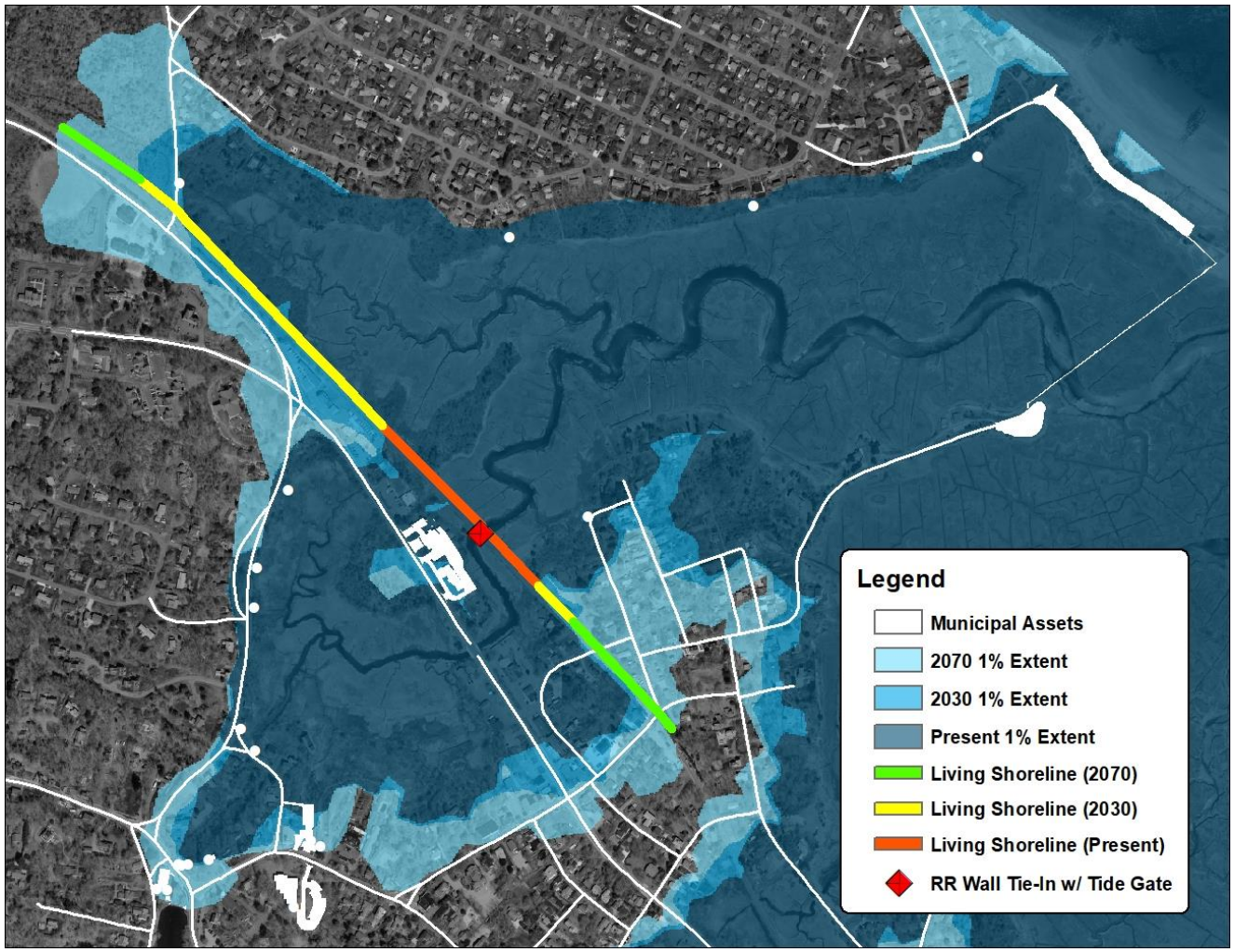
Vulnerability Assessment and Adaptation Planning

Adaptation Strategies – Route 6A (Sandy Neck to Howland)

