Beneficially Using Dredged Sediment to Enhance Marshes, Build Resiliency and Restore Habitats in New Jersey's Back Bays

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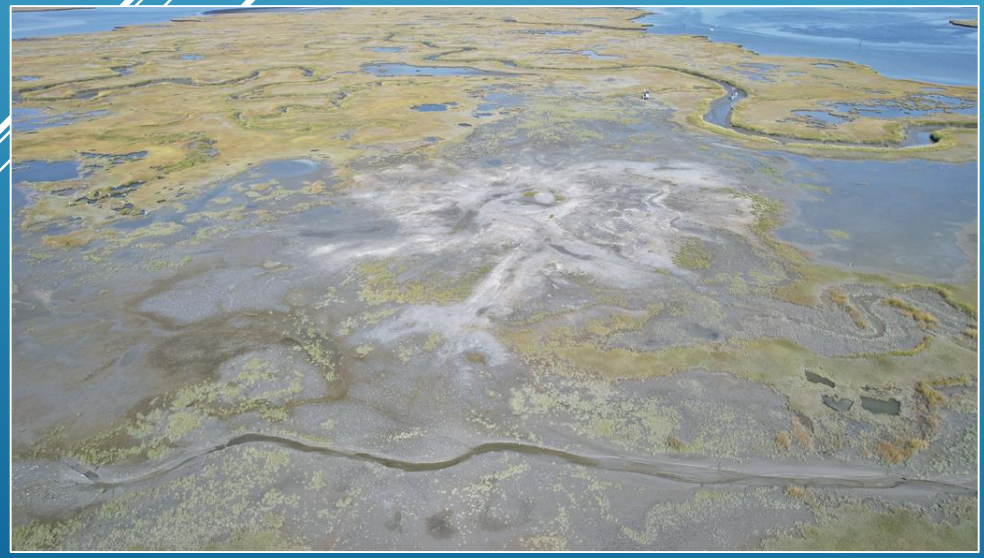
Lisa Ferguson, Sam Collins, The Wetlands Institute
Christina Davis, NJ Fish and Wildlife



- A Proving Ground Using Natural and Nature-Based Features to Provide Ecological Uplift and Enhanced Resilience for Ecosystems and Coastal Communities
- A Test Bed to Advance and Improve Dredging Techniques and Marsh Restoration and Coastal Feature Creation Techniques in Coastal New Jersey
- Using a Landscape Approach and Adaptive Management to Move From Pilot Projects to Ecosystem Solutions
- Based on an International Concept Pioneered by the Dutch
- 24 sq mi Back Bay Marsh Dominated System with Shallow Bays, Sounds and Tidal Inlets Bisected by the NJ Intracoastal Waterway
- 50+ Member Working Group for Knowledge Sharing
- More than 30 Scientists Working in SMIIL

