Modeling the Effects of Sea Level Rise on Massachusetts Coastal Wetlands

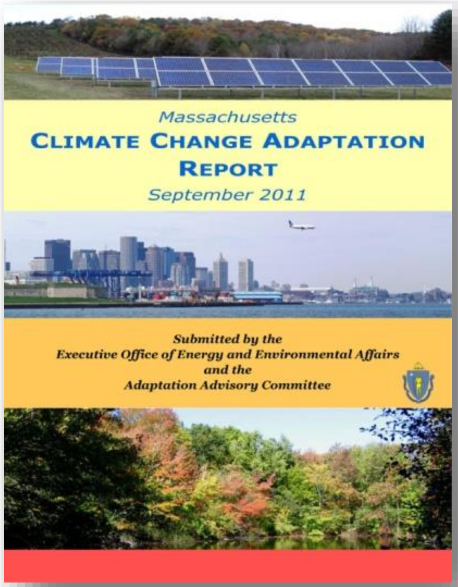
Improving Protection, Management, and Climate Change Adaptation Planning

Photo credit: Mike McHugh, MassDEP

Marc Carullo
Massachusetts Office of Coastal Zone Management

Massachusetts Climate Change Adaptation Report

Select adaptation strategies identified for coastal ecosystems:



- ✓ Identify and protect undeveloped areas that are upgradient from coastal wetlands to allow wetland migration and buffer intact ecosystems
- ✓ Identify, assess and mitigate existing impediments to inland migration of coastal wetlands
- ✓ Track the movement of tidal resources as they respond to sea level rise

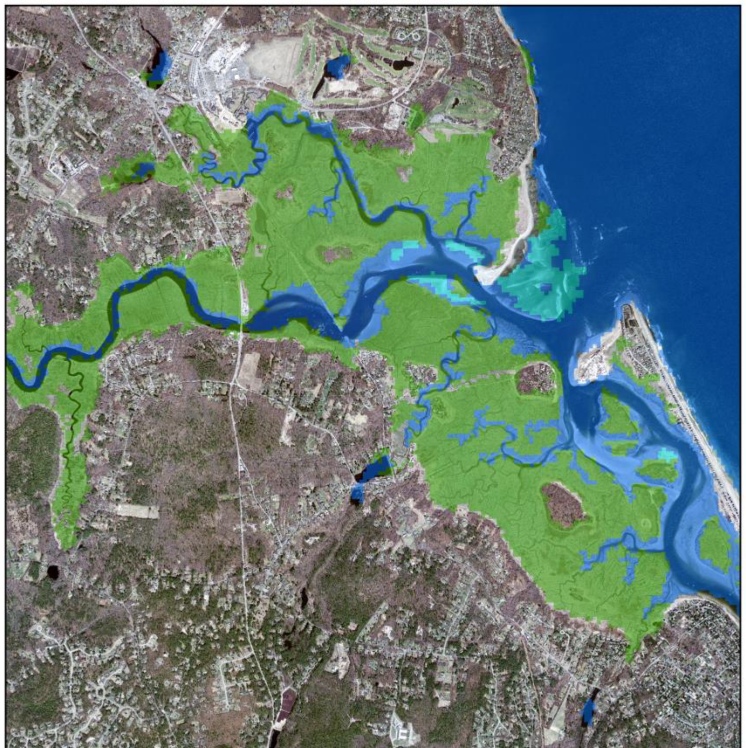
Project Goals

1. Identify potential changes to wetland type across multiple temporal and spatial scales.
2. Identify barriers to and opportunities for landward marsh migration.
3. Communicate results via web-based maps, reports, and workshops/ meetings.
4. Begin to develop and implement adaptation strategies to address potential SLR impacts to coastal wetlands.
5. Establish a network of long-term monitoring stations to measure impacts of sea level rise and potential marsh migration.

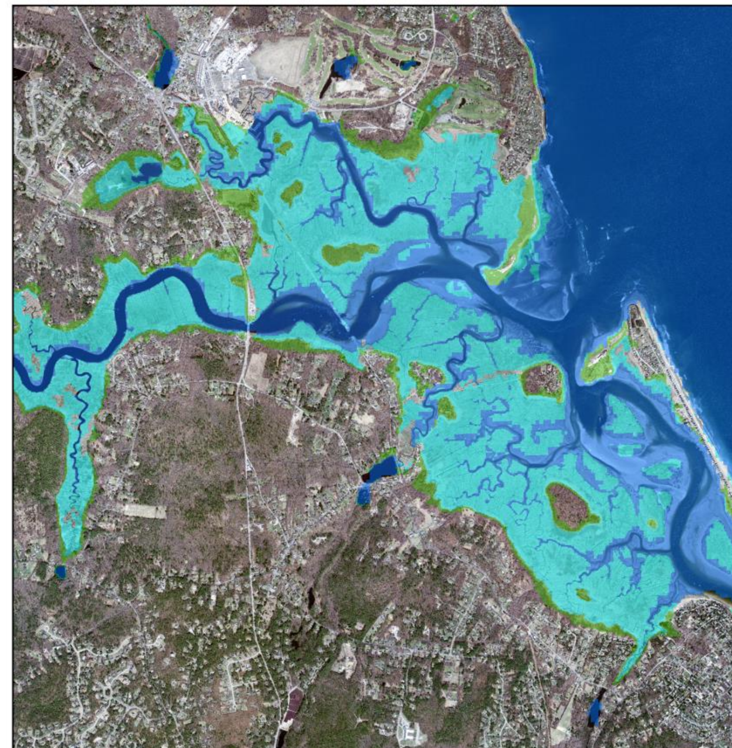
1. **Identify potential changes to wetland type across multiple temporal and spatial scales.**

**North and South Rivers in Marshfield and Scituate*

Current MHHW

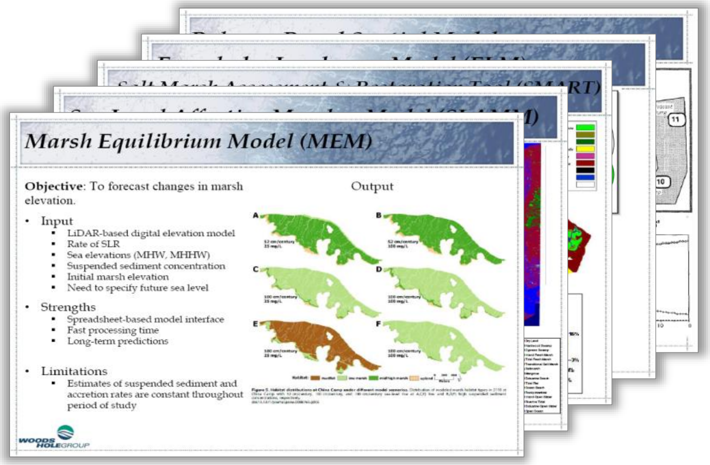


Potential MHHW + 6 ft SLR

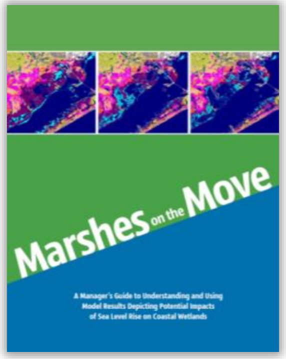


Model Selection

- Things to consider
  - Time step/simulation period
  - Spatial Resolution
  - Parameters simulated
  - Input data requirements
  - Typical scenarios/applications



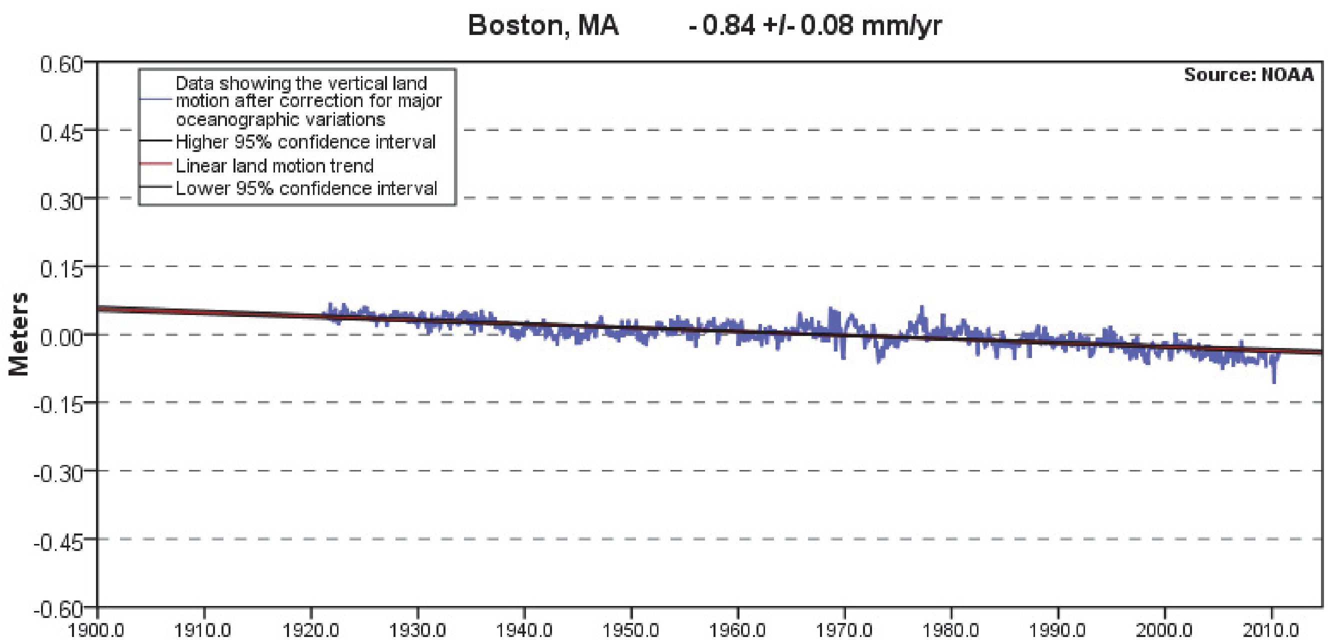
- Models considered
  - Salt Marsh Assessment & Restoration Tool (SMART)
  - Polygon-Based Spatial Model (PBS)
  - Everglades Landscape Model (ELM)
  - Marsh Equilibrium Model (MEM)
  - Sea Level Affecting Marshes Model (SLAMM)



Four scenarios with estimates of global SLR by 2100

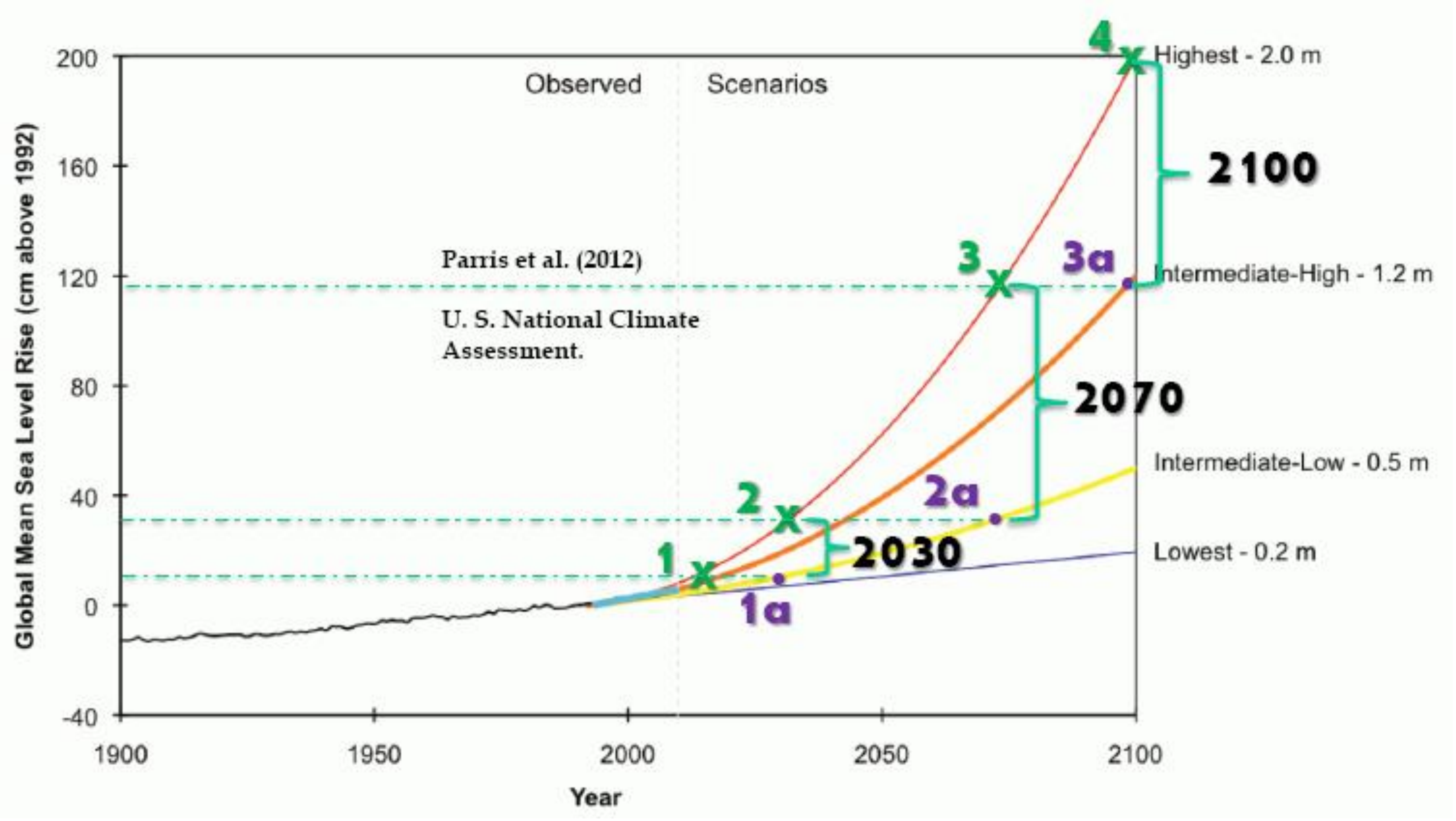
Global Sea Level Rise Scenarios for the United States National Climate Assessment (Parris et al., 2012)

Scenario	SLR (m)	SLR (ft)	Summary
Highest	2.0	6.6	Based on ocean warming and maximum ice sheet loss
Intermediate-High	1.2	3.9	Based on limited ice sheet loss plus ocean warming
Intermediate-Low	0.5	1.6	Based primarily on sea level rise from ocean warming
Lowest	0.2	0.7	Linear extrapolation of historical sea level rise rate



Local vertical land movement at the Boston tide gauge.

Using Projections to Bracket Uncertainty and Risk



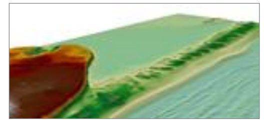
Graphic courtesy of Woods Hole Group.

Data Compilation

Contributors
- NOAA (CO-OPS)
- MBL/PIE LTER
- USFWS (NWI, PRNWR)
- MassGIS
- USGS
- Waquoit Bay NERR
- NPS (CACO)
- Others

Additional data inputs
- Dam locations
- Dam crest elevations
- SLR historic trend
- Beach sedimentation rate
- MEM accretion rates
- Other

SLAMM 6.2 Data Inputs

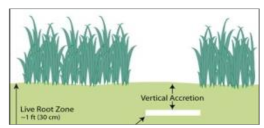


Digital Elevation Model (lidar-derived)

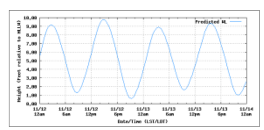
Wetland Map Data

Impervious Surface

Erosion Rates (horizontal)



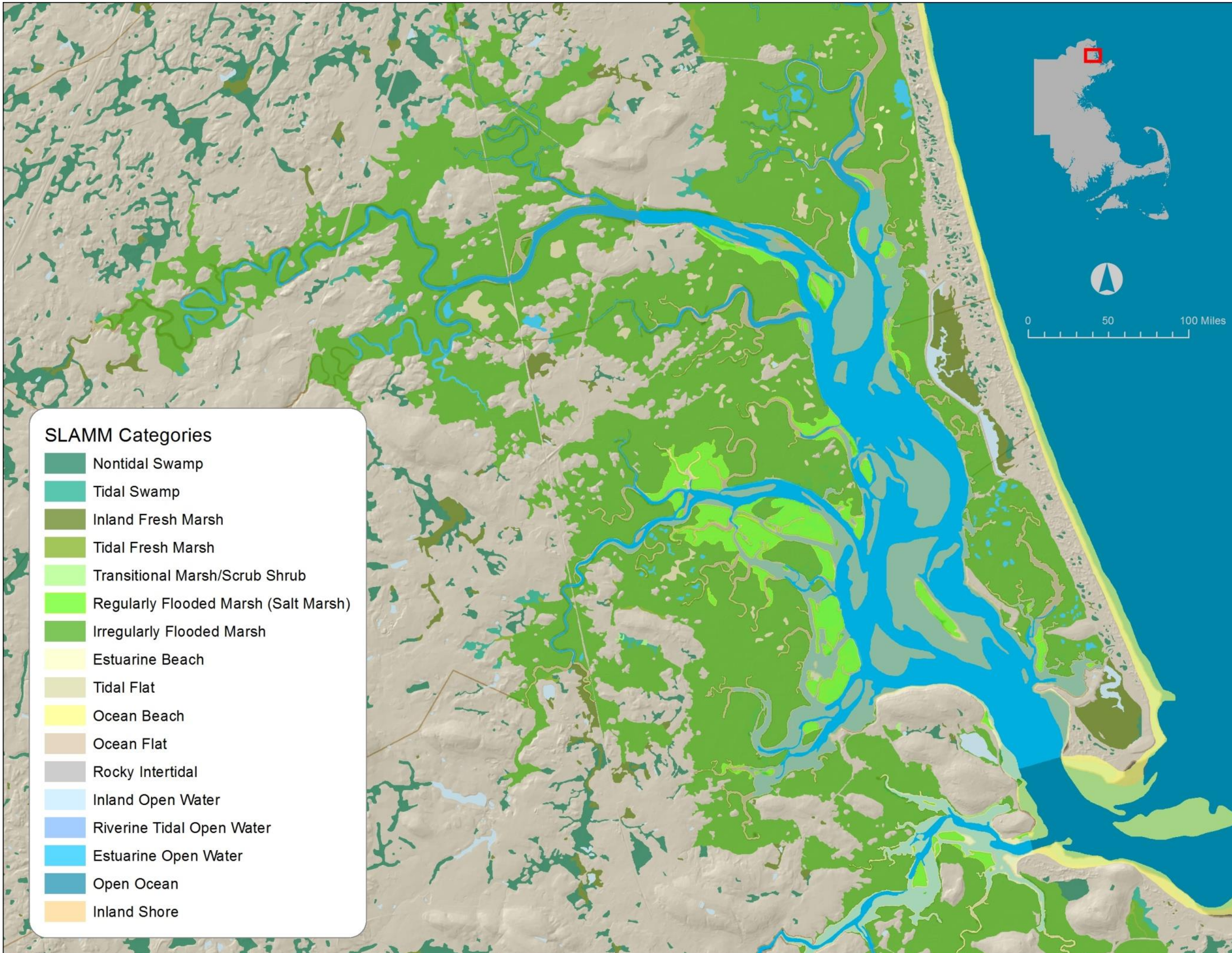
Accretion Rates (vertical)