- Option ~ $12,150,000
  - Bridge span elevated 7 ft. and elevated roadway tie-ins
  - Protective to 1% chance 2070 event
- Long-term outlook
  - State-owned roadway, need to coordinate with MassDOT
  - Consider other flood vulnerabilities along Route 6A

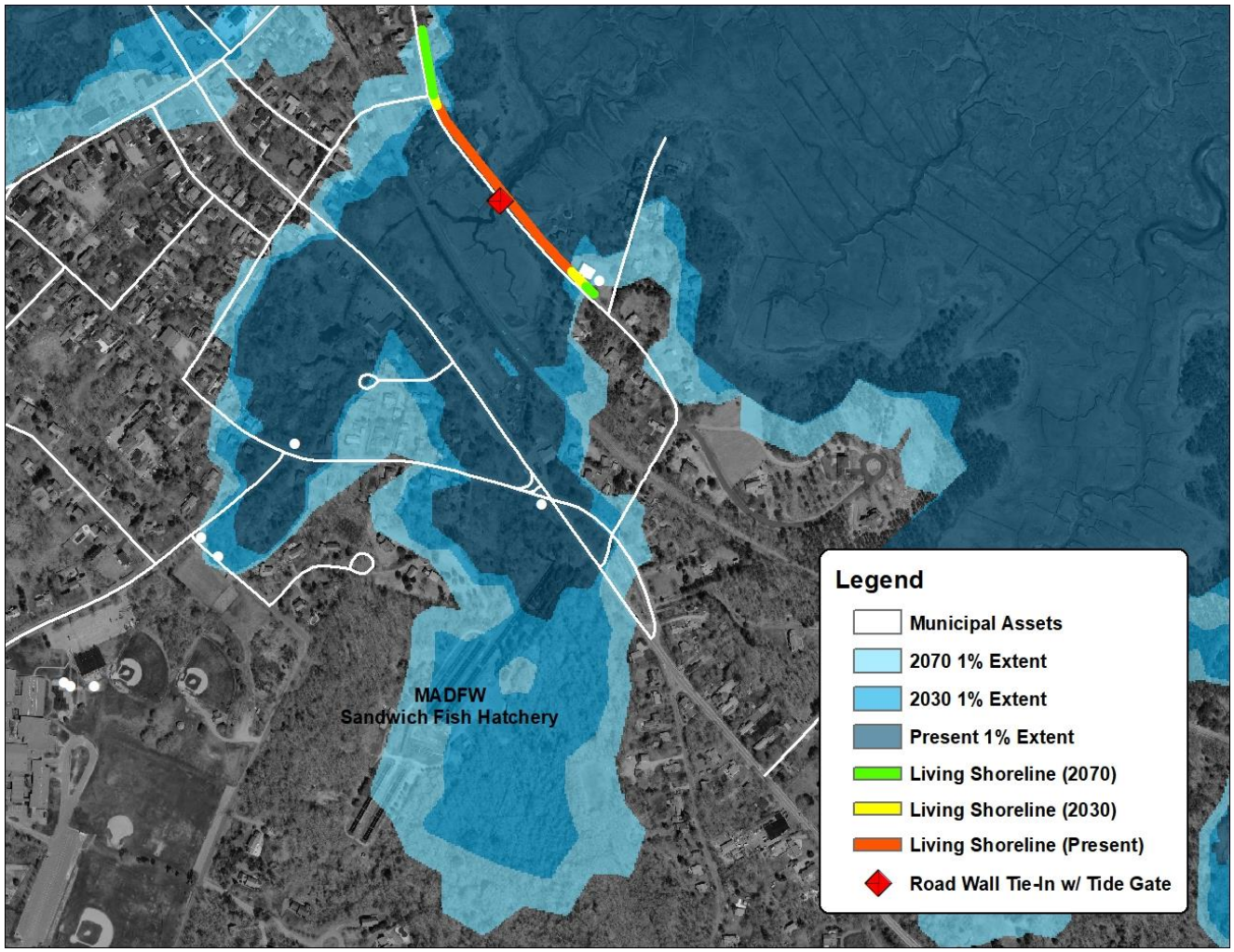
Vulnerability Assessment and Adaptation Planning