SEVEN MILE ISLAND INNOVATION LABORATORY

US Army Corps of Engineers®

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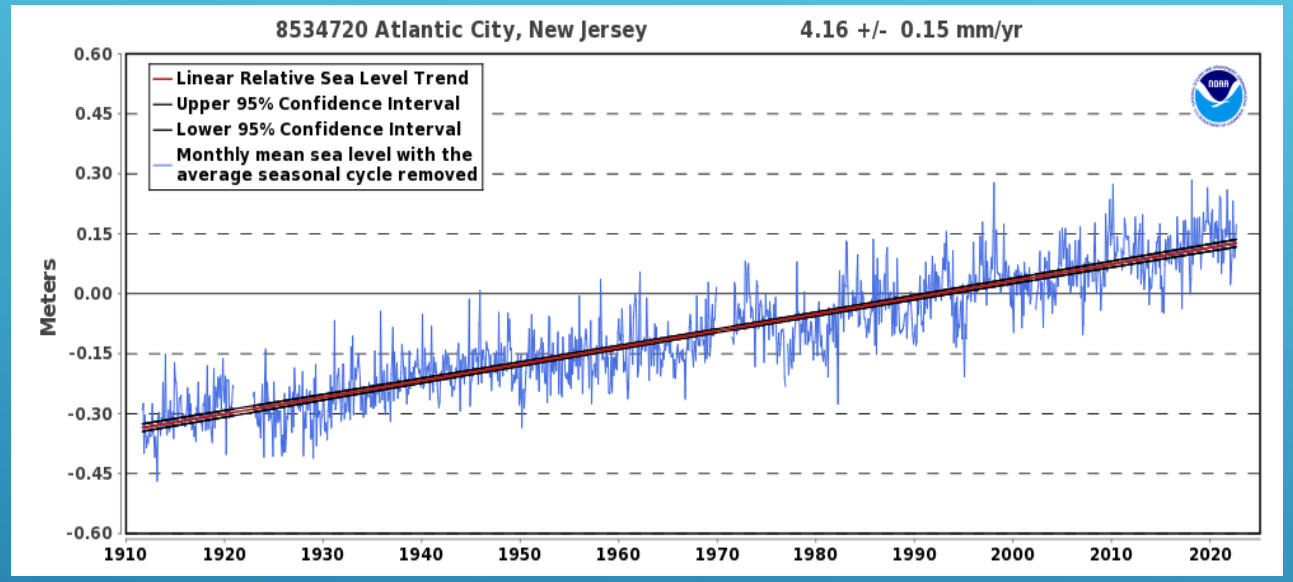
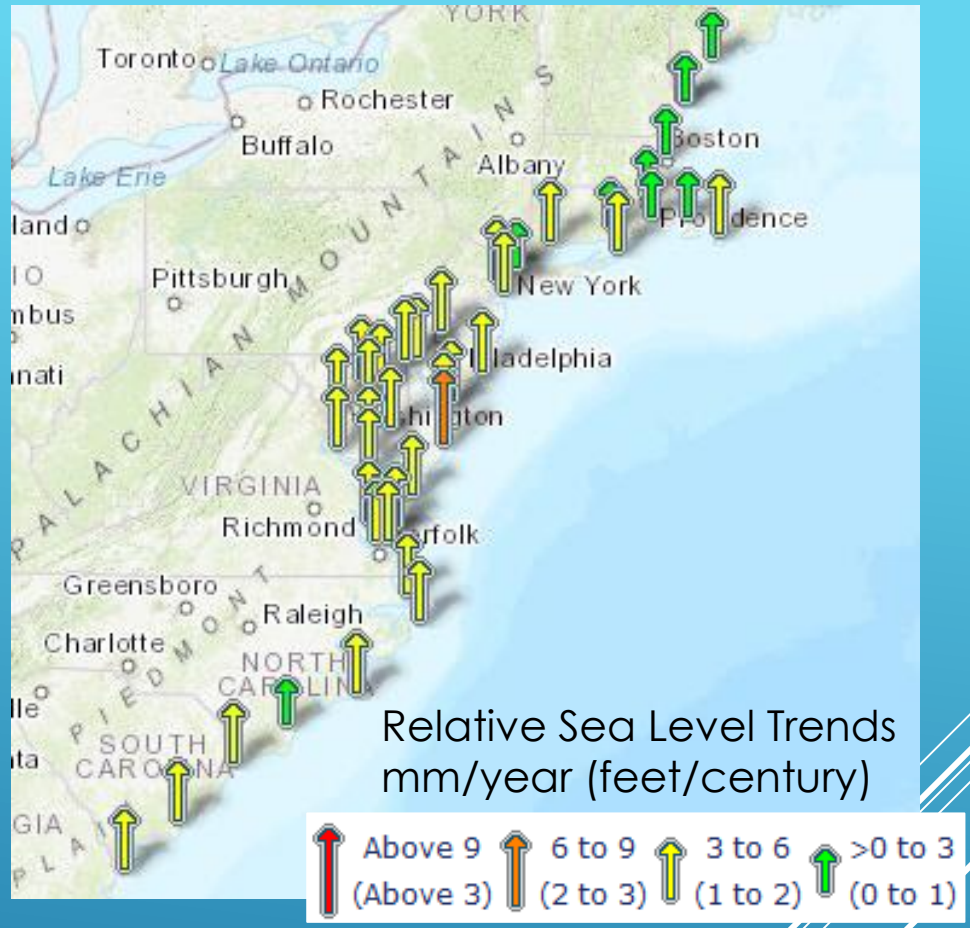
New Jersey Department of Environmental Protection

NJ New Jersey Fish and Wildlife

RELATIVE SEA LEVEL TREND





- New Jersey SLR is 2x Global Average
- 1911 – 2021 rose 1.36 feet in 100 years
- Rate has increased from 2010 of 4.04 mm/year to 4.16
- Rate is >6 mm/year from 2008 - 2023