GD Tide Range (MHHW-MLLW)

Salt Elevation (+ MTL)

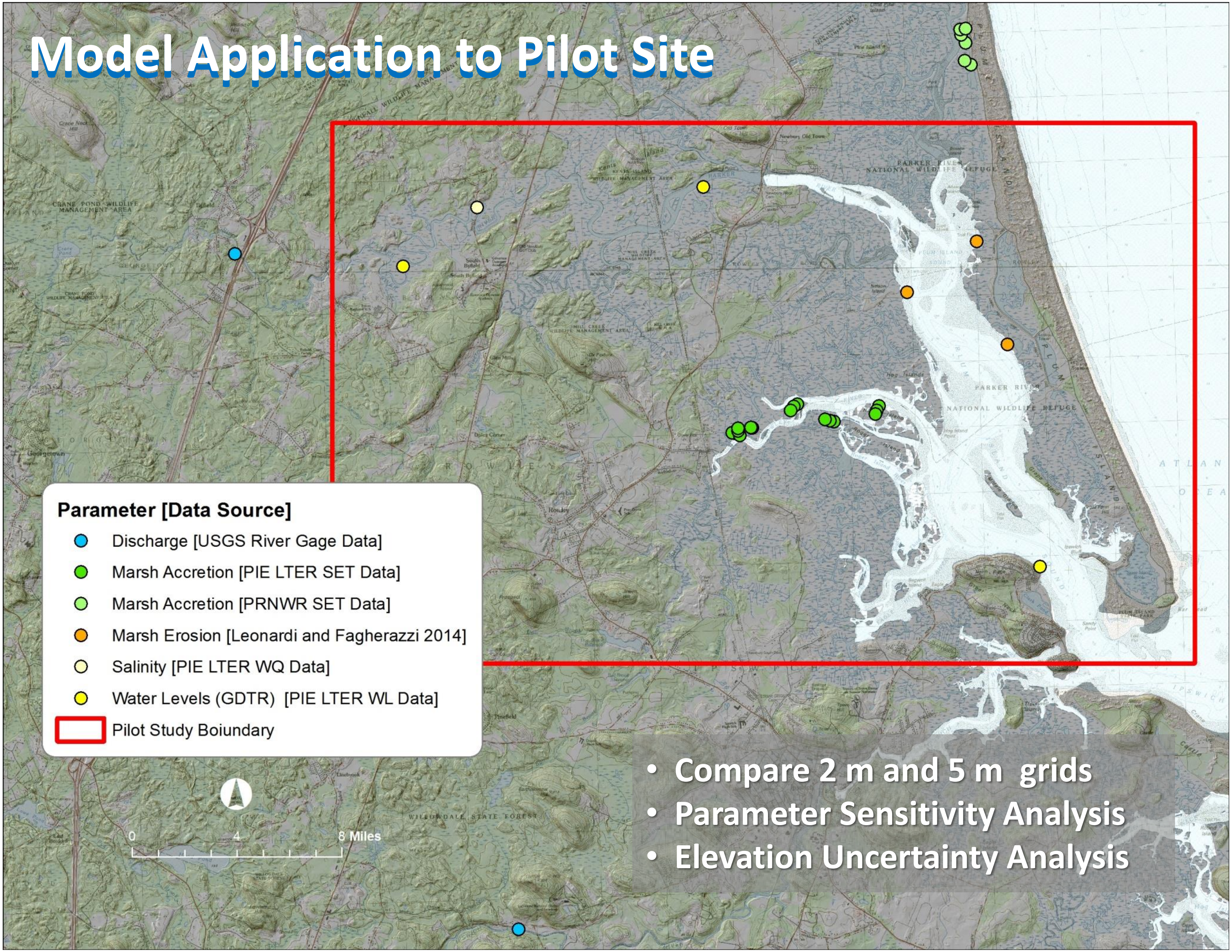
Freshwater Parameters (flow, etc.)



SLAMM Categories
Nontidal Swamp
Tidal Swamp
Inland Fresh Marsh
Tidal Fresh Marsh
Transitional Marsh/Scrub Shrub
Regularly Flooded Marsh (Salt Marsh)
Irregularly Flooded Marsh
Estuarine Beach
Tidal Flat
Ocean Beach
Ocean Flat
Rocky Intertidal
Inland Open Water
Riverine Tidal Open Water
Estuarine Open Water
Open Ocean
Inland Shore
0
50
100 Miles

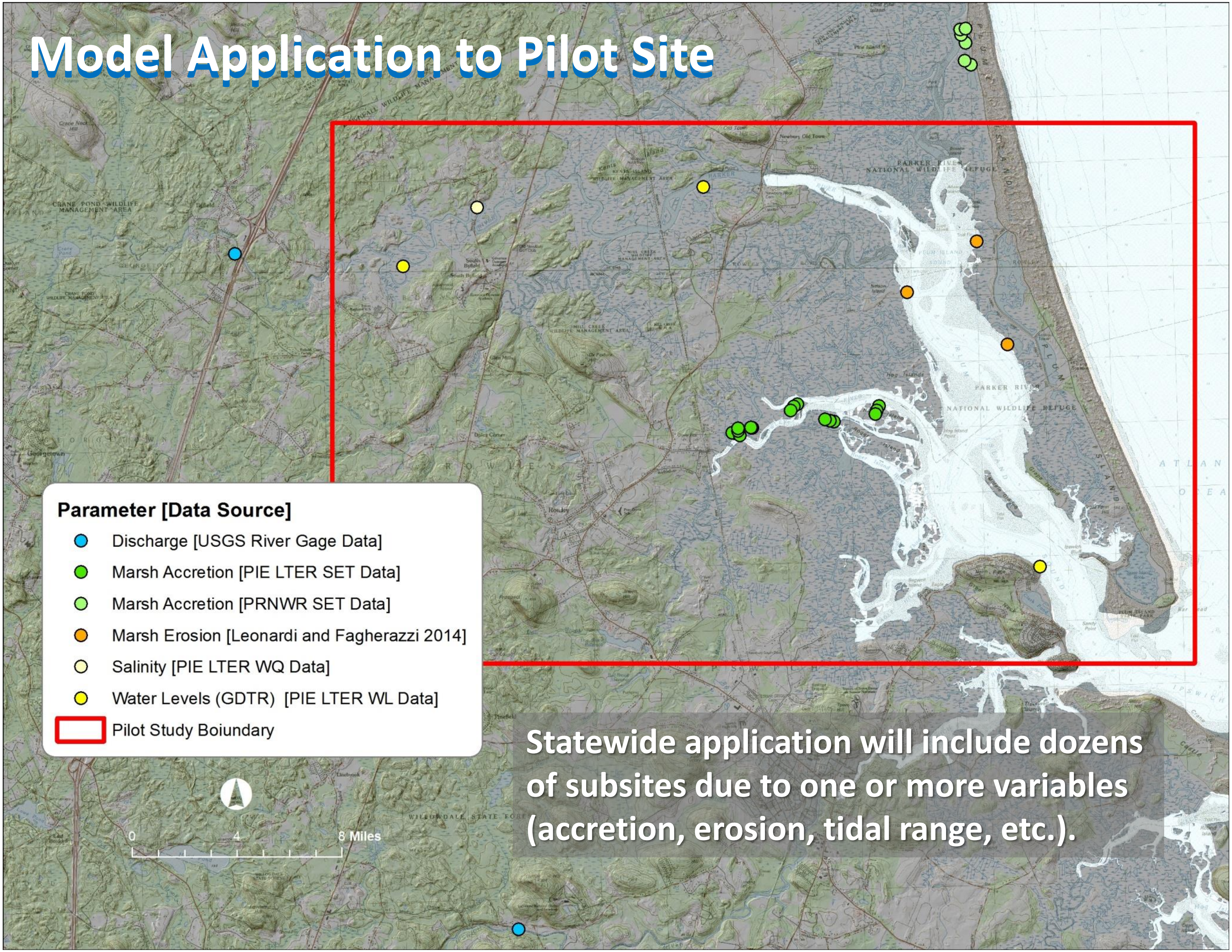
Rowley River
SLAMM Categories
Regularly Flooded Marsh
0
4
8 Miles

Model Application to Pilot Site



- Compare 2 m and 5 m grids
- Parameter Sensitivity Analysis
- Elevation Uncertainty Analysis

Model Application to Pilot Site



Statewide application will include dozens of subsites due to one or more variables (accretion, erosion, tidal range, etc.).

Parameter Sensitivity Analysis

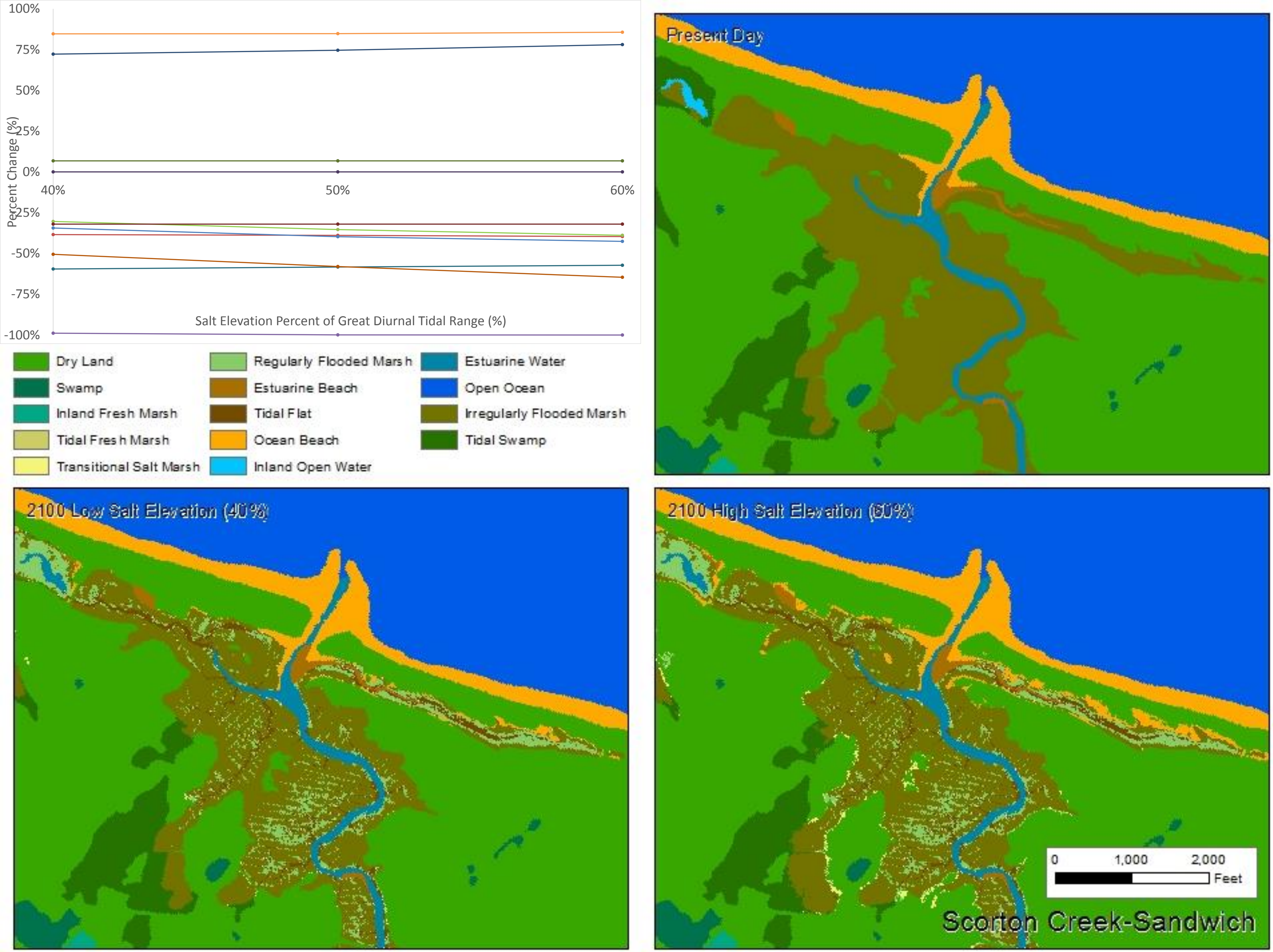
- Small estuaries
- Variety of wetland classes
- Closed systems with simple hydrology

Sandwich, MA

Sandwich Estuaries Parameter Sensitivity Analysis

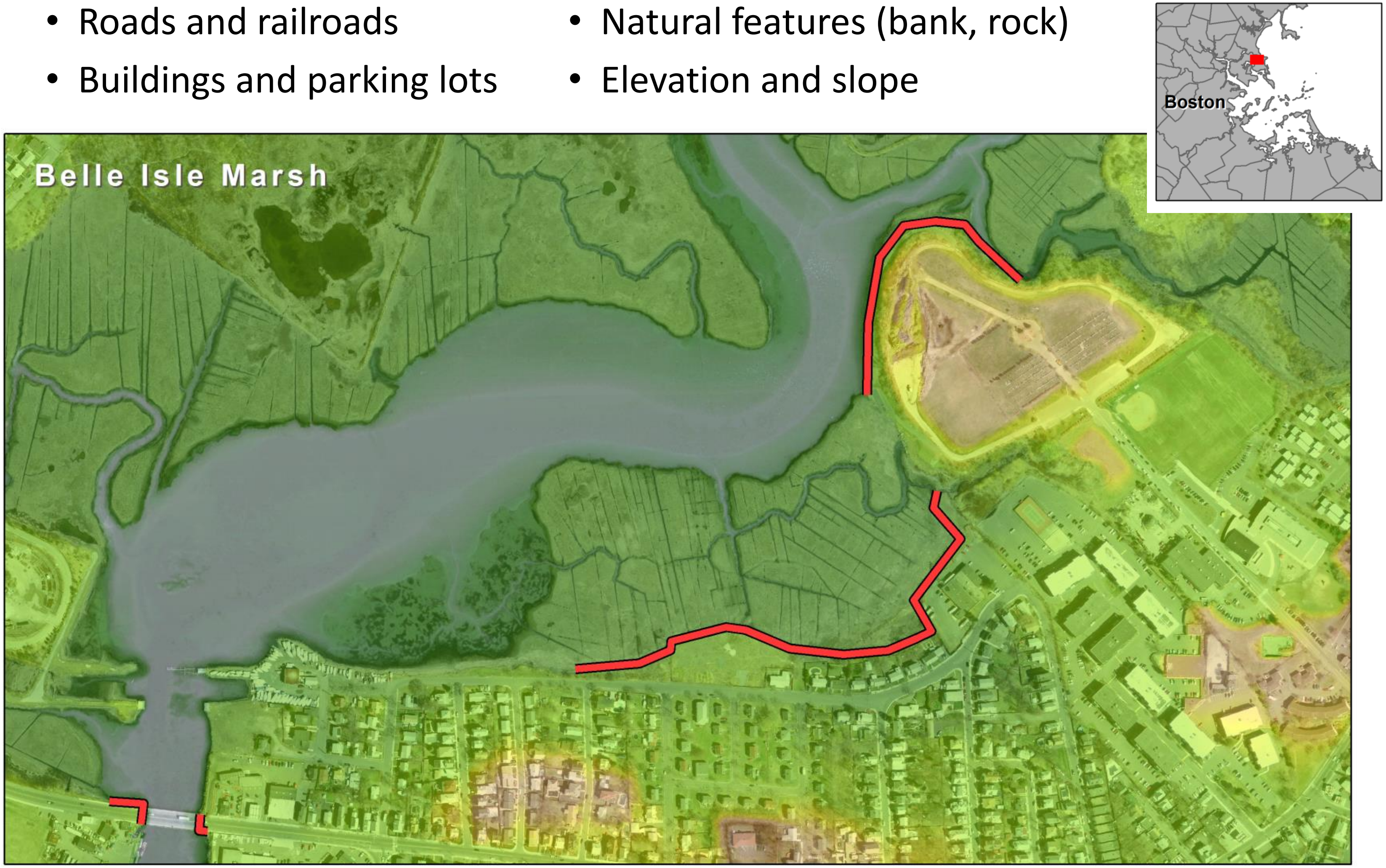
Parameter	Range of Values Tested			Land Types Affected*
	Typical	Min	Max	
Historic Trend (mm/yr)	0 - 4	-10	+10	9
Great Diurnal Tide Range (% State Max Range)**	10-100	0	110	12
Salt Elevation (% Tide Range)***	40 – 60	0	100	9
Marsh Erosion (m/yr)	0 – 2	-10	+10	0
Swamp Erosion (m/yr)	0 – 2	-10	+10	0
Tidal Flat Erosion (m/yr)	0 – 2	-10	+10	5
Regularly Flood Marsh Accretion (mm/yr)	0 – 4	-25	+25	2
Irregularly Flooded Marsh Accretion (mm/yr)	0 – 4	-25	+25	3
Tidal/Inland Fresh Marsh Accretion (mm/yr)	0 – 4	-25	+25	5
Tidal/Inland Fresh Swamp Accretion (mm/yr)	0 – 40	-250	+250	6
Beach Sedimentation Rate (mm/yr)	0 – 10	-1,000	+1,000	1
Frequency of Overwash (yrs)	0 – 100	0	100	9

*Land Types Affected: A total of 14 different Land Types are present in the pilot study area. The Land Types Affected are land types that have a larger than 1% difference between the change in percent increase/decrease of that land type over the range of typical values.
** % State Max Range: The maximum tidal range observed on the MA coast is 10.7 ft.
***% Tide Range: The salt elevation is the height above mean tide which was related to the tidal range as opposed to being evaluated independently.