Regional Strategies – Downtown District



Vulnerability Assessment and Adaptation Planning

Regional Strategies – Dewey Avenue

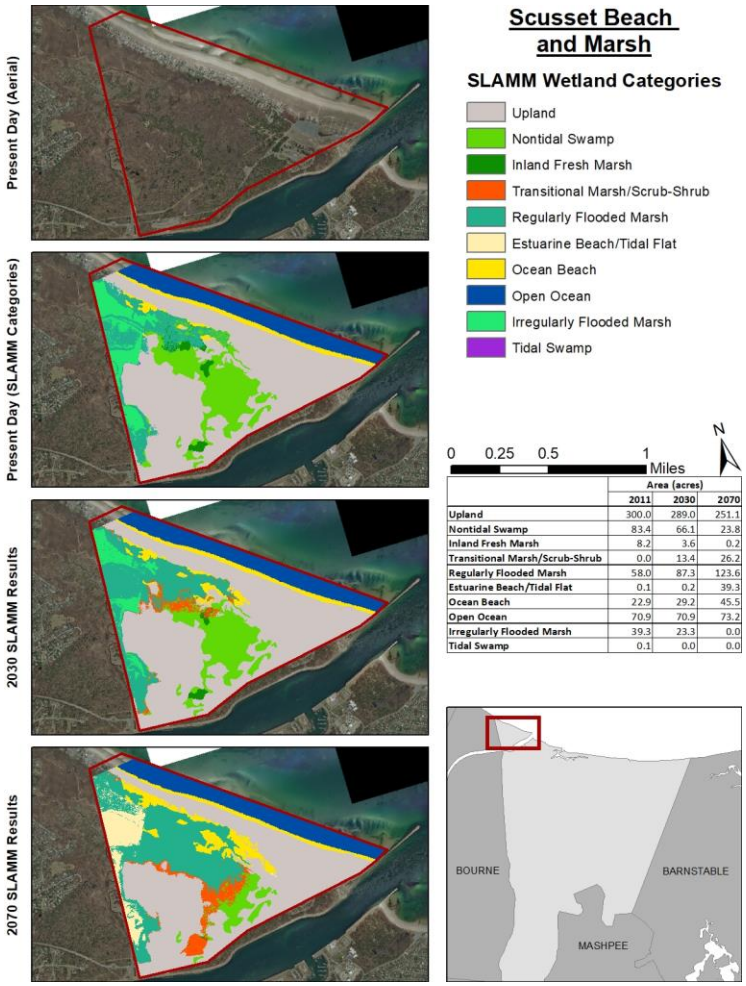


Vulnerability Assessment and Adaptation Planning

Regional Strategies – Town Neck Beach

Vulnerability Assessment and Adaptation Planning

Natural Resources Recommendations - Scusset



Scusset Beach and Marsh

SLAMM Wetland Categories

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

0 0.25 0.5 1 Miles

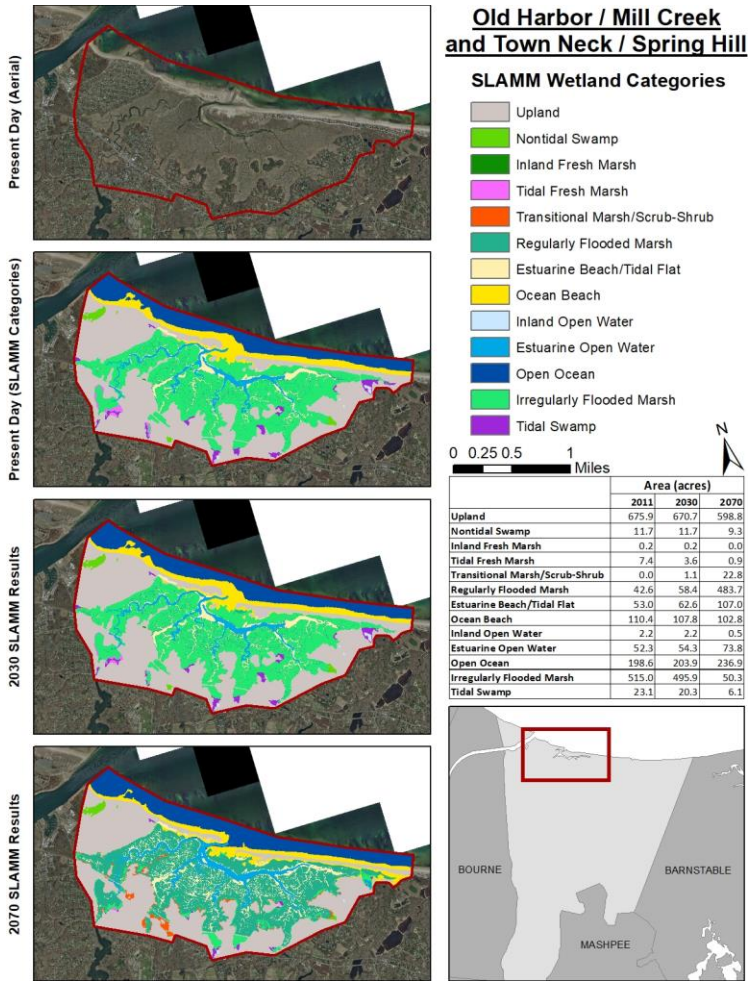
N

	Area (acres)		
	2011	2030	2070
Upland	300.0	289.0	251.1
Nontidal Swamp	83.4	66.1	23.8
Inland Fresh Marsh	8.2	3.6	0.2
Transitional Marsh/Scrub-Shrub	0.0	13.4	26.2
Regularly Flooded Marsh	58.0	87.3	123.6
Estuarine Beach/Tidal Flat	0.1	0.2	39.3
Ocean Beach	22.9	29.2	45.5
Open Ocean	70.9	70.9	73.2
Irregularly Flooded Marsh	39.3	23.3	0.0
Tidal Swamp	0.1	0.0	0.0

- Scusset Beach
  - Monitor the beach and dune system to make sure accretion keeps pace with SLR
  - Fortify dune by consolidating walking paths and/or building walkovers
  - Bypass excess sediment to Town Neck Beach
- Scusset Marsh
  - Allow migration to occur naturally
  - Use thin-layer deposition to help low areas (historically subsided?) keep pace with SLR and prevent marsh loss to tidal flat