- Has risen 4" since 2000
- Typical marsh accretion rates in the area can be 4 mm/year; SMIIL marshes confirm 4.13 mm/yr
- Regional subsidence rates are ~2 mm/year

https://tidesandcurrents.noaa.gov/sltrends/sltrends.html

EVIDENCE OF MARSH DROWNING

- Marsh conversion to mudflat
- Swiss cheese marshes and expanding pool margins

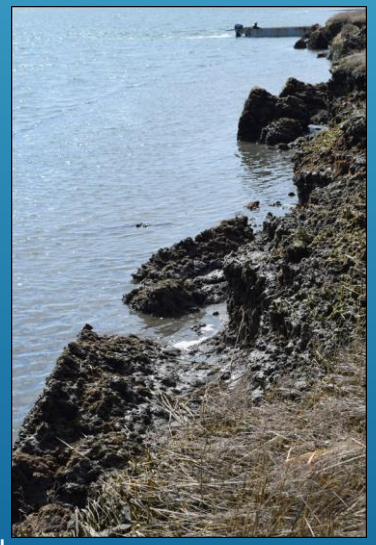
MARSH EDGE EROSION CONTRIBUTION TO WETLAND LOSS

Along open fetch areas from storms

Boat wake induced erosion

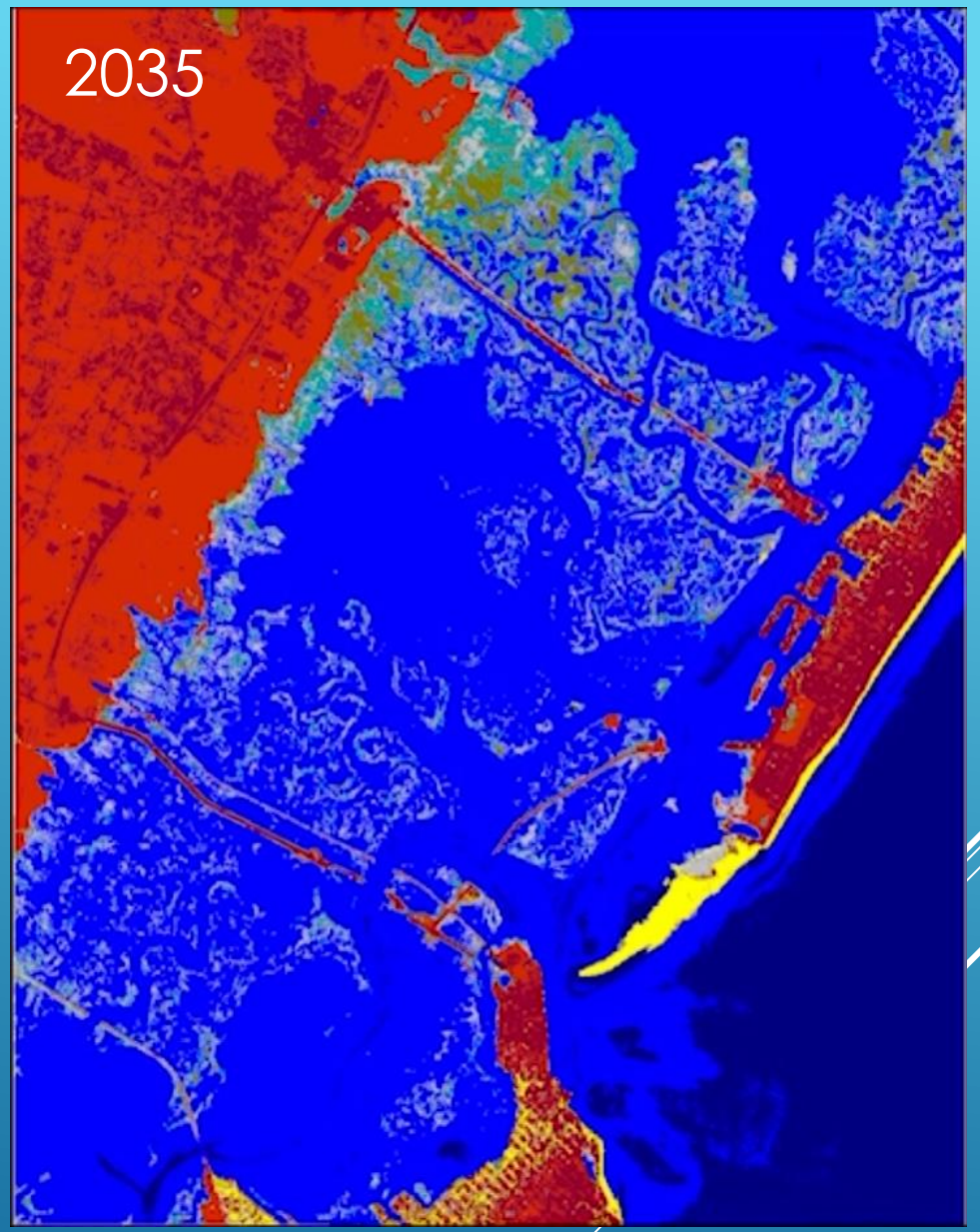
Other causes?