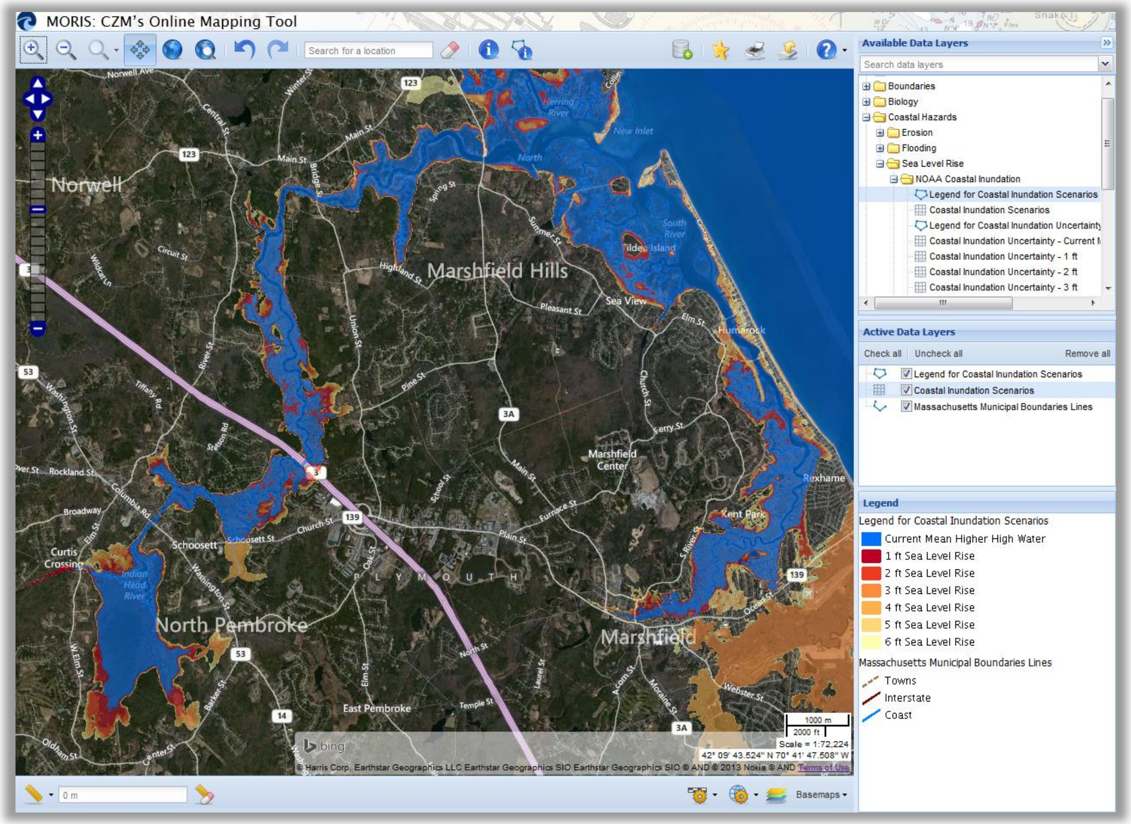

100%
75%
50%
25%
0%
-25%
-50%
-75%
-100%
Percent Change (%)
40%
50%
60%
Salt Elevation Percent of Great Diurnal Tidal Range (%)
Dry Land
Swamp
Inland Fresh Marsh
Tidal Fresh Marsh
Transitional Salt Marsh
Regularly Flooded Marsh
Estuarine Beach
Tidal Flat
Ocean Beach
Inland Open Water
Estuarine Water
Open Ocean
Irregularly Flooded Marsh
Tidal Swamp
Present Day
2100 Low Salt Elevation (40%)
2100 High Salt Elevation (60%)
0
1,000
2,000
Feet
Scorton Creek-Sandwich

2. Identify barriers to and opportunities for marsh migration.

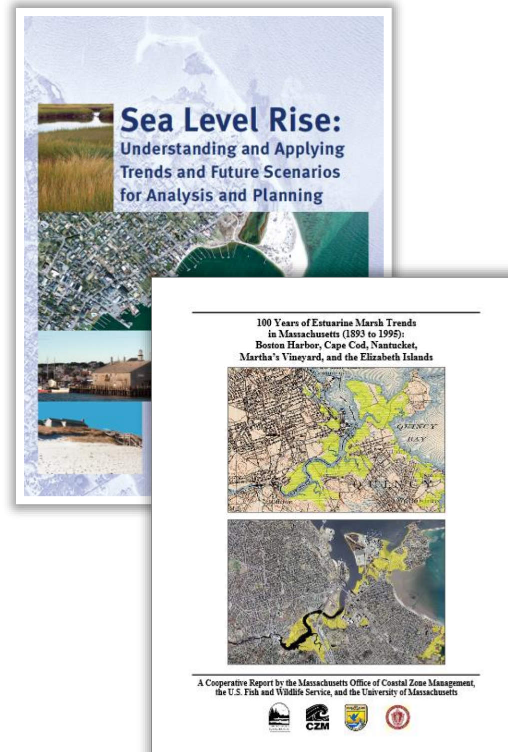
- Coastal structures
- Roads and railroads
- Buildings and parking lots
- Berms and dikes
- Natural features (bank, rock)
- Elevation and slope



3. **Communicate results via web-based maps** (e.g., MORIS and ArcGIS Online Story Maps)**, reports, and workshops.**



MORIS: CZM's Online Mapping Tool



4. Begin to develop and implement adaptation strategies to address potential SLR impacts to coastal wetlands.

Regulatory and Restoration

a. Support for regulatory decisions, federal consistency determinations, and the interpretation and implementation of specific performance standards.

b. Augmented or new coastal program policies.

c. Determination of priority restoration areas.

d. Assessment of current wetland buffer and setback regulations.

4. Begin to develop and implement adaptation strategies to address potential SLR impacts to coastal wetlands.

Land Management and Education

e. Identification of sites for land acquisition, conservation easement actions, and/or changes in land management practices.

f. Improved management of hardened coastal structures (proposal, maintenance, or removal).

g. Better integration of salt marshes into CZM's StormSmart Coasts program.

h. Public outreach and education on the potential effects of sea level rise on wetlands.

Marsh Restoration/Adaptation Strategies

- Facilitated marsh migration
- Living shorelines
- Thin-layer deposition (beneficial reuse of dredged material)
- Invasive species control (manage *Phragmites* in transition)
- Enhance ecological integrity to increase resilience to SLR

Delaware Department of Natural Resources and Environmental Control

Burke Environmental Associates via VIMS Center for Coastal Resources Management

5. Establish a network of long-term monitoring stations.

- ~ 20 salt marsh monitoring stations coast-wide.
- Track the movement of plant community structure, especially in the marsh border-upland and marsh-open water ecotones.
- Collect physical data on hydroperiod, surface elevation, relative vertical accretion/erosion, and soil characteristics.*

**Possible addition at select sites*

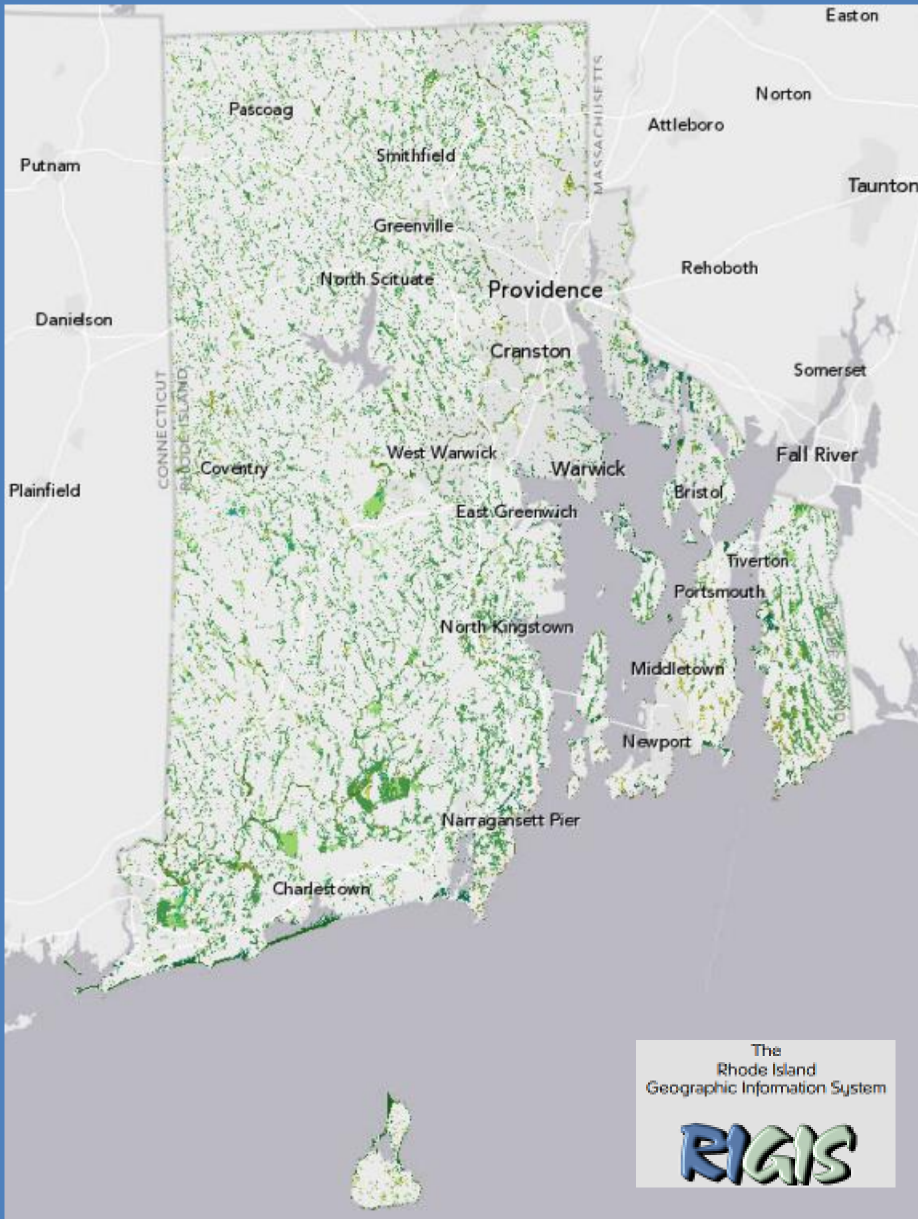

marc.carullo@state.ma.us
Photo credit: Adrienne Pappal, CZM

Sea Levels Affecting Marshes Model
Rhode Island SLAMM Project

NROC Marsh Migration Workshop
Hugh Gregg Coastal Conservation Center, Greenland, NH
December 2, 2014

James Boyd, Coastal Policy Analyst
RI Coastal Resources Management Council

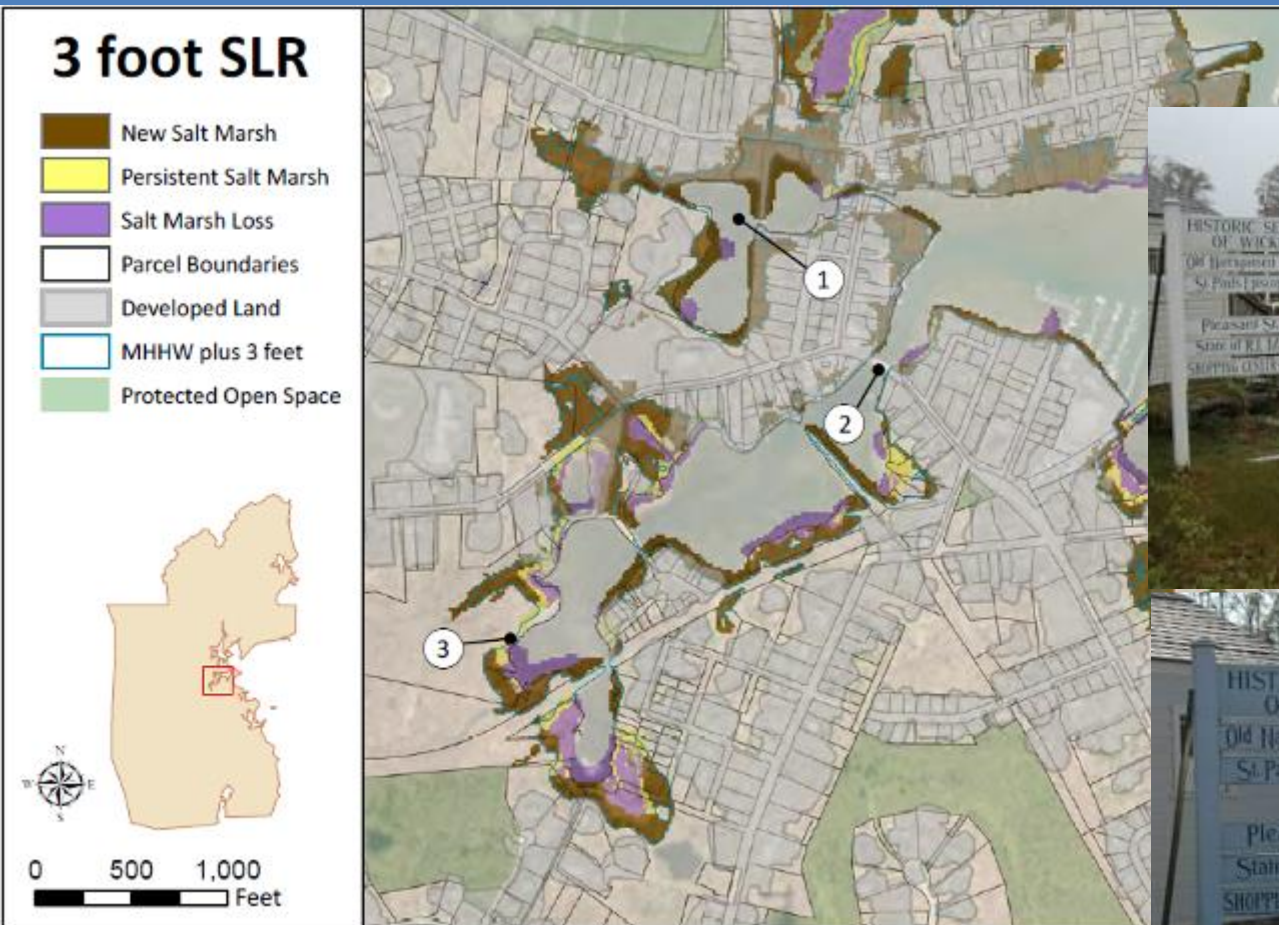
Photo: R. Hancock



Rhode Island has lost 53% of its historic salt marshes over the last two centuries* due to man-made alterations (ditching and filling) resulting in a loss of about 4000 acres statewide

* Bromberg and Bertness, 2005

Sea Level Affecting Marshes Model
North Kingstown Pilot Project (2011)



http://seagrant.gso.uri.edu/climate/habitat.html

RI SLAMM Project Goals

1. Develop marsh migration modeling results (maps)
2. Identify existing vulnerable wetlands
3. Identify affected upland parcels – opportunities and challenges
4. Develop new CRMC coastal program adaptive strategies, policies and standards (Beach SAMP)
5. Increase local capacity to proactively incorporate sea level rise for wetlands within comprehensive plans, zoning overlays, conservation efforts, etc.

All 21 Coastal Communities Completed

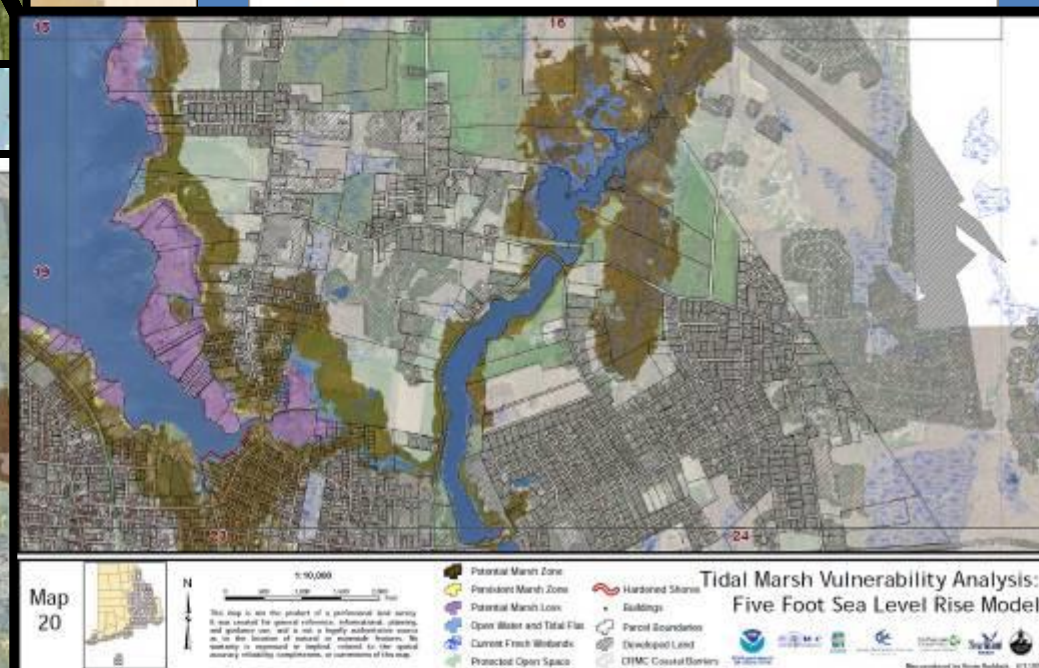
RI SLAMM Project

May 2013 – Regional Meeting

Engaging Communities through Stakeholder Input

October 2013 Barrington and East Providence meeting

Critical Coastal Wetlands



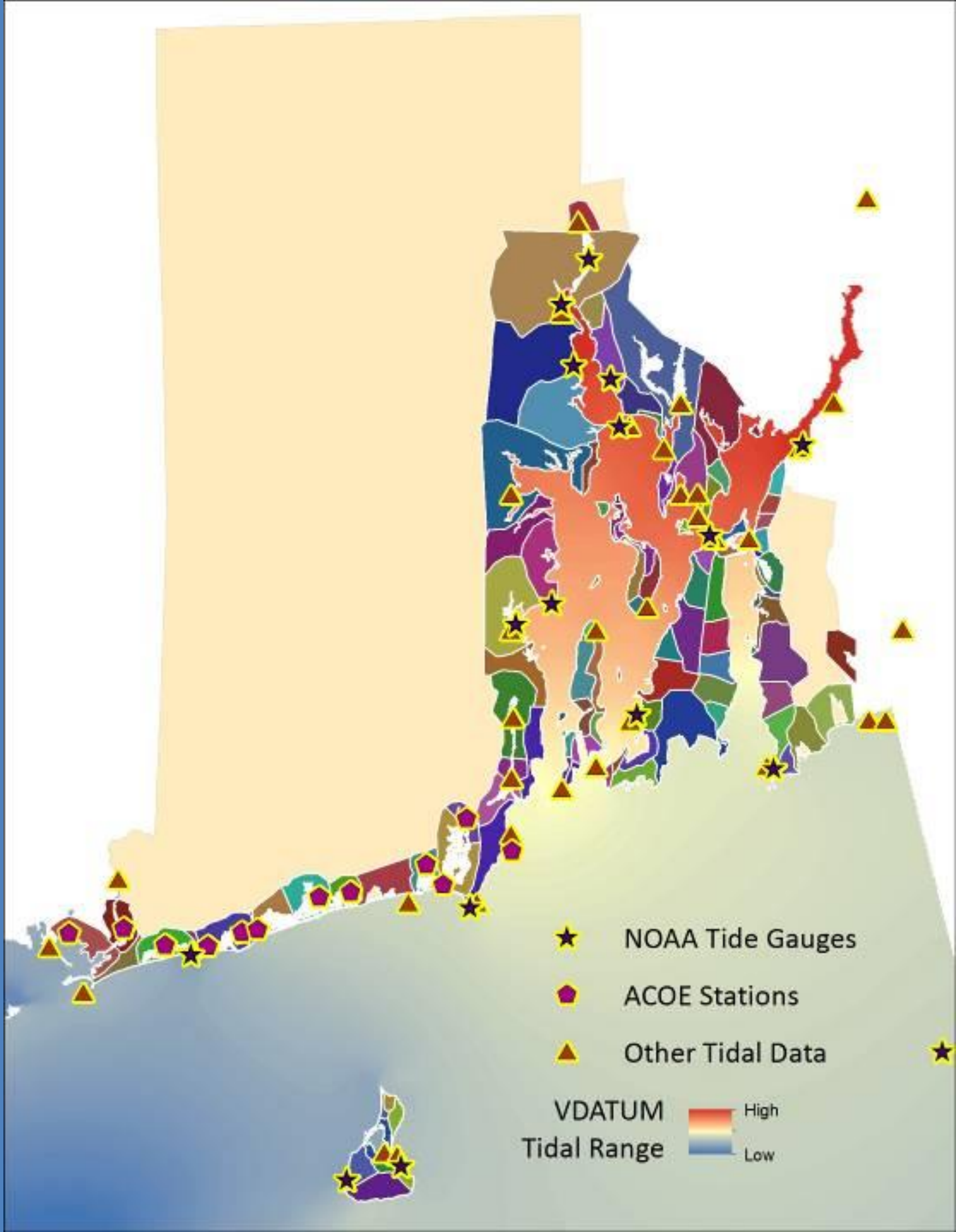
Model Parameters

Accretion = 3.8 mm/yr

•Observations from NBNERR SET monitoring (K. Raposa)
•Consistent with median value from literature