Vulnerability Assessment and Adaptation Planning

Natural Resources Recommendations – Old Harbor/Mill Creek and Beaches



Old Harbor / Mill Creek and Town Neck / Spring Hill

SLAMM Wetland Categories

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

0 0.25 0.5 1 Miles

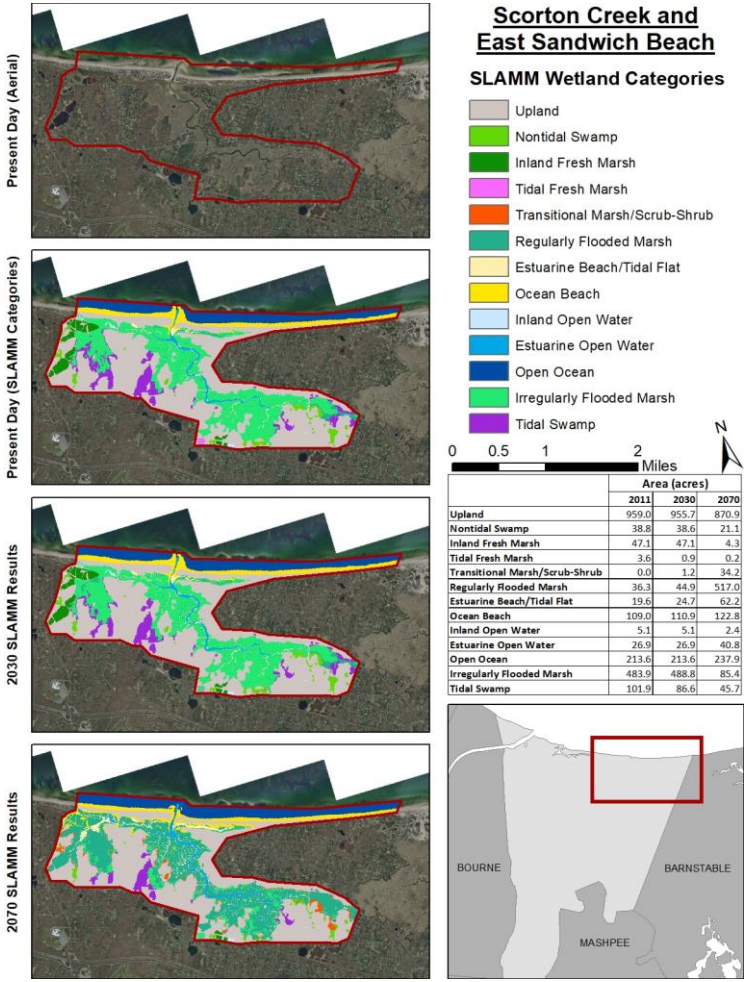
N

	Area (acres)		
	2011	2030	2070
Upland	675.9	670.7	598.8
Nontidal Swamp	11.7	11.7	9.3
Inland Fresh Marsh	0.2	0.2	0.0
Tidal Fresh Marsh	7.4	3.6	0.9
Transitional Marsh/Scrub-Shrub	0.0	1.1	22.8
Regularly Flooded Marsh	42.6	58.4	483.7
Estuarine Beach/Tidal Flat	53.0	62.6	107.0
Ocean Beach	110.4	107.8	102.8
Inland Open Water	2.2	2.2	0.5
Estuarine Open Water	52.3	54.3	73.8
Open Ocean	198.6	203.9	236.9
Irregularly Flooded Marsh	515.0	495.9	50.3
Tidal Swamp	23.1	20.3	6.1

- Town Neck Beach
  - Protect and enhance the eroding dune/beach system, since it protects inland areas and creates conditions for salt marsh growth
- Spring Hill Beach
  - Restore dune and fortify by consolidating walking paths and/or building walkovers
  - Living shoreline flood protection on backside of dune
- Old Harbor / Mill Creek
  - Use ditch filling and thin layer deposition to keep future low marsh contiguous and prevent ponding/sloughing
  - Inventory undersized culverts to prioritize salt marsh restoration opportunities
  - Remove barriers to salt marsh migration

Vulnerability Assessment and Adaptation Planning

Natural Resources Recommendations – Scorton Creek and Beaches



Scorton Creek and East Sandwich Beach

SLAMM Wetland Categories

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

0 0.5 1 2 Miles

N

	Area (acres)		
	2011	2030	2070
Upland	959.0	955.7	870.9
Nontidal Swamp	38.8	38.6	21.1
Inland Fresh Marsh	47.1	47.1	4.3
Tidal Fresh Marsh	3.6	0.9	0.2
Transitional Marsh/Scrub-Shrub	0.0	1.2	34.2
Regularly Flooded Marsh	36.3	44.9	517.0
Estuarine Beach/Tidal Flat	19.6	24.7	62.2
Ocean Beach	109.0	110.9	122.8
Inland Open Water	5.1	5.1	2.4
Estuarine Open Water	26.9	26.9	40.8
Open Ocean	213.6	213.6	237.9
Irregularly Flooded Marsh	483.9	488.8	85.4
Tidal Swamp	101.9	86.6	45.7

- East Sandwich Beach
  - Dune restoration west of Hammond Rd.
  - Living shoreline coastal bank protection east of Hammond Rd.
  - Living shoreline along Scorton Harbor
- Scorton Creek
  - Monitor marsh system to see if it keeps pace with SLR
  - Use ditch filling and thin layer deposition to keep future low marsh contiguous and prevent ponding/sloughing
  - Inventory undersized culverts to prioritize salt marsh restoration opportunities
  - Remove barriers to salt marsh migration
  - Long-term potential for Long Creek marsh restoration at Ploughed Neck Road, but need to weigh impacts

THANK YOU…

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