USFWS Sea Level Affecting Marshes Model



Marsh Loss: 1930 – 2012 (204.74 Acres)

1930 Marsh Limits



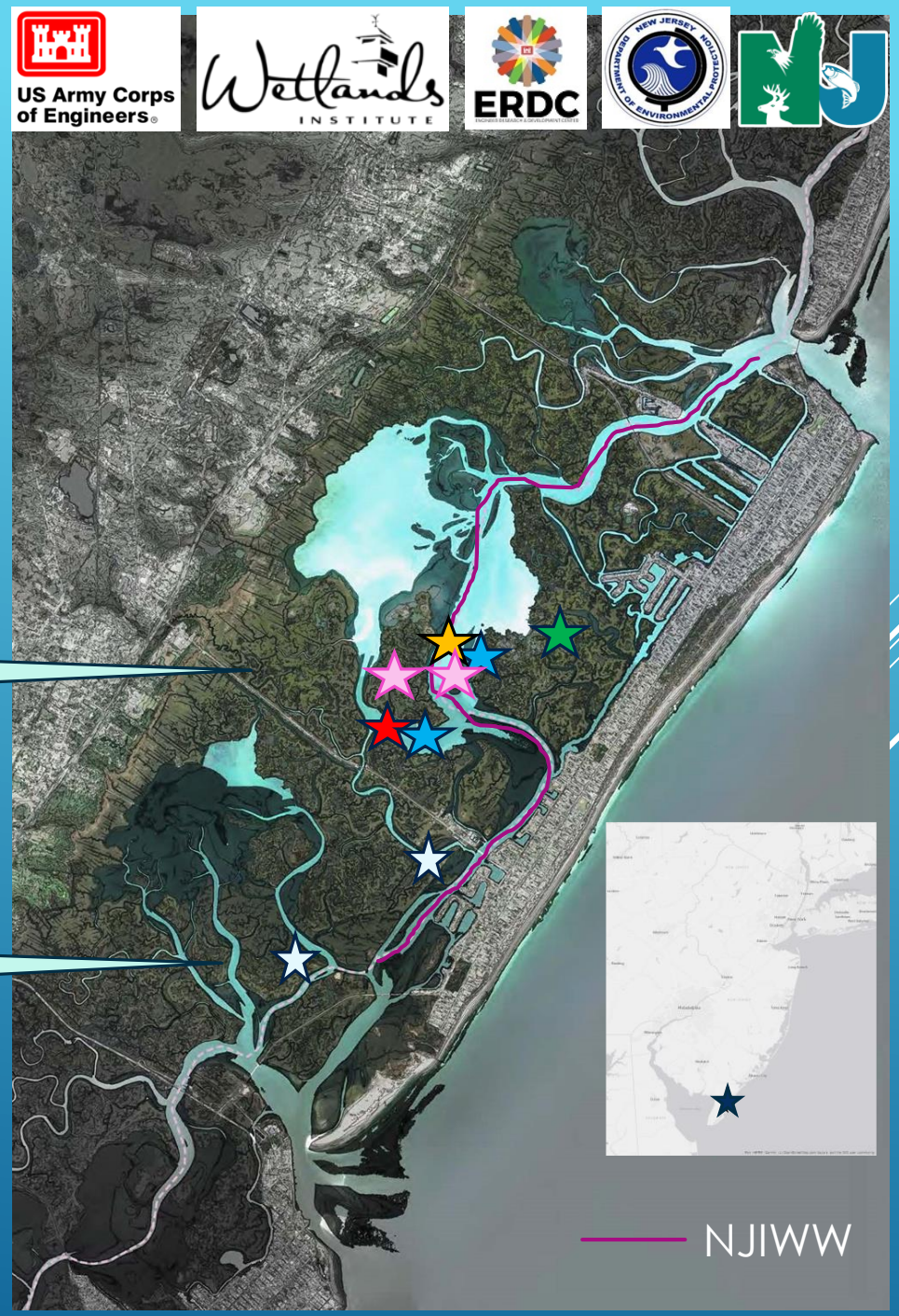
HIGH TIDE FLOODING (MHW SLAMM) AND COASTAL RESILIENCE

Weitzman SCHOOL OF DESIGN
UNIVERSITY of PENNSYLVANIA

- Marsh Elevation Enhancement/Wading Bird Nesting Habitat
- Sandy Marsh Edge Protection
- Intertidal Shallows and Tidal Delta Enhancement
- Edge Protection and Tidal Flat Enhancement
- Marsh Elevation Enhancement
- Elevated Nesting Habitat