105 Sub-Sites

•Historic SLR Trend to estimate subsidence/lift
•Direction offshore
•Erosion/sedimentation
•Storm Frequency
• **Tidal Data**
    • Range
    • Datum Adjustment



Model Limitations

Uncertainty in Sea Level Rise Projections

Ground Conditions

- Some uplands may be more suitable than others
- Multiple stressors on salt marshes
- Freshwater wetlands may convert to open water

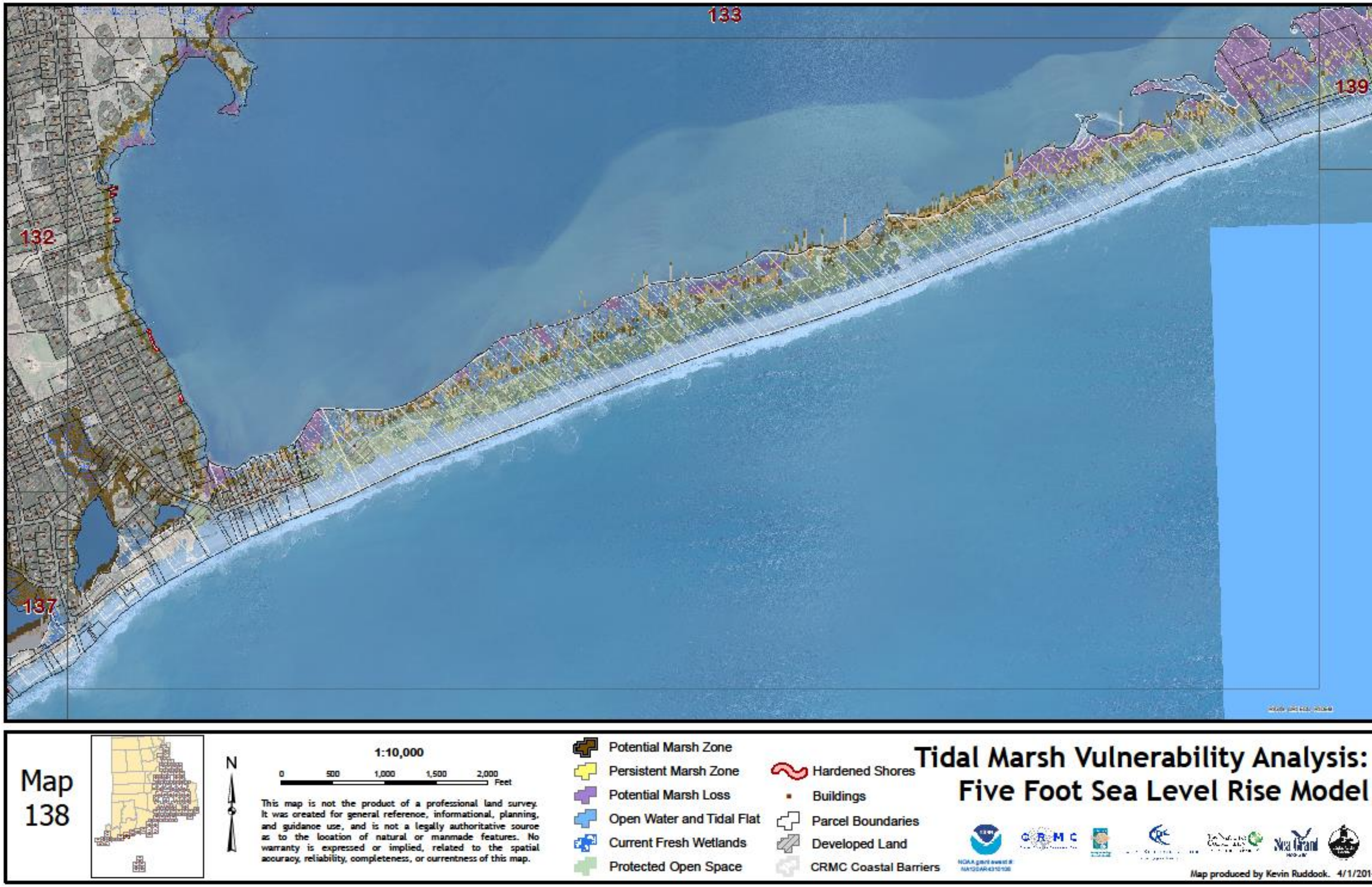
Model Simplifications

- Accretion rates are variable
- Salinity dynamics are simplified

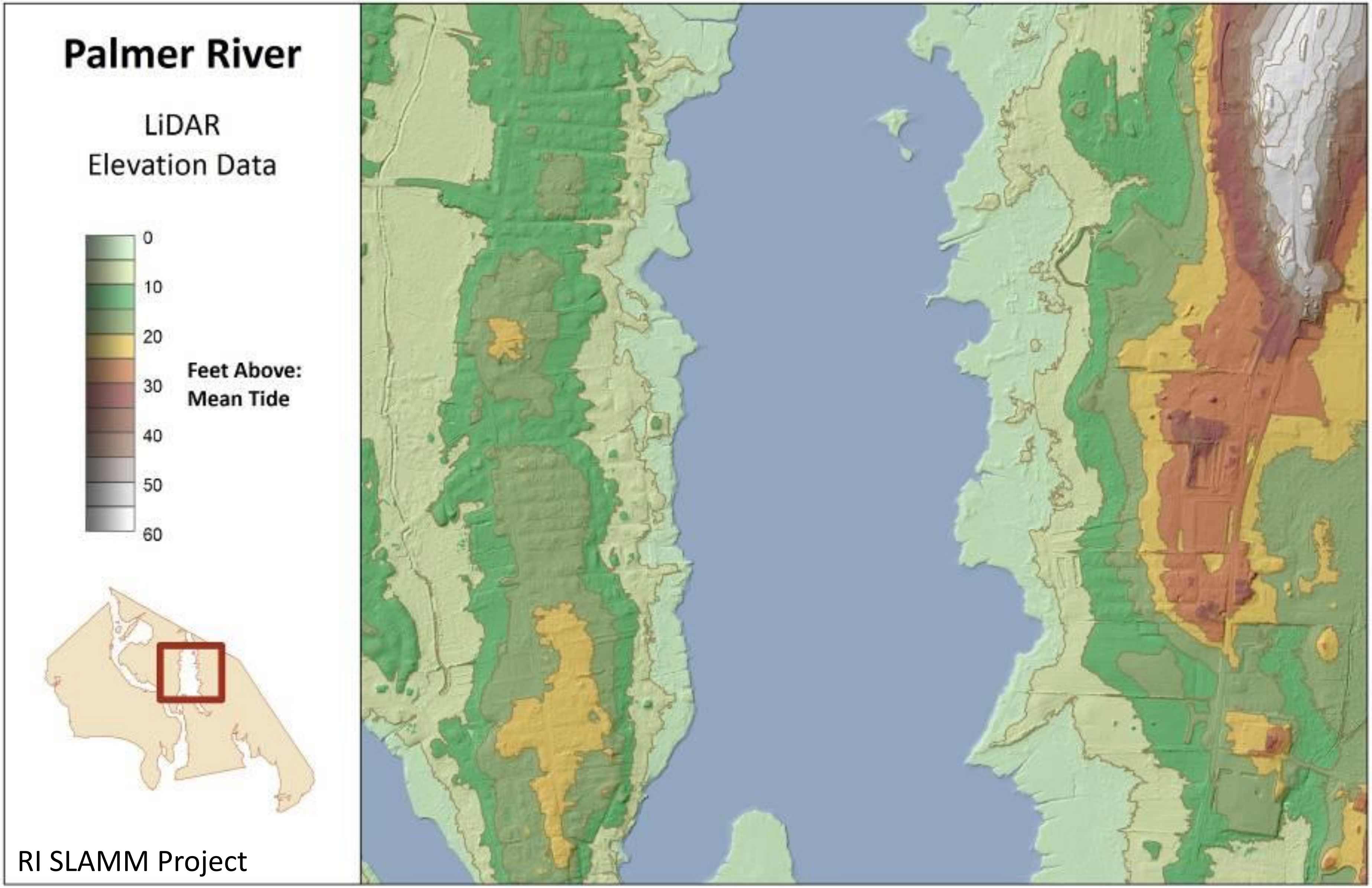
Changing Coastline

- Storm events
- Barrier migration

Barrier Migration Issue



Model Input: USGS 2011 LiDAR