Sediment Type: Mixed Fine Sand and Mud
Maintenance Dredging NJIWW
Hydraulic Dredging and Transport

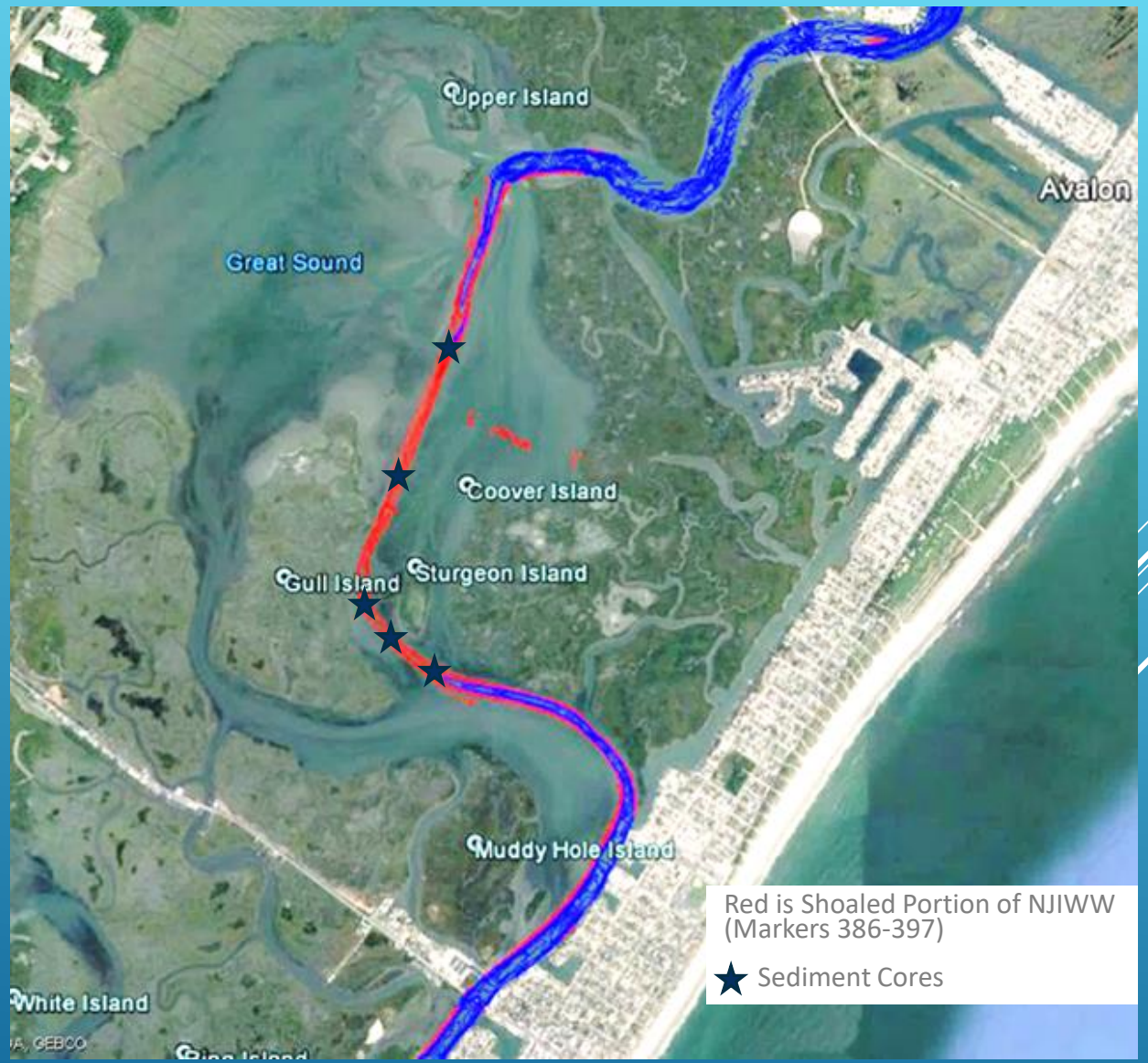
Sediment Type: Fine to Medium Sand
Maintenance Dredging NJIWW
Hydraulic Dredging and Transport



SMIIL BENEFICIAL USE PROJECTS

MARRYING SITE SELECTION WITH DREDGING NEEDS

- Once Source Sediments and Dredging Need is Identified Ecological Aspects Take Center Stage
- Marsh Condition Assessments, Habitat and Sensitive Species Status and Concerns Identified, Connections to Community Resilience and Benefits
- Develop Set of Projects to Address Ecosystem and Community Resiliency Needs Utilizing Available Sediment to Address Navigational Dredging Needs
- Marsh Condition Alone is Unlikely to Drive Site Selection
  - Abundant marsh and wildlife need so typically good partnering opportunities
  - Exceptions may be dredging specifically to source material for marsh restoration



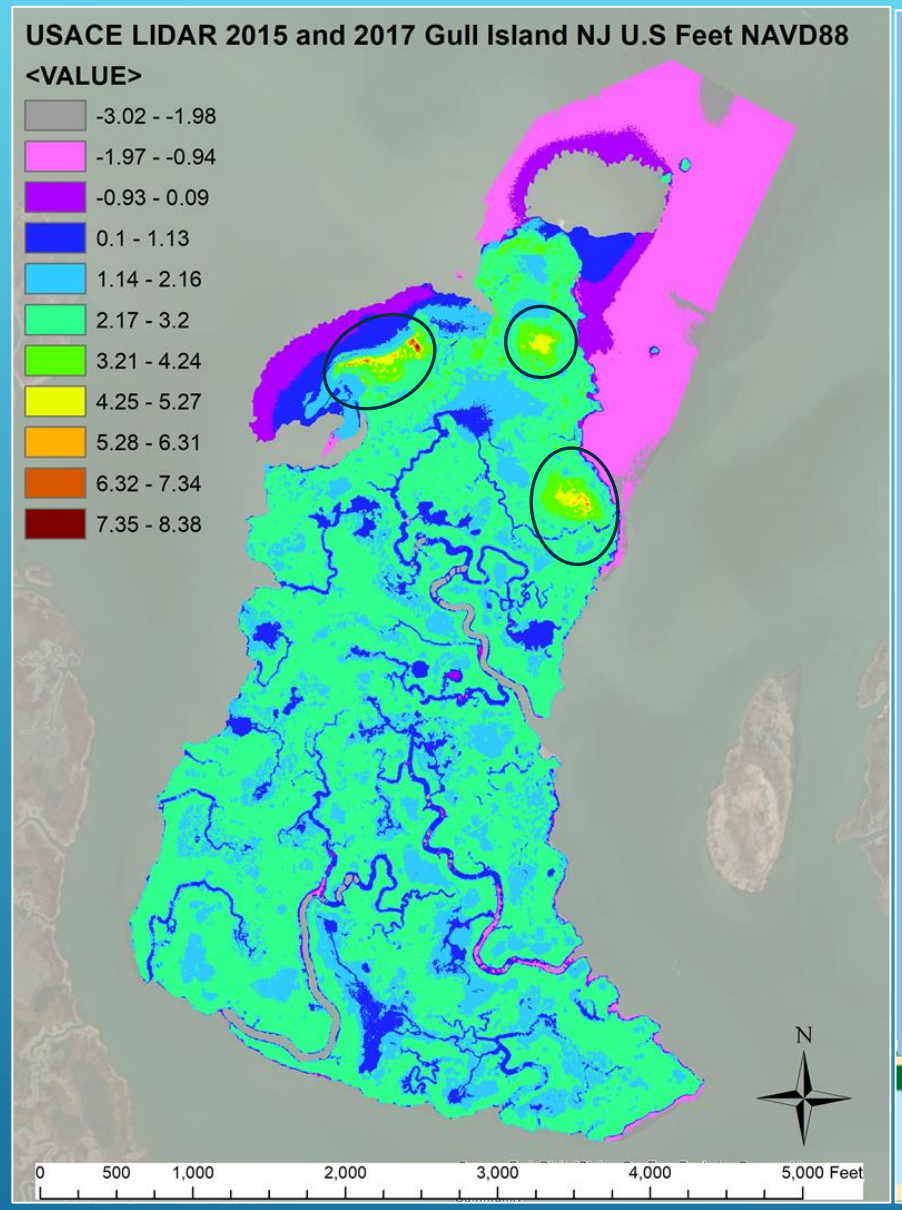
NJIWW Maintenance Dredging Needs

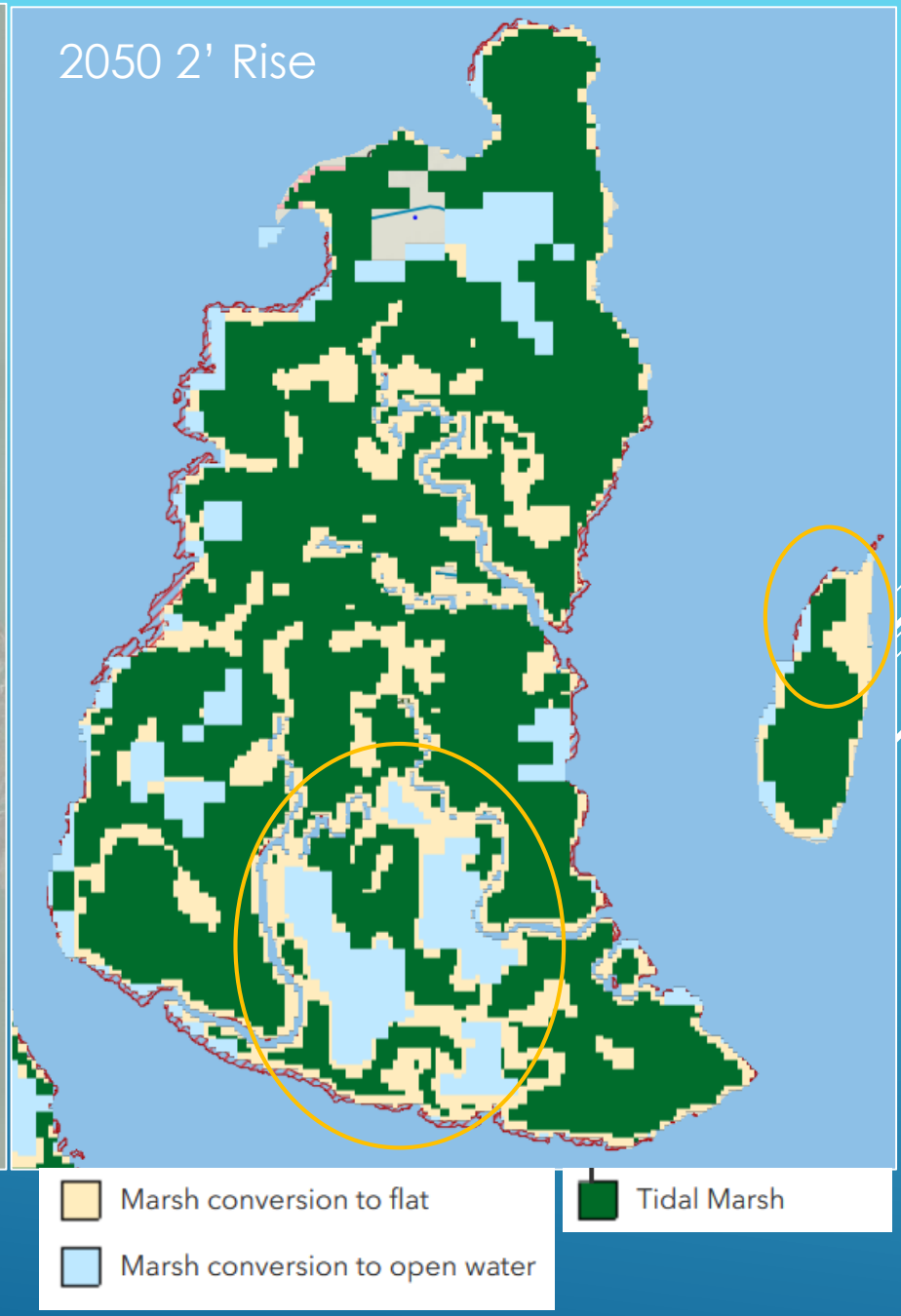
US Army Corps of Engineers
Wetlands Institute
ERDC
New Jersey Department of Environmental Protection
New Jersey Division of Fish and Wildlife

- Sturgeon and Gull Islands are low lying marsh islands that are drowning
- Historic dredge material placement sites created important wading bird habitat
  - Nesting areas account for nesting for 35% of all colonial wading birds in NJ
- Habitat degrading with elevation loss
- Island drowning destabilizing marshes