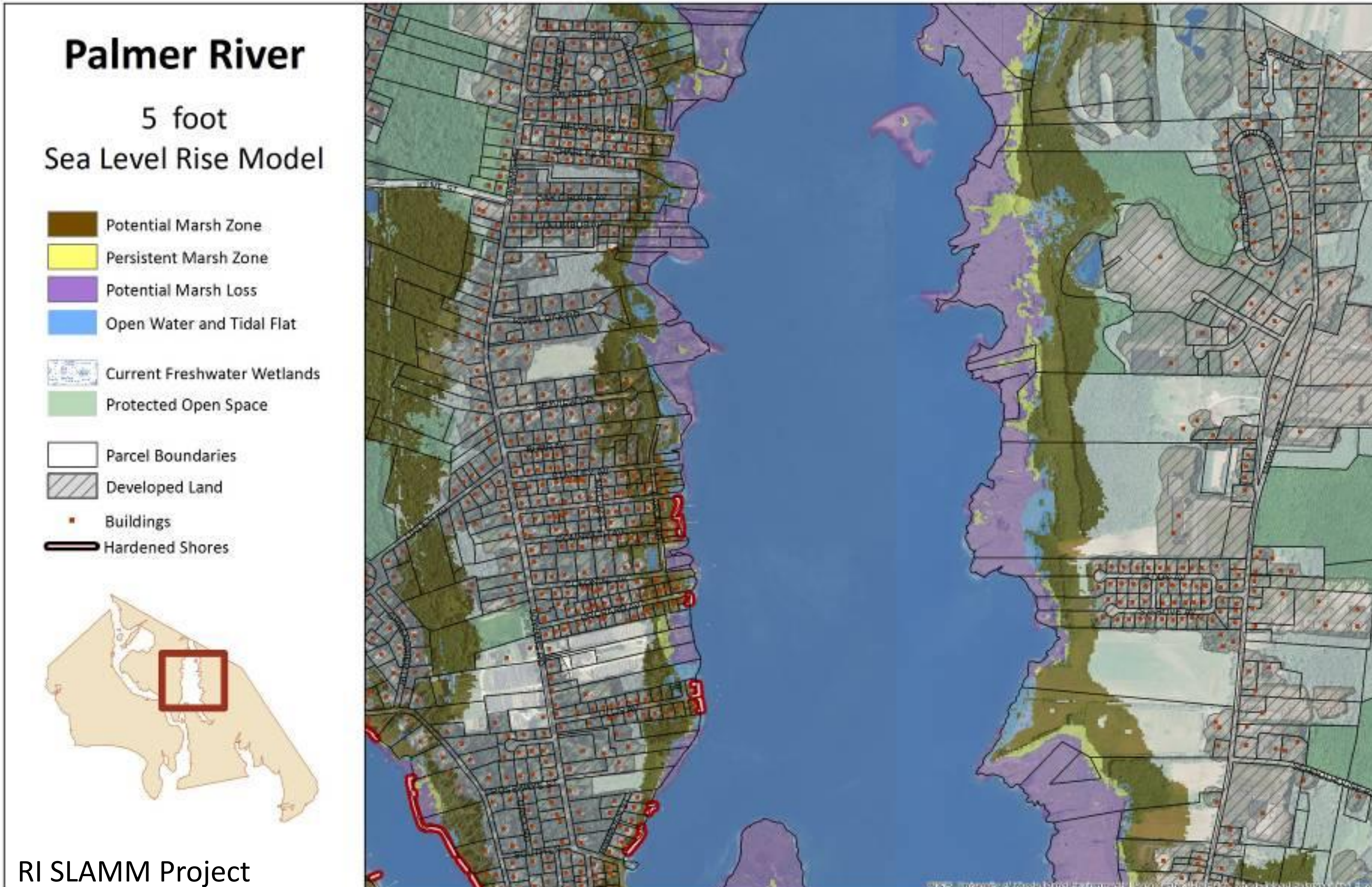


Model Input: National Wetland Inventory 2010

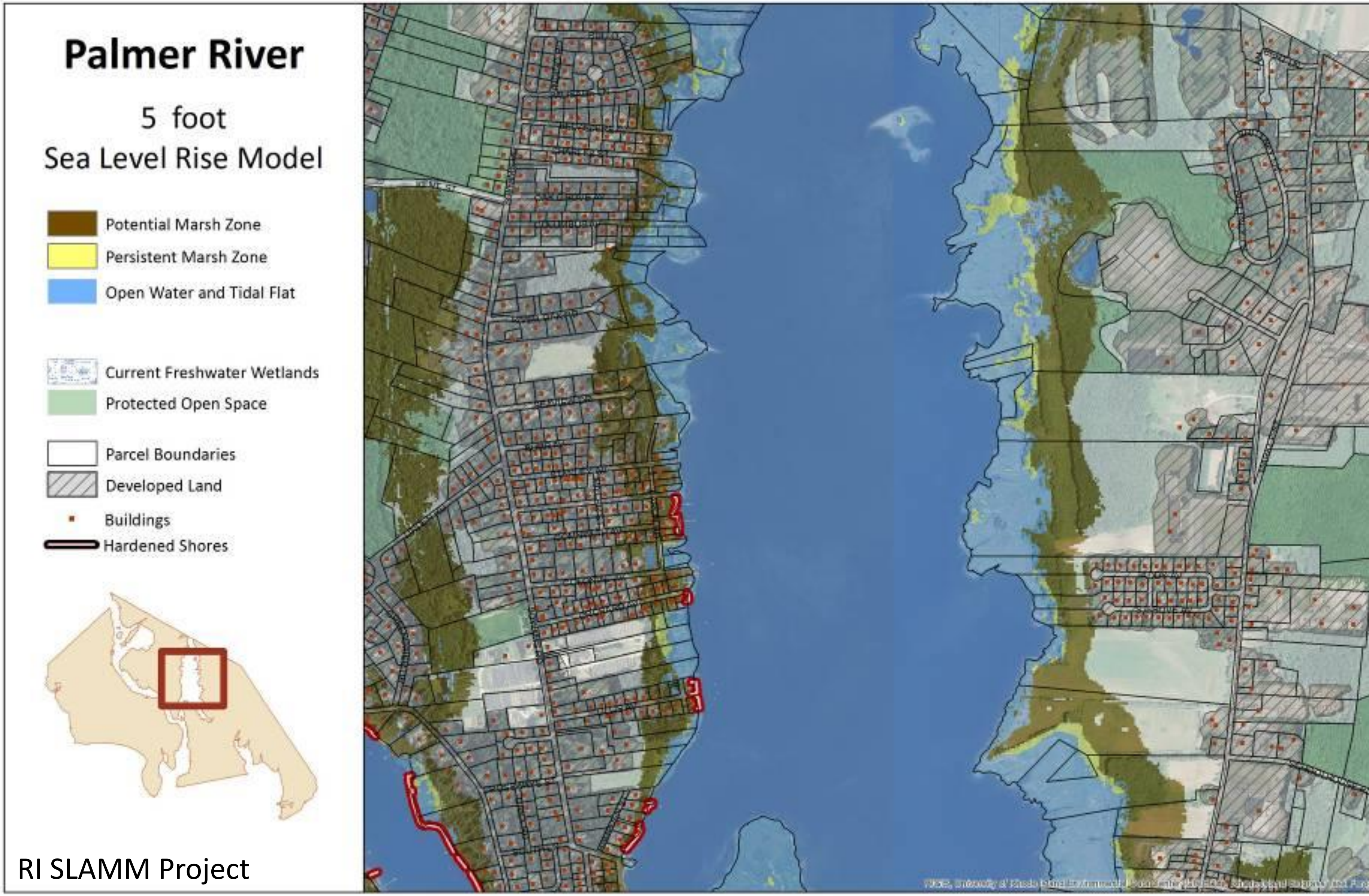
SLAMM Model Results

SLAMM Model Results

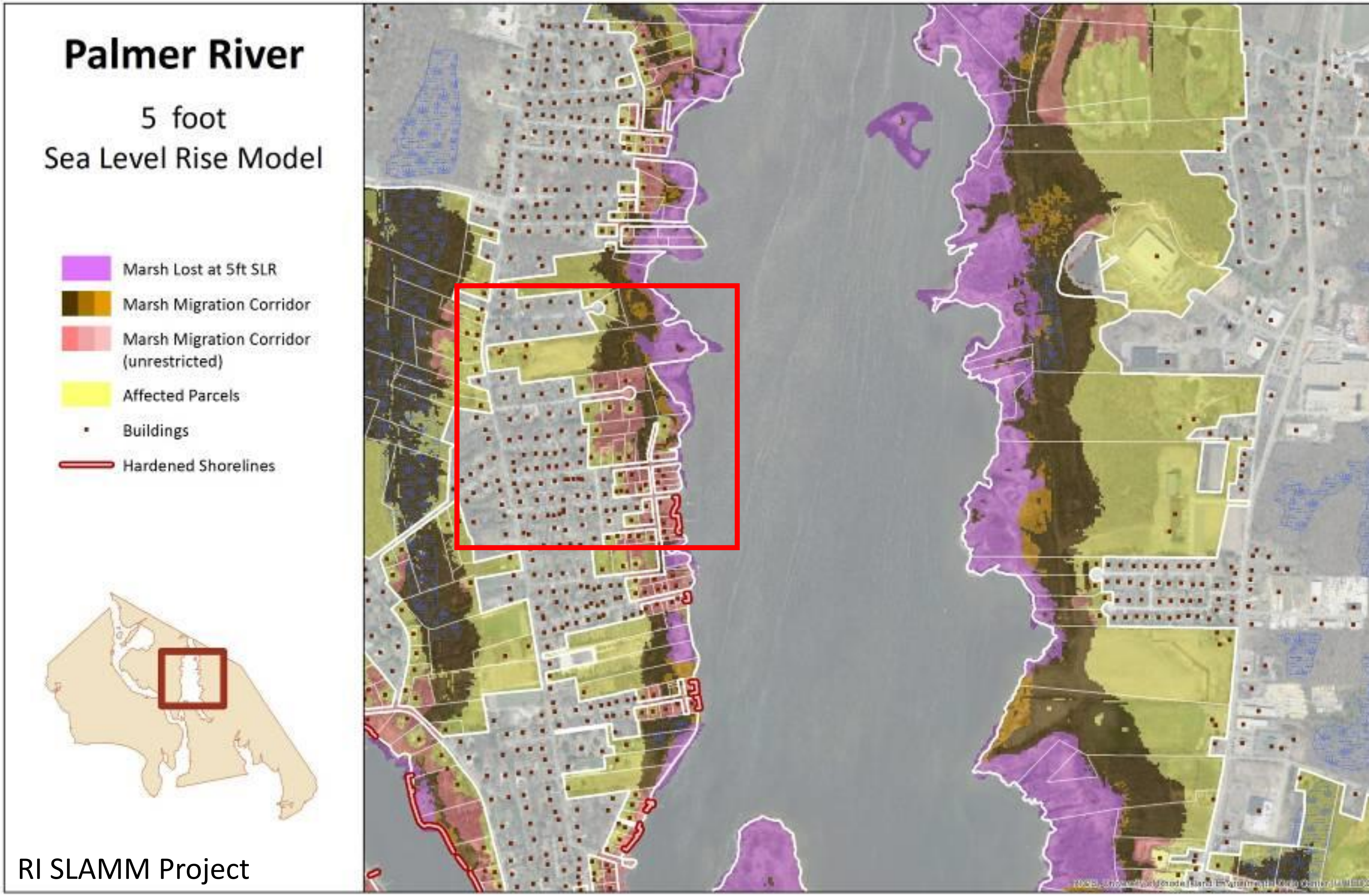
SLAMM Model Results



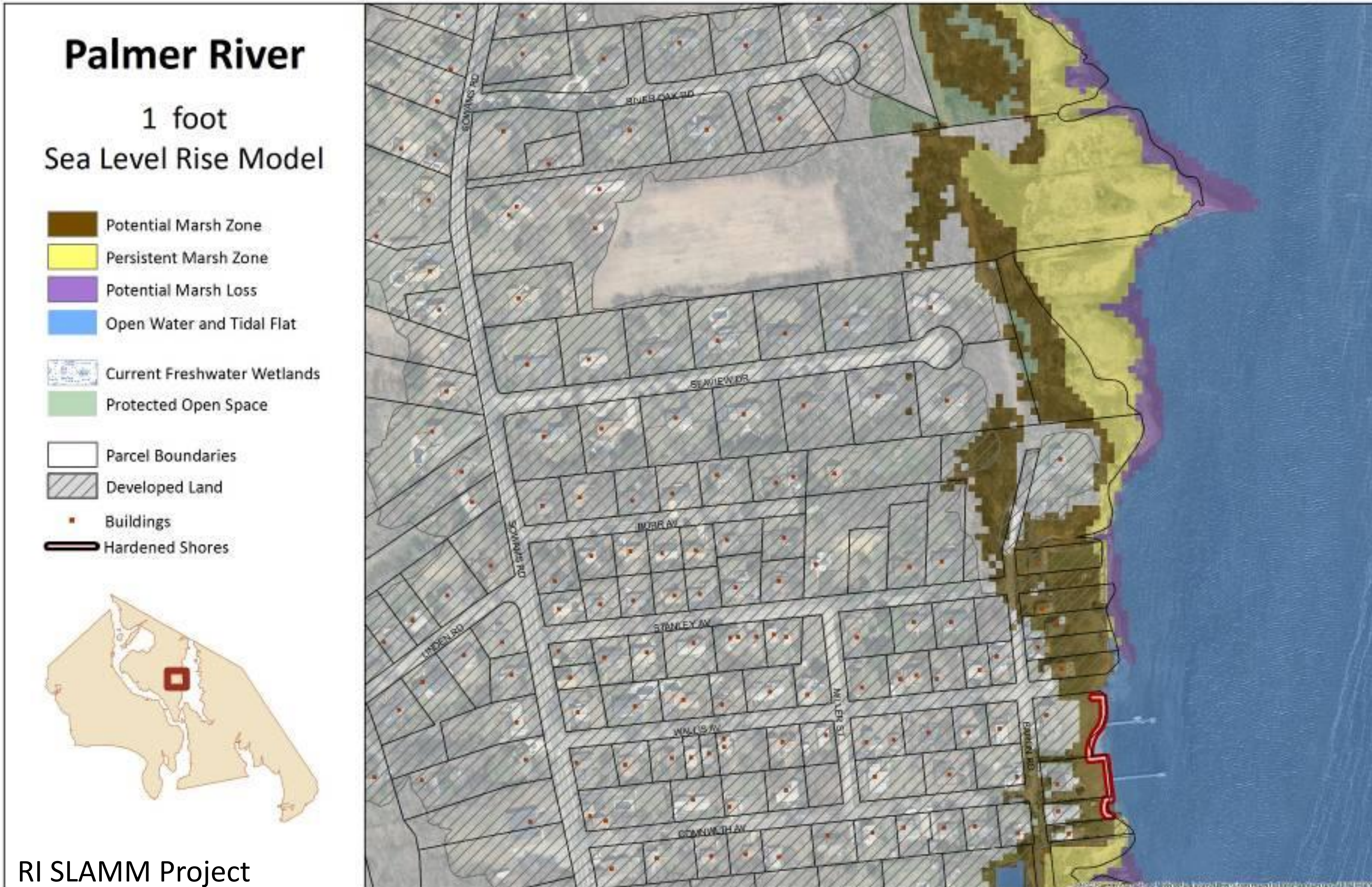
SLAMM Model Results



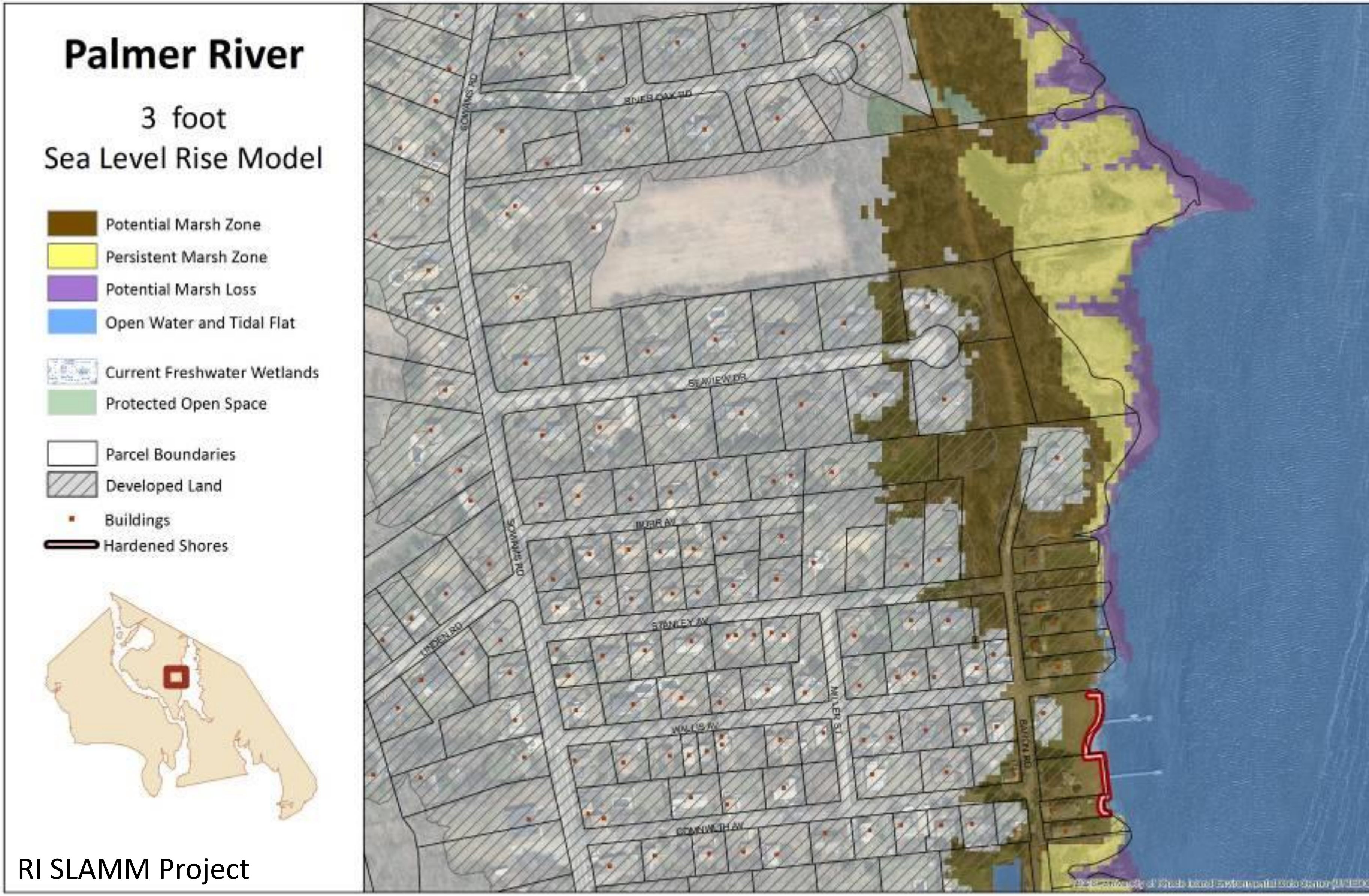
SLAMM Model Results



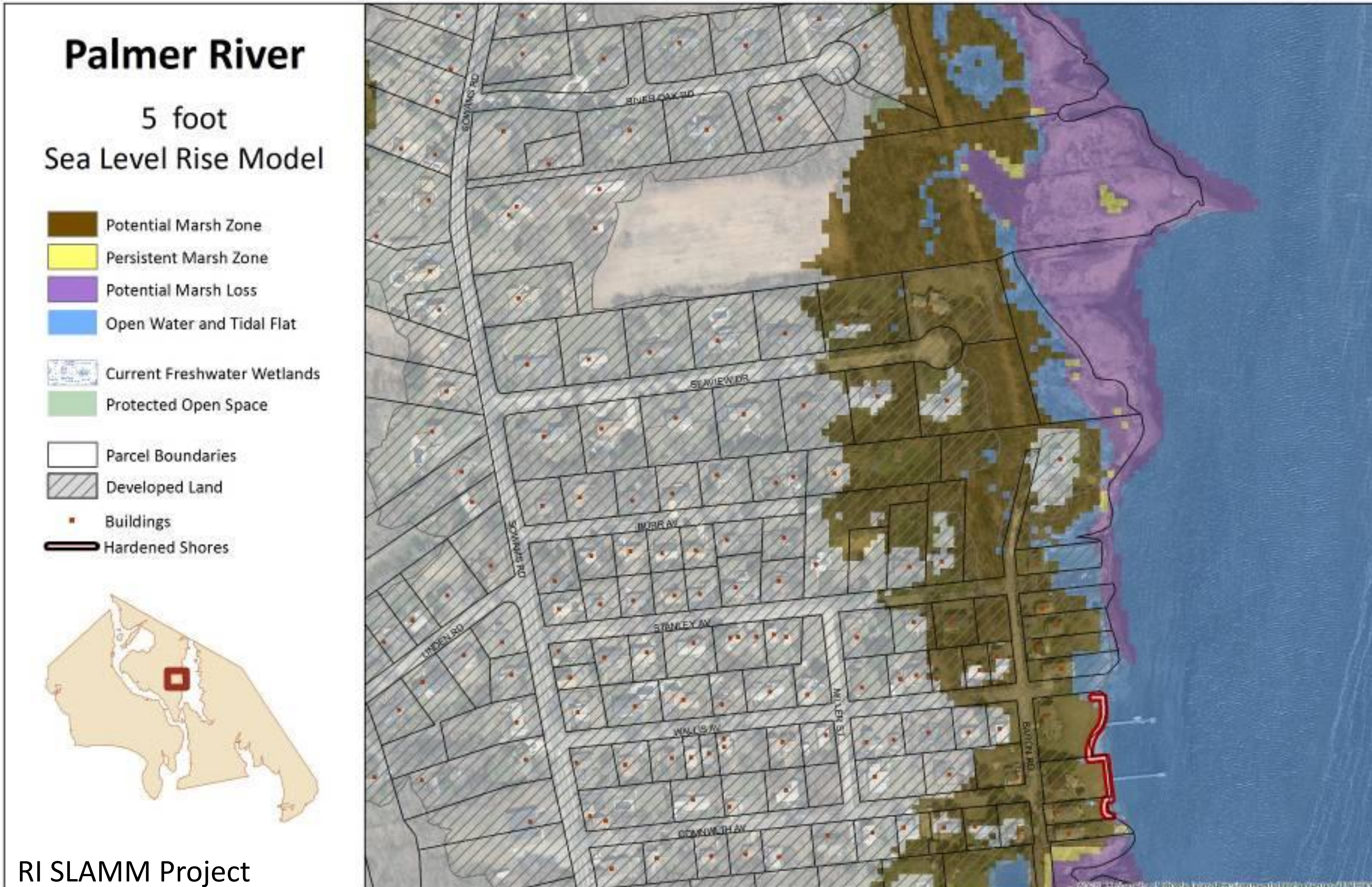
SLAMM Model Results



SLAMM Model Results



SLAMM Model Results



SLAMM Model Results

SLAMM Projected Statewide Salt Marsh Changes due to Sea Level Rise

50% of Current Salt Marshes

SLR	1 Ft.	3 Ft.	5 Ft.
Loss (Acres)	450	1895	3189
Gain (Acres)	1057	1148	2151
Net Change (Acres)	607	**-747**	**-1038**

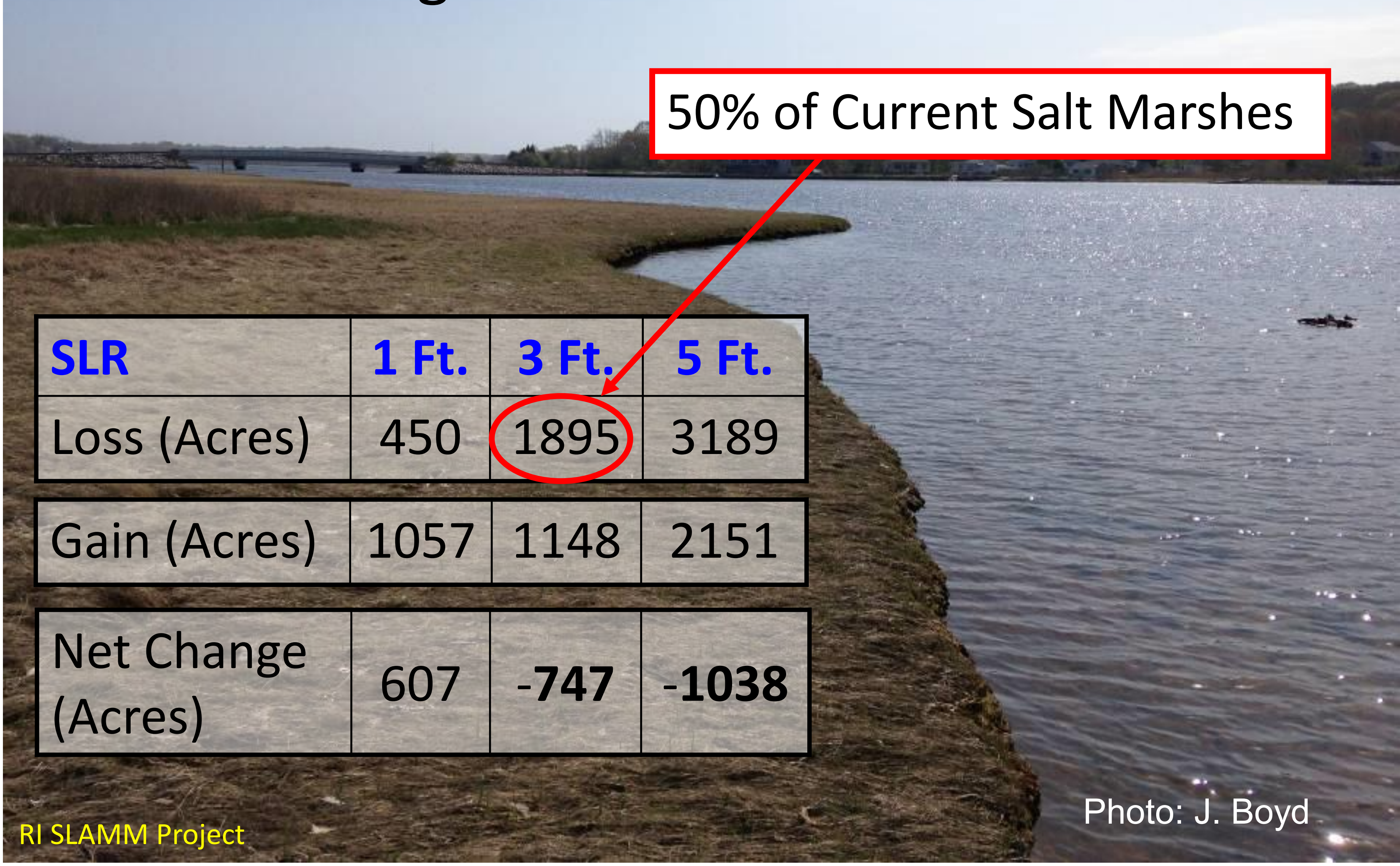


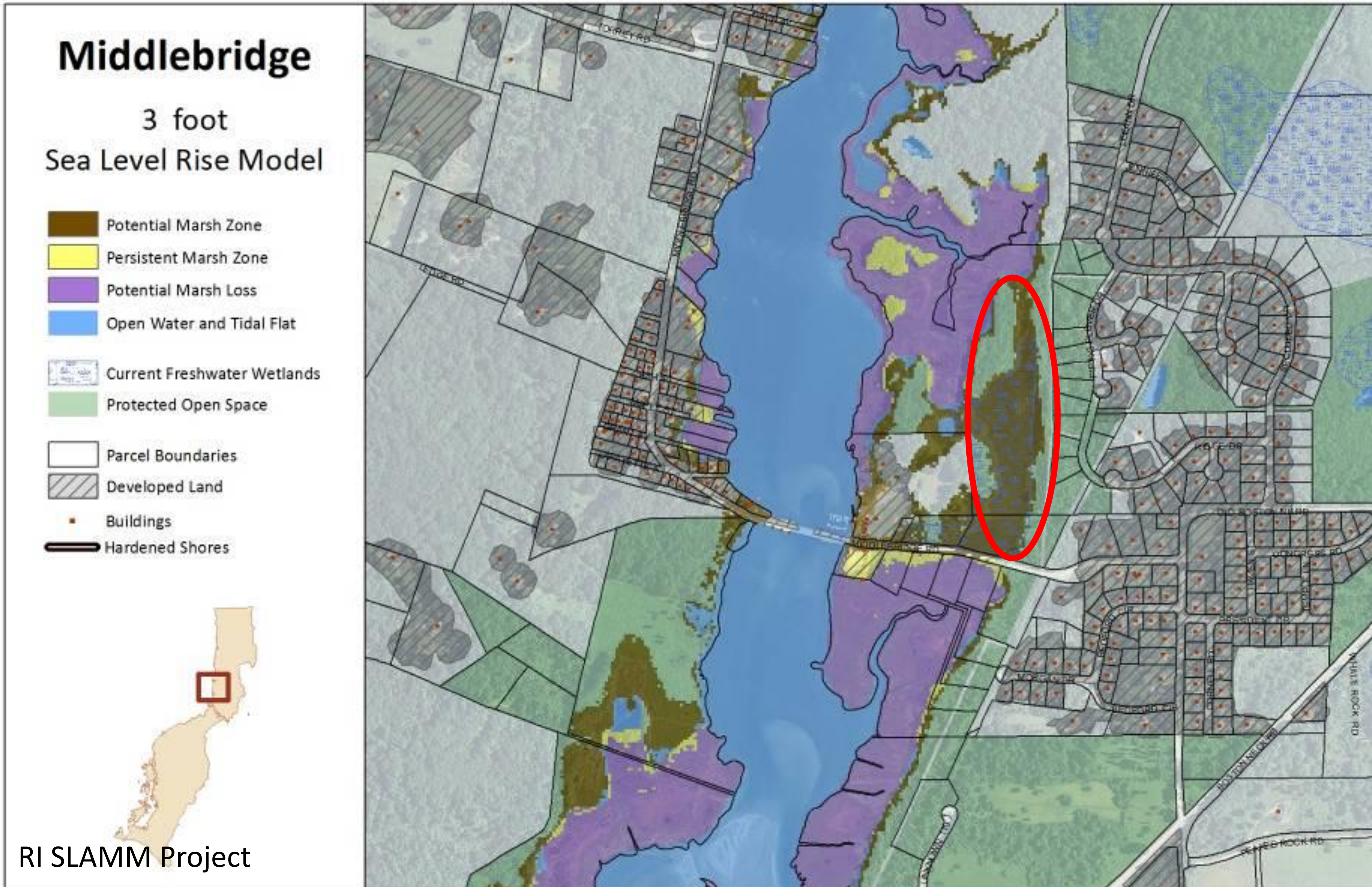
Photo: J. Boyd

RI SLAMM Project

Statistics for Coastal Wetland Loss with 5 feet Sea Level Rise

Town	Coastal Wetland Loss (acres)
Barrington	330.5
Bristol	99.2
Charlestown	321.9
Cranston	2.3
East Greenwich	0.4
East Providence	71.1
Jamestown	116.0
Little Compton	96.5
Middletown	42.6
Narragansett	354.0
New Shoreham	61.4
Newport	19.1
North Kingstown	148.6
Pawtucket	0.1
Portsmouth	357.6
Providence	3.1
South Kingstown	275.9
Tiverton	273.9
Warren	242.4
Warwick	195.9
Westerly	246.3
TOTAL	**3,258.8**

Freshwater (palustrine) wetland losses due to SLR

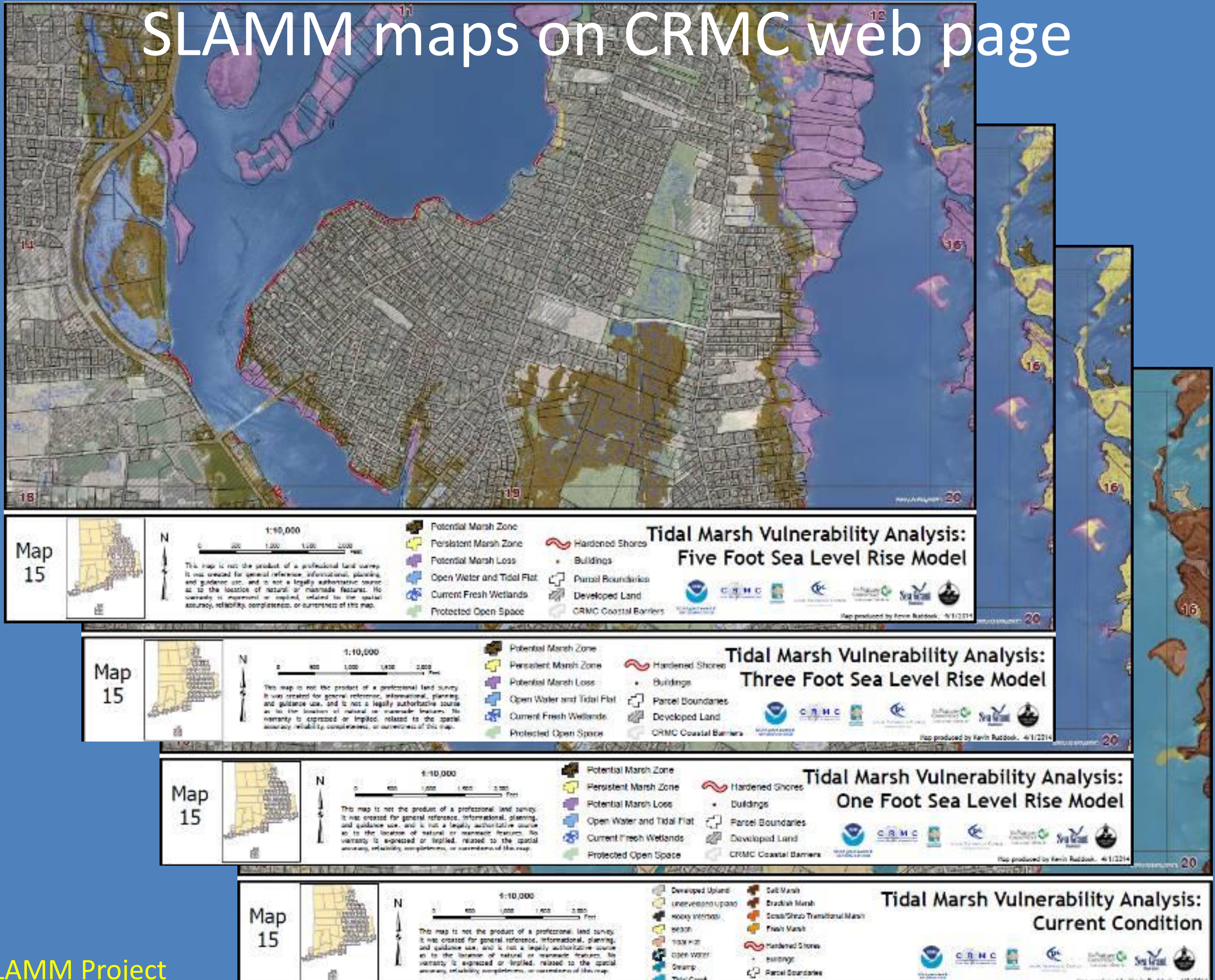


Town	1ft SLR	3ft SLR	5ft SLR
Barrington	32.9		
Bristol	5.9		
Charlestown	7.0		
Cranston			
East Providence	2.8		
Jamestown	5.6		
Little Compton	12.1		
Middletown	9.0		
Narragansett	5.2		
New Shoreham	26.3		
Newport	5.0		
North Kingstown	9.6		
Portsmouth	7.7		
South Kingstown	9.2		
Tiverton	32.2		
Warren	13.3		
Warwick	4.3		
Westerly	15.6		
Total	**203.8**		

Rhode Island Freshwater Wetland Losses due to SLR

Narrow River Cattail Marsh
Photo: J. Boyd – 09/12/2014

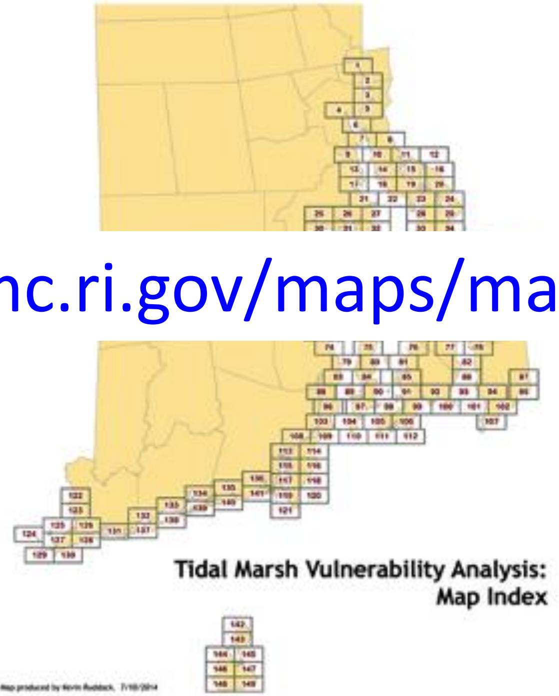
SLAMM maps on CRMC web page



RI SLAMM Project

Sea Level Affecting Marshes Model (SLAMM) Maps – DRAFT

The Rhode Island Coastal Resources Management Council (CRMC) and its partners have developed Sea Level Affecting Marshes Model (SLAMM) Maps for the coastal wetlands of all 21 Rhode Island coastal communities. The purpose of these SLAMM maps is to show how coastal wetlands will likely transition and migrate onto adjacent upland areas under projected sea level rise scenarios of 1, 3 and 5 feet in the coming decades. These maps are intended to support state and local community planning efforts and to help decision makers prepare for and adapt to future coastal wetland conditions despite the inherent uncertainties associated with future rates of sea level rise.



http://www.crmc.ri.gov/maps/maps_slamm.html

The SLAMM maps were developed using a digital wetlands coverage derived from the 2010 National Wetlands Inventory for Rhode Island. The elevation data used in the model was developed from the 2011 USGS LIDAR elevation dataset. These maps were developed using the "protection off" mode for the model simulations, thereby depicting the highest potential for marsh migration despite current limitations such as parking lots, roads or other development. In this way the maps illustrate opportunities for conservation and potential land modification to enhance wetland migration and restoration. The SLAMM data do not consider natural processes such as coastal erosion or the impacts of coastal storms that can have significant influence on shoreline location and sediment dynamics. In cases where coastal barriers are shown on maps, they will be cross-hatched and identified as "CRMC Coastal Barriers." Due to the model limitations with barrier erosion and sediment transport, there is higher uncertainty of coastal wetland migration accuracy abutting these barriers. Despite these limitations the data still provide a valuable tool to identify those places that provide the best opportunity for future saltmarsh habitat and conservation priorities, and provide valuable information to help plan for new development and infrastructure.

You can view a set of PDF maps for each coastal Town or City by clicking on one of the 21 coastal municipality PDF file links below.

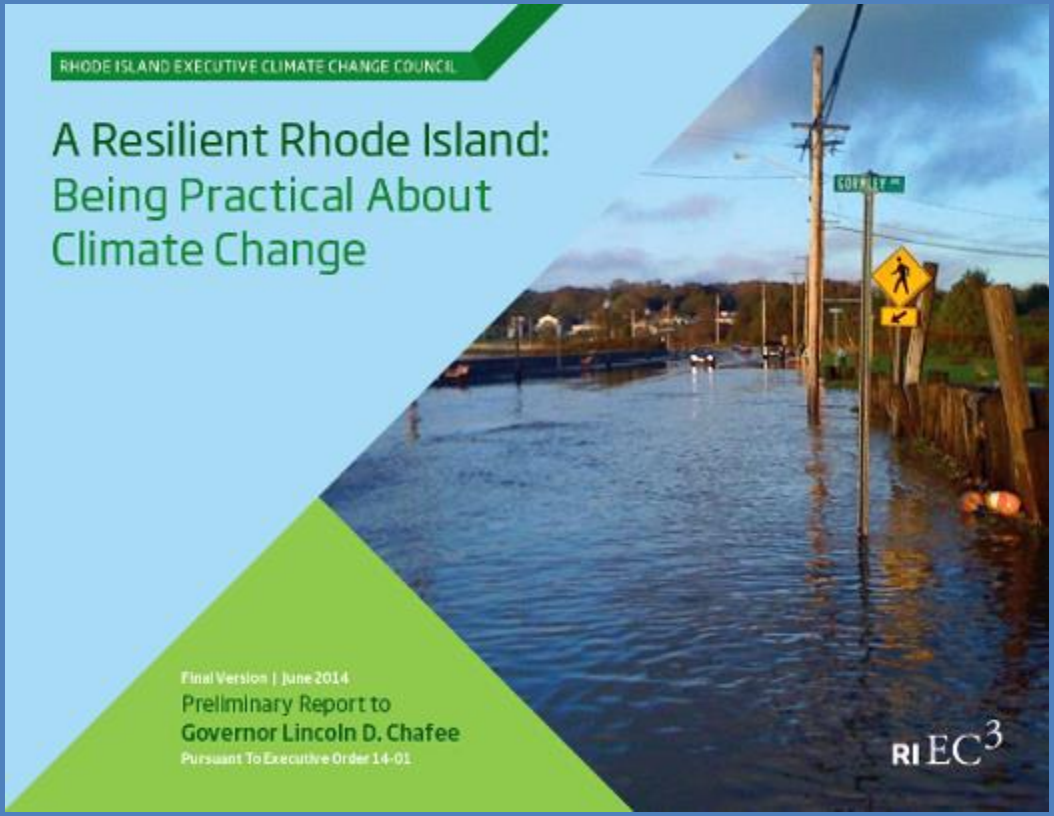
These SLAMM maps are Geographic Information System (GIS)-based map images exported as PDF files to reduce file size and ease of access. In total there are 149 map panels that cover the entire Rhode Island shoreline and each panel has four maps showing the initial (current) wetland condition followed by the 1, 3, and 5-feet of sea level rise scenarios.

No warranty is expressed or implied by the CRMC and its SLAMM project partners related to the spatial accuracy of these maps and promote no other use of these maps and data other than as a planning tool. These maps should not be used for, and are not intended for, survey and engineering purposes. The data do not take the place of a legal survey or other primary source documentation. They were created for general reference, informational, planning, and guidance use. They are not a legally authoritative source as to the exact location of natural or manmade features.

These maps may also be examined at the CRMC office in Wakefield.

Map Index		
Barrington	Jamestown	Portsmouth
New Shoreham (Block Island)	Little Compton	Providence
Bristol	Middletown	South Kingstown
Charlestown	Narragansett	Tiverton
Cranston	Newport	Warren
East Greenwich	North Kingstown	Warwick
East Providence	Pawtucket	Westerly

RI Executive Climate Change Coordinating Council



Action 6.5.3 - Adopt Sea Level Affecting Marshes Model (SLAMM) data and projections as planning and decision-making support tool in statewide coastal wetland monitoring, protection and restoration strategy

http://www.planning.ri.gov/statewideplanning/climate/index.php

Municipal SLAMM Training Workshops

Please join us for a workshop on…

Protecting Coastal Wetlands in Your Community in Consideration of Sea Level Rise

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Tuesday, October 28, 2014 **9:00 am to 12:00 pm** *RWU School of Law* *Bristol, RI*	*OR*	**Thursday, October 30, 2014** **9:00 am to 12:00 pm** *URI Coastal Institute* *Narragansett, RI*

~~~~~3 AICP credits offered~~~~~

Our coastal wetlands are some of the most productive ecosystems on Earth.They are extremely important for wildlife, contributing greatly to Rhode Island's valuable commercial and recreational fisheries, they purify water, and they help reduce storm damage to our valuable coastal areas by absorbing high wind and wave energy. Unfortunately, our coastal wetlands are very susceptible to impacts from climate change, particularly sea level rise. Projections show that RI could lose one-half of its existing coastal wetlands with 3 feet of sea level rise.

Please join us to learn about the results of a project investigating the potential impacts to our coastal wetlands resulting from climate change-induced sea level rise and the landward migration possibilities of these wetlands in RI's coastal communities. Hear from experts about **how to access and use new maps** showing upland areas in your community that may provide the best opportunity for wetland migration and **how to incorporate the new information and tools into your community's plans and initiatives** while **aligning them with state efforts.** Also learn about **specific adaptation strategies** that can be used to help protect and restore our coastal wetlands into the future.

This workshop is free of charge. A light breakfast will be provided from 8:30-9:00 am. **Please register here to attend** (or copy and paste https://www.surveymonkey.com/s/PKDQPLN into your browser). Please register by Tuesday, October 21.

Questions? Please contact Jennifer West at jennifer@nbnerr.org or 401-222-4700, x 7413.

~~~~~~~~~Please spread the word!~~~~~~~~~

RI SLAMM Project
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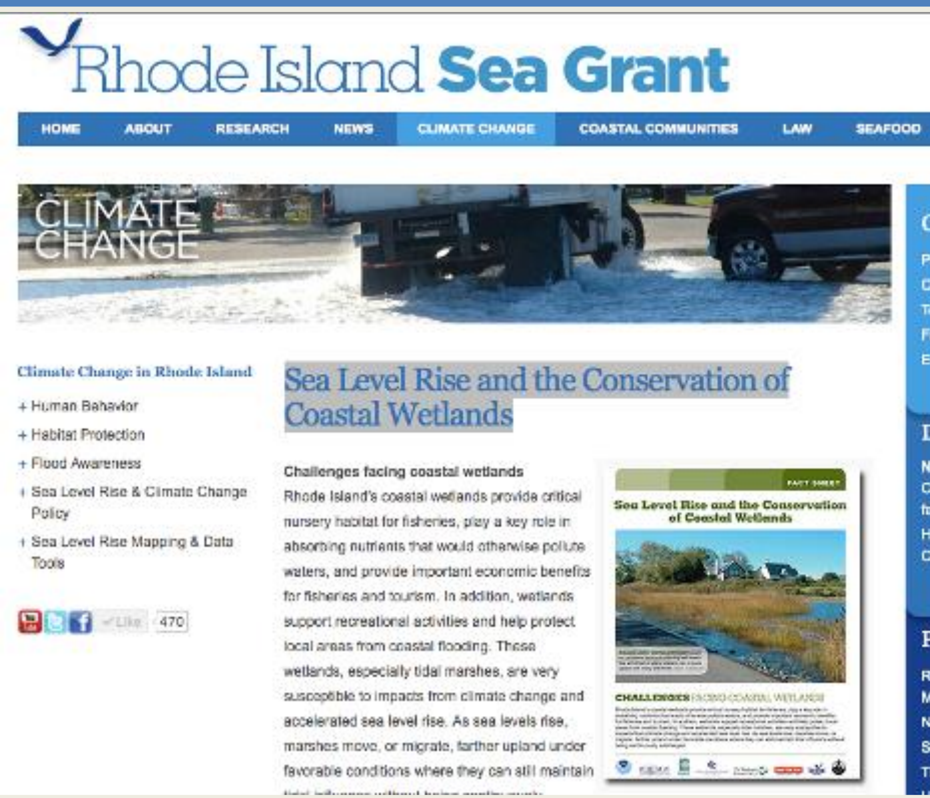
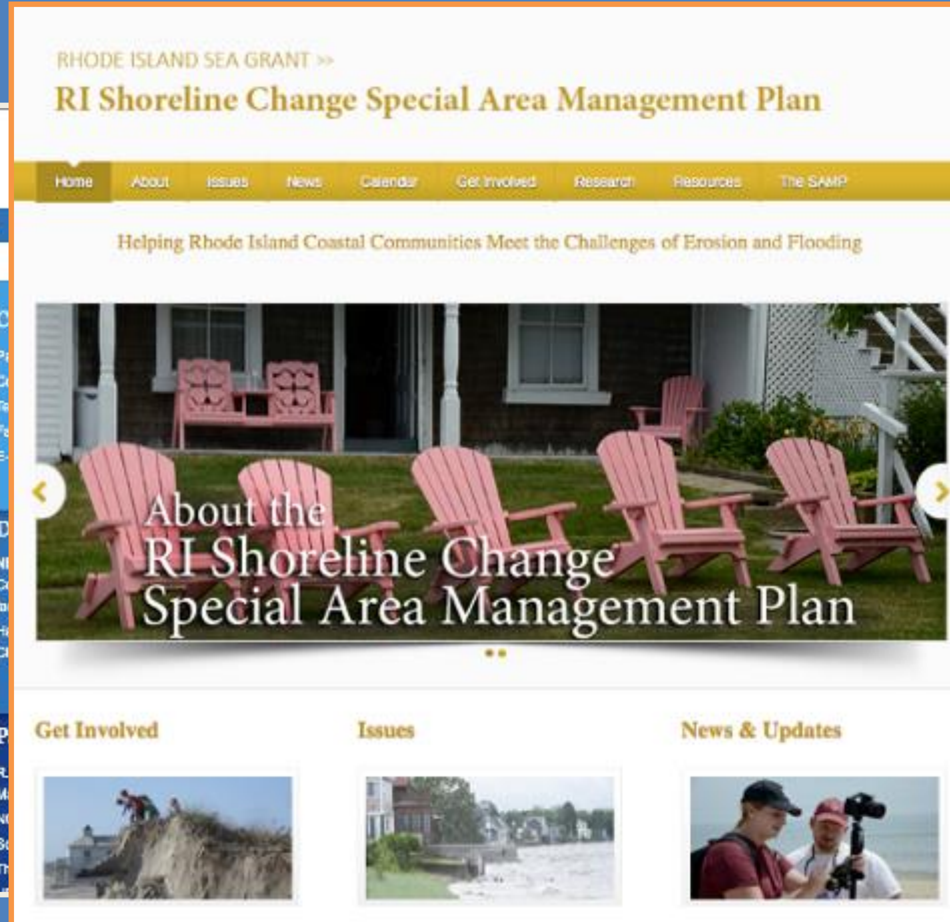
SLAMM Project is part of the Shoreline Change (Beach) SAMP





http://seagrant.gso.uri.edu/climate/habitat.html

www.beachsamp.org

A Very Big Thank You to NOAA for Funding the RI SLAMM Project with a Coastal and Ocean Climate Applications Grant!

Photo: R. Hancock

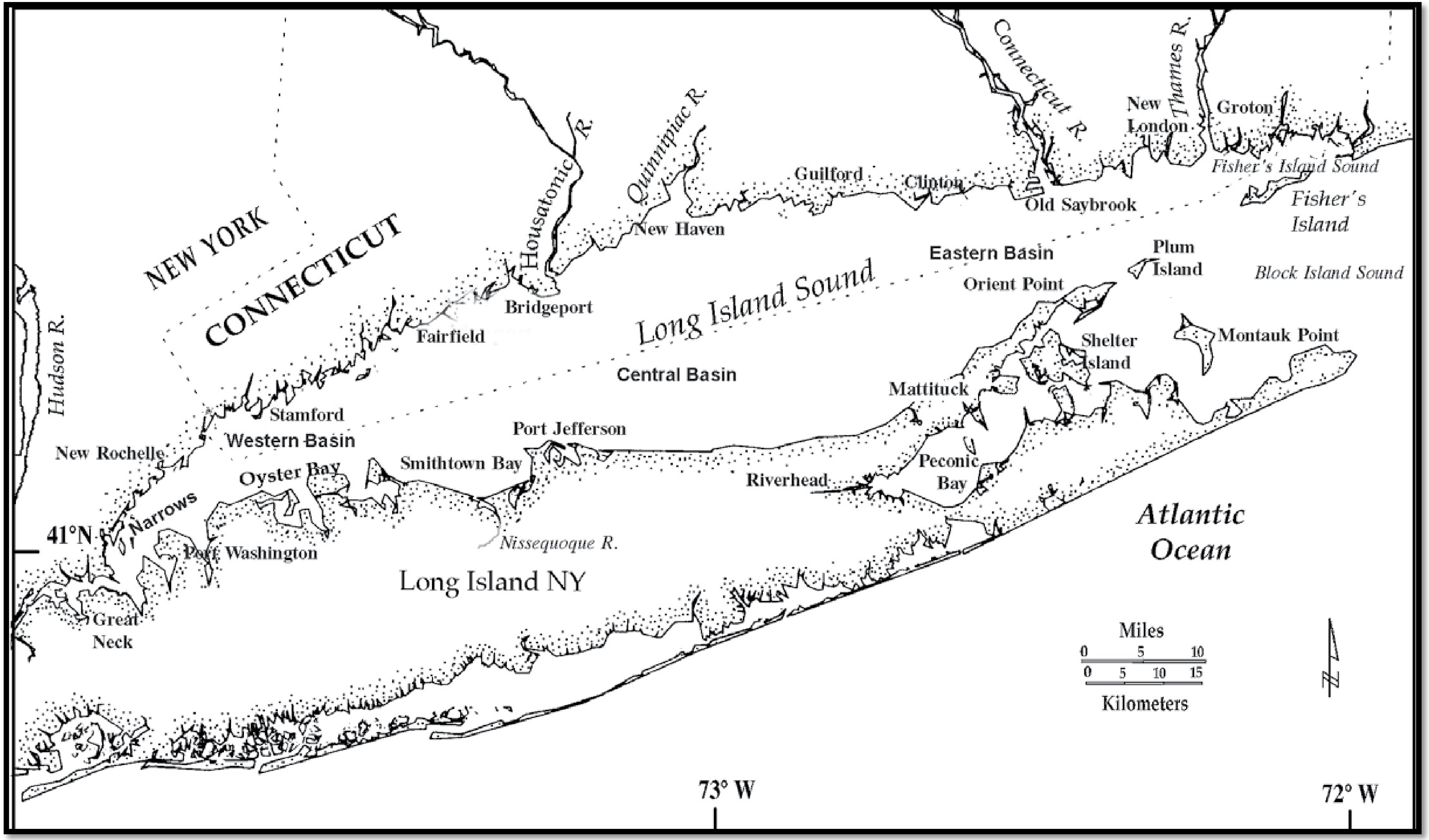
NOAA — CRMC Coastal Resources Management Council — Narragansett Bay Research Reserve — Coastal Resources Center, University of Rhode Island — The Nature Conservancy — SAVE THE BAY. Narragansett Bay — Sea Grant Rhode Island — Marine Affairs Institute

Marsh Migration Modeling in Long Island Sound

David Kozak <david.Kozak@ct.gov>, CT DEEP-Office of Long Island Sound Program
Kevin O'Brien <kevin.Obrien@ct.gov>, CT DEEP- Office of Long Island Sound Program

Saltmarsh sparrows waits as Black grass invades forest understory, photos by Scott Warren and Paul Fusco

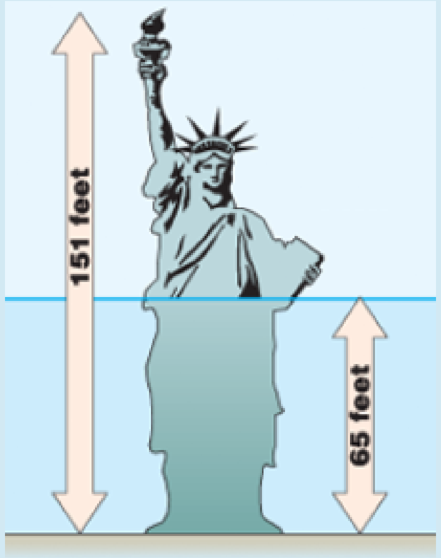
Long Island Sound – America's Urban Sea



Long Island Sound – By the Numbers

Area of the Long Island Sound	1,320 square miles
Area of the drainage basin or watershed	16,820 square miles
Average Depth	63 feet (60-120 feet)
Water Volume	18 trillion gallons
Length of Coastline	600 miles
Salinity range at the western end	23 parts per thousand
Salinity range at the eastern end	35 parts per thousand
% of fresh water that comes from three major rivers	90%
Avg. winter and summer water temperatures (2011)	37°F winter/69°F summer
No. of tides each day (greatest tides in the west)	4 tides (2 high, 2 low)
Population living within 50 miles	more than 23 million people
Estimated value to the local economy per year	$8.91 billion (2011 dollars)
No. of finfish species found in the Sound	More than 120 finfish species
No. of tropical species that stray here seasonally	21 tropical species
No. of species that spawn in the Sound	at least 50 species

Sound Facts

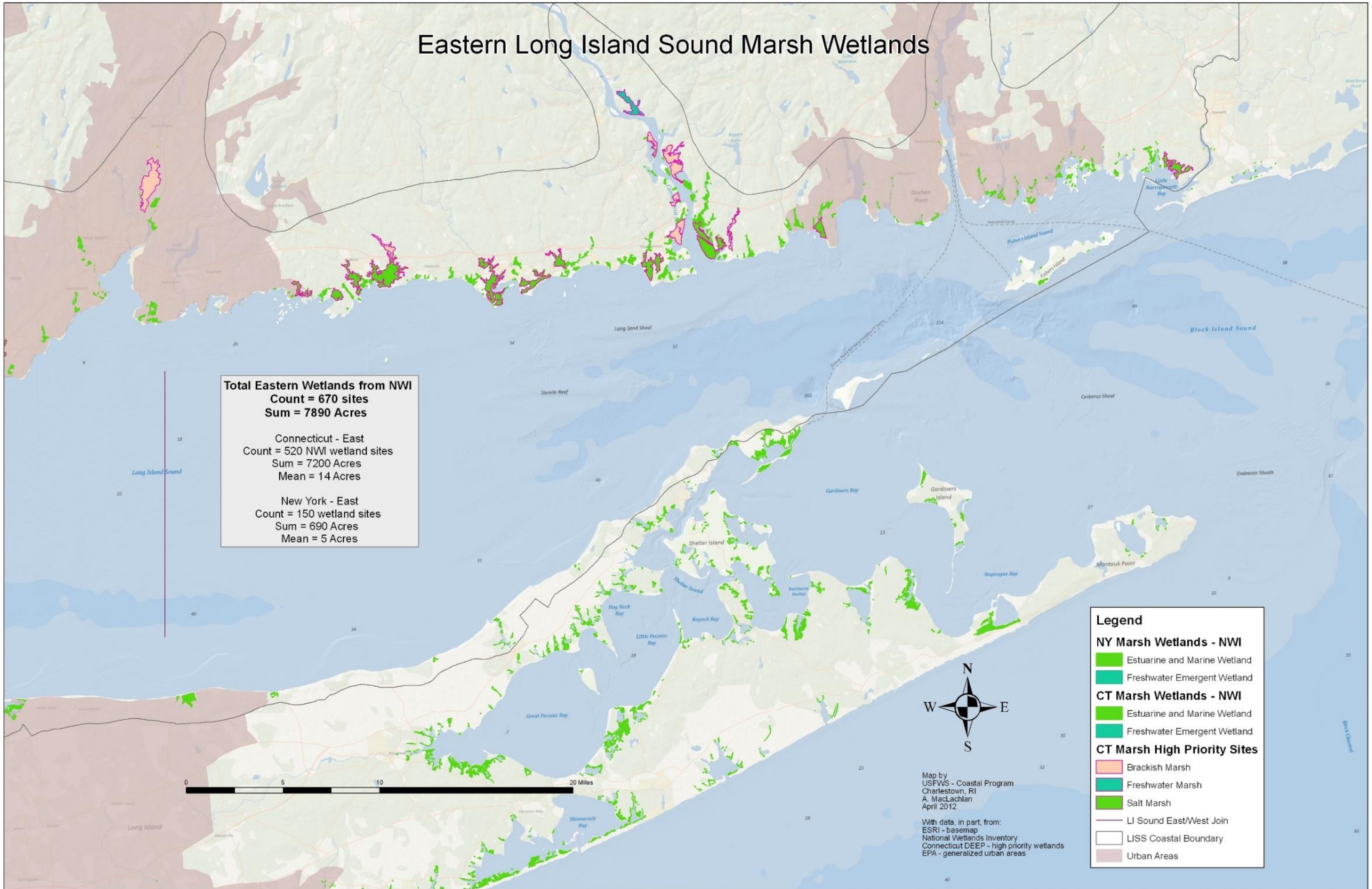


It's long, narrow and shallow

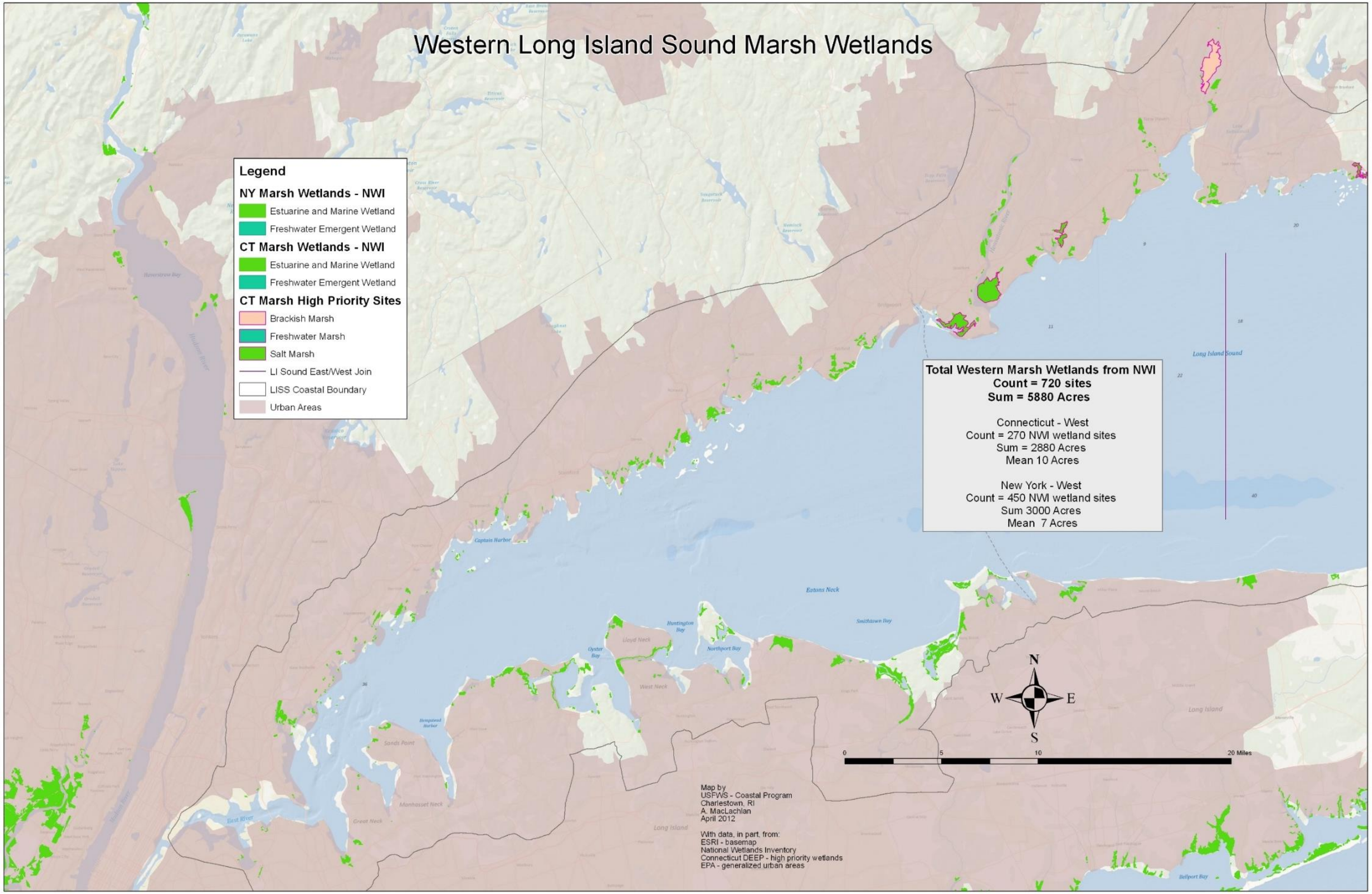
Long Island Sound is an estuary, a place where fresh and salt water mix. It gets salt water from the Atlantic Ocean and 90% of its freshwater from three major rivers: the Thames, the Housatonic and the Connecticut.

Learn more about this fact →

Long Island Sound (LIS) Tidal Marshes-East



Long Island Sound (LIS) Tidal Marshes-West



Modeling Approach

- SLR Affecting Marsh Migration (SLAMM) with uncertainty analysis*

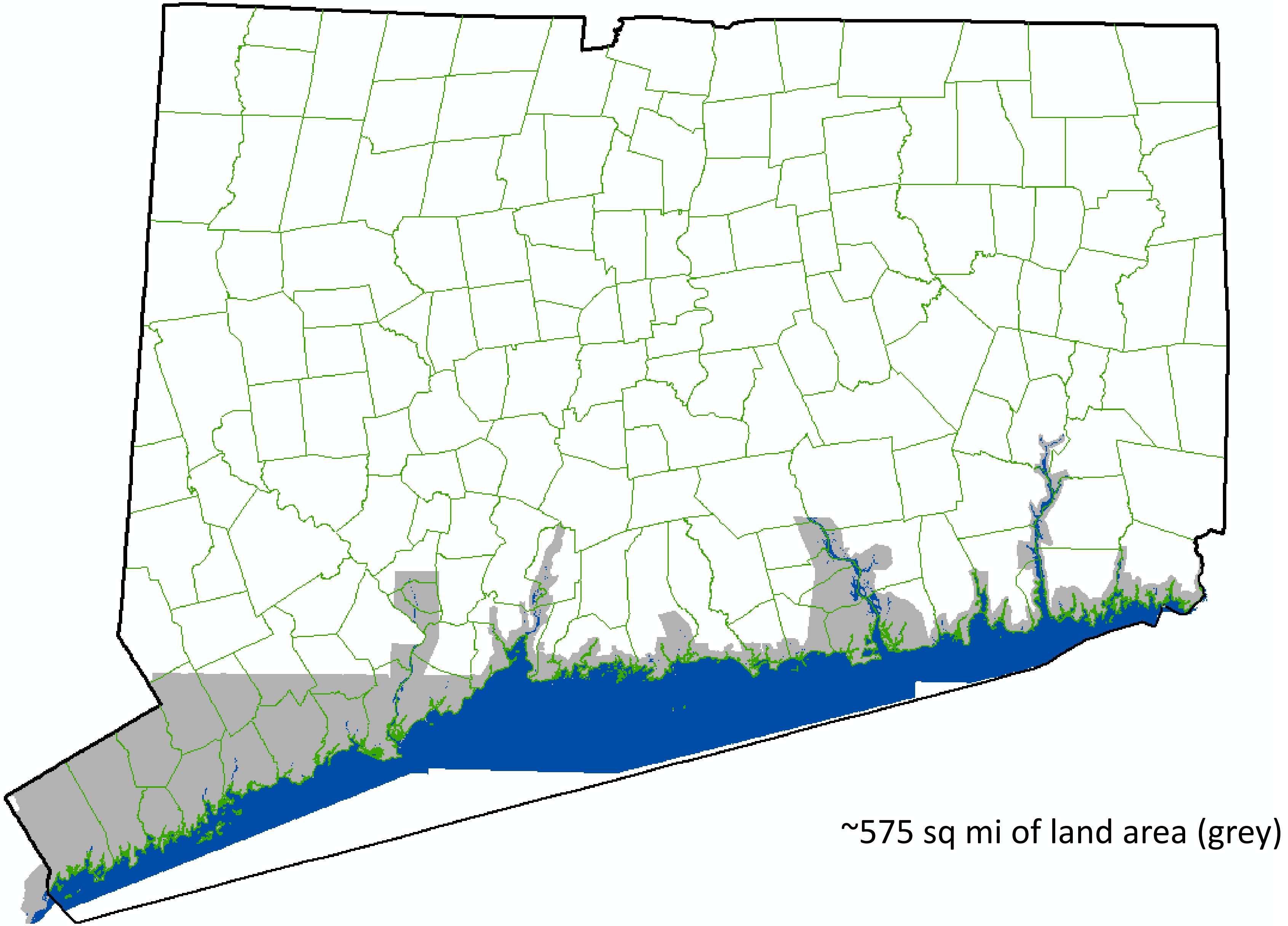
- Study period: 4 time-steps 2010 → 2100

- SLR scenarios: 0.4 ft → 5.6 ft
  (2025) → (2100)

- Area of study: Area up to +5 meters (MSL)

* Version 6.2, by Warren Pinnacle Consulting. Funding by EPA LIS Study, NOAA-OCRM. Cost: ~$ 109K (CT) + ~ $ 14K (NY's Westchester Cty.) = $123K

CT's SLAMM Study Area: + 5 meters (MSL)



Sea-Level-Rise Scenarios

SLR scenarios relative to the base year of (2002) in meters / **feet**

Scenario	2025	2055	2085	2100
General Climate Model Maximum	.13 / **.4**	.31 / **1.0**	.58 / **1.9**	.72 / **2.4**
1 m by 2100	.13 / **.4**	.43 / **1.4**	.81 / **2.7**	1.0 / **3.3**
Rapid Ice Melt Minimum	.13 / **.4**	.48 / **1.6**	1.0 / **3.3**	1.3 / **4.3**
Rapid Ice Melt Maximum	.25 / **.8**	.74 / **2.4**	1.40 / **4.6**	1.72 / **5.6**

North Shore LIS SLAMM Results CT + Westchester, NY

Modeled land cover change 2010 - 2100

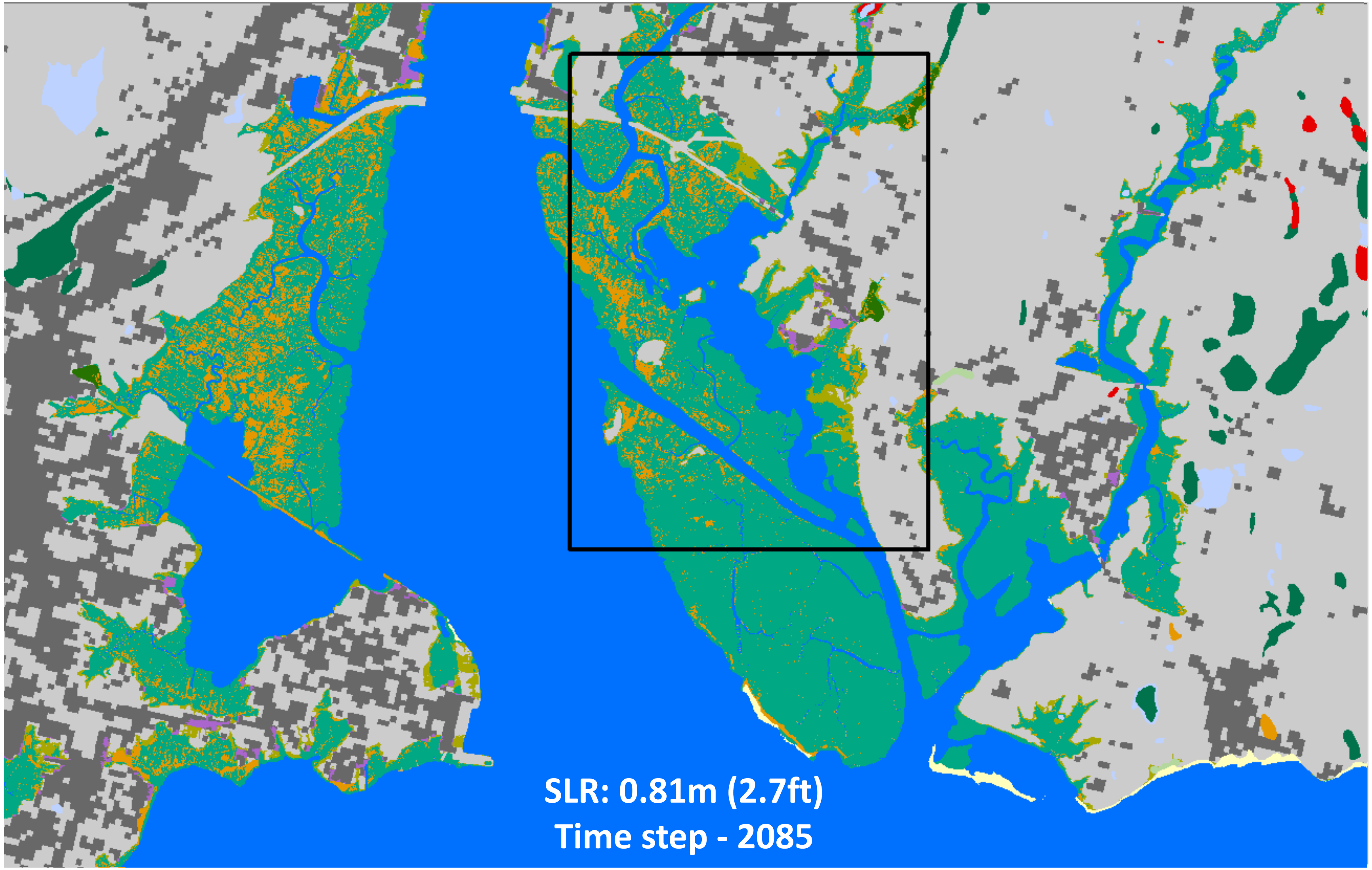
Land cover category	Acres in 2010	Percent land cover change from 2010 to 2100				CT Acres in 2100 (1m)	Westchester 2100 (1m)	Acres No. Shore LIS 2100 (1m)
		GCM Max	1m	RIM Min	RIM Max*			
Undeveloped Dry Land	195,337	-1.5	-2.3	-3.3	-4.2			
Estuarine Open Water	119,861	1.2	1.7	3.3	6.9			
Developed Dry Land	88,153	-2.6	-4.6	-7.0	-9.5			
Irreg.-Flooded Marsh	10,306	-50.0	-87.7	-95.1	-97.4	1,268	57	**1,325**
Swamp	8,531	-2.6	-4.3	-6.1	-8.4			
Inland Open Water	4,523	-2.3	-3.1	-3.9	-4.5			
Estuarine Beach	2,406	-23.8	-34.4	-47.2	-57.0			
Regularly-Flooded Marsh	2,114	363.3	592.7	533.3	462.5	14,643	200	**14,843**
Transitional Salt Marsh	1,472	40.7	57.0	66.0	57.3	2,311	102	**2,413**
Inland-Fresh Marsh	819	-14.0	-21.4	-26.2	-28.8			
Tidal-Fresh Marsh	710	-8.8	-27.6	-62.8	-85.6			
Tidal Swamp	629	-43.8	-61.0	-72.7	-80.6			
Riverine Tidal	387	-83.3	-85.6	-87.7	-89.5			
Flooded Developed Dry Land	351	642.7	1148.8	1749.3	2390.2			
Tidal Flat	159	40.7	395.8	2037.9	2114.8			
Inland Shore	120	0.0	0.0	0.0	0.0			
Rocky Intertidal	58	-19.6	-27.2	-39.5	-51.1			
Σ	**14,115** [1]					**18,222**	**359**	**18,581**
Σ* (RIM Max.)	**14,115** [1]					**12,361**	**603**	**12,964**

1. Includes 223 acres in Westchester

Sample Model Output Data- CT River Estuary

Land Cover Classes:

- Developed Dry Land
- Undeveloped Dry Land
- Swamp
- Inland Fresh Marsh
- Tidal Fresh Marsh
- Transitional Salt Marsh
- Regularly-flooded Marsh
- Estuarine Beach
- Tidal Flat
- Rocky Intertidal
- Inland Open Water
- Riverine Tidal
- Estuarine Open Water
- Irregularly-flooded Marsh
- Inland Shore
- Tidal Swamp
- Flooded Developed Dry Land



Sample Model Output Data- CT River Estuary

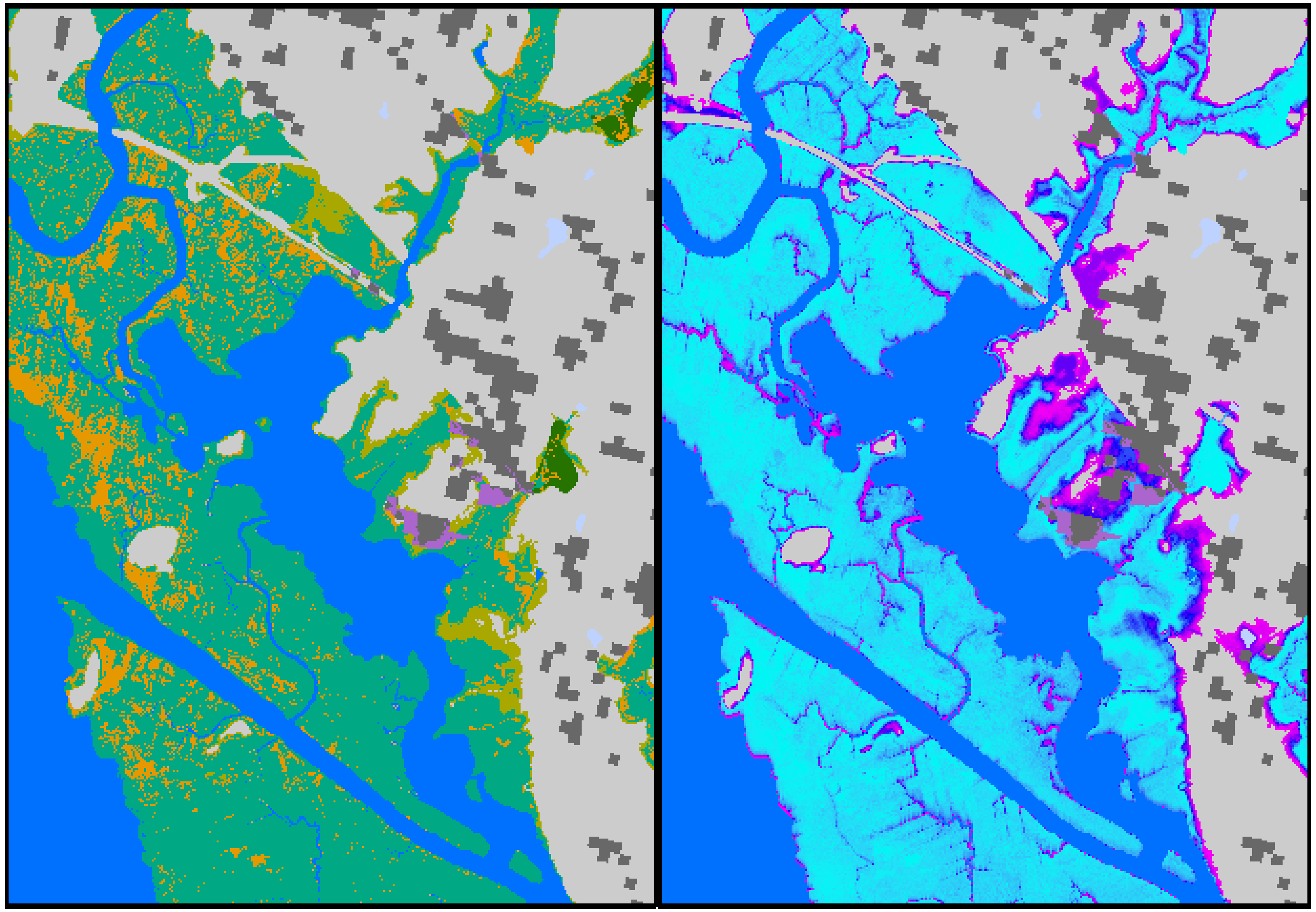
Uncertainty Range:

High : 100

Low : 0

Land Cover Classes:

- Developed Dry Land
- Undeveloped Dry Land
- Swamp
- Inland Fresh Marsh
- Tidal Fresh Marsh
- Transitional Salt Marsh
- Regularly-flooded Marsh
- Estuarine Beach
- Tidal Flat
- Rocky Intertidal
- Inland Open Water
- Riverine Tidal
- Estuarine Open Water
- Irregularly-flooded Marsh
- Inland Shore
- Tidal Swamp
- Flooded Developed Dry Land



SLR: 0.81m (2.7ft)

Time Step - 2085

Rates of Saltmarsh Migration ?

Modeling Limitations/Considerations

- LiDAR error/accuracy (what is acceptable std. dev. with actual bare earth elevation?)
- Limited IFM accretion (SET) data spanning entire elevation range
- NWI → SLAMM wetland/land cover codes
- Not all model data sets (e.g. impervious cover) had the same 5m LiDAR resolution
- Variation in state wetland and SLAMM nomenclature /classification (e.g., tidal swamp)
- Insufficient SET data low in the tidal frame (RFMs)

Modeling Limitations/Considerations (cont.)

- Hydraulic connectivity may not be corrected through hydro-modifications
- Not a hydrodynamic model (accurate river/embayment predictions?)
- Incomplete accretion rates for RFMs using MEM

Key MEM data deficiencies:

- *Suspended sediment concentration*
- *Standing biomass density*
- *Organic matter decay rates*
- *Below ground biomass contribution parameters*
- *Sediment settling velocities*
- *Partition between organic and non-organic accretion components*

LIS SLAMM II?

What Would We Do Differently?

- Re-evaluate how SLAMM **converts dry land to saltmarsh** based on results of forthcoming research by Anisfeld, et al.
- Assemble **more robust data for RFM** accretion
- Re-examine **MEM model assumptions** and input values
- More **detailed short term modeling** (2020-2025?) with field monitoring to test accuracy of predictions (or hind-casting?)

Don’t Get Caught with Your Back to a Rising Tide

Use SLAMM!