ECOLOGICAL CONDITION ASSESSMENTS & HABITAT NEEDS

- Gull Island
  - Large portion of tidal marsh projected to convert to mud flats and open water
  - Southern margin experiencing marsh edge erosion and risks of breaching
  - Pre-placement almost all of Gull Island flooded daily with vast areas of interior intertidal flats and open water area
  - High marsh areas are now restricted to prior dredged material placement sites
- Sturgeon Island
  - Northern portions of island at risk of conversion to flats and experiencing marsh edge erosion





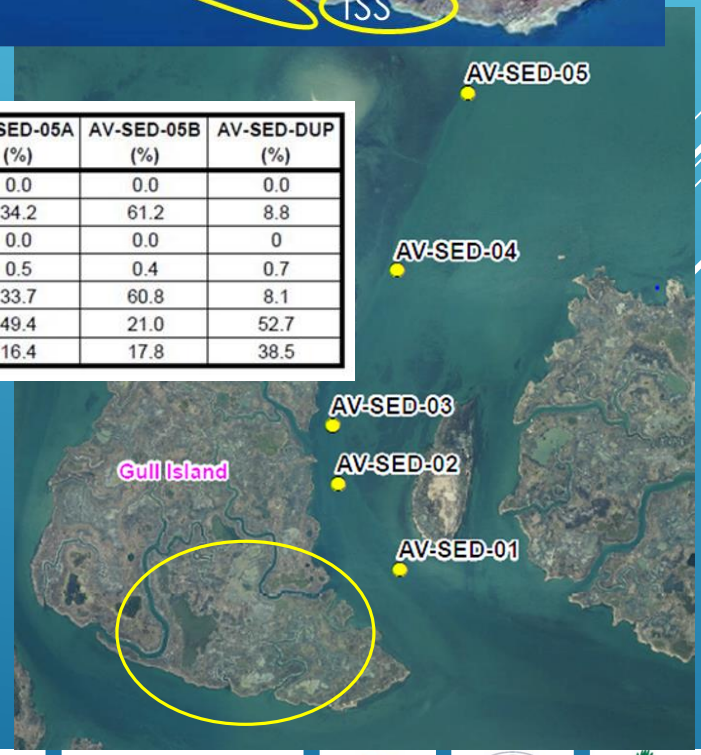
NJ Floodmapper

CREATE A SYSTEM OF SOLUTIONS

Ecological Goals for Both Gull and Sturgeon Island Placements

- Raise Elevations of Marsh Platform Across a Gradient of Elevations (MEE)
  - Target Wading Bird Nesting Elevations - Transitional Upland Shrub Habitat (>3.5' NAVD88)
  - Target High Marsh Elevations for Salt Marsh Sparrow (2.7' – 3.1' NAVD88)
  - Target Low Marsh Elevation for Fish Habitat (2.0 – 2.7' NAVD88) and Shorebird and Wader Foraging
- Create Marsh Edge Protection Zone (MEP)
  - More Natural Marsh Edge Slope and Wave Energy Buffer
  - Strategic Placement for Marsh Nourishment
  - Intertidal Shoal to Marsh Edge Elevation (2.0'NAVD88)
- Enhance Intertidal and Subtidal Shallows (ISS)
  - Target Elevations to MLLW Where Macroalgal Flats Transition from Sparse to Densely Vegetated (-1.0 MLLW – 0' MLLW)

Sample ID / Analyte	AV-SED-01 (%)	AV-SED-02/03 (%)	AV-SED-04 (%)	AV-SED-05A (%)	AV-SED-05B (%)	AV-SED-DUP (%)
Gravel	0.0	0.0	0.0	0.0	0.0	0.0
Sand	23.1	9.8	17.9	34.2	61.2	8.8
Coarse Sand	0.0	0.0	0	0.0	0.0	0
Medium Sand	1.2	1.5	1.3	0.5	0.4	0.7
Fine Sand	21.9	8.3	16.6	33.7	60.8	8.1
Silt	53.5	61.1	60.1	49.4	21.0	52.7
Clay	23.4	29.1	22	16.4	17.8	38.5



US Army Corps of Engineers
Wetlands Institute
ERDC
NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION
NEW JERSEY DIVISION OF Fish and Wildlife

GULL AND STURGEON ISLAND ECOLOGICAL GOALS

- Ecologic Goals
  - Raise Elevations of Marsh Platforms Across a Gradient of Elevations – Gull and Sturgeon Islands (MEE)
    - Target Wading Bird Nesting Elevations - Transitional Upland Shrub Habitat (>3.5' NAVD88)
    - Target High Marsh Elevations for Salt Marsh Sparrow (2.7' – 3.1' NAVD88)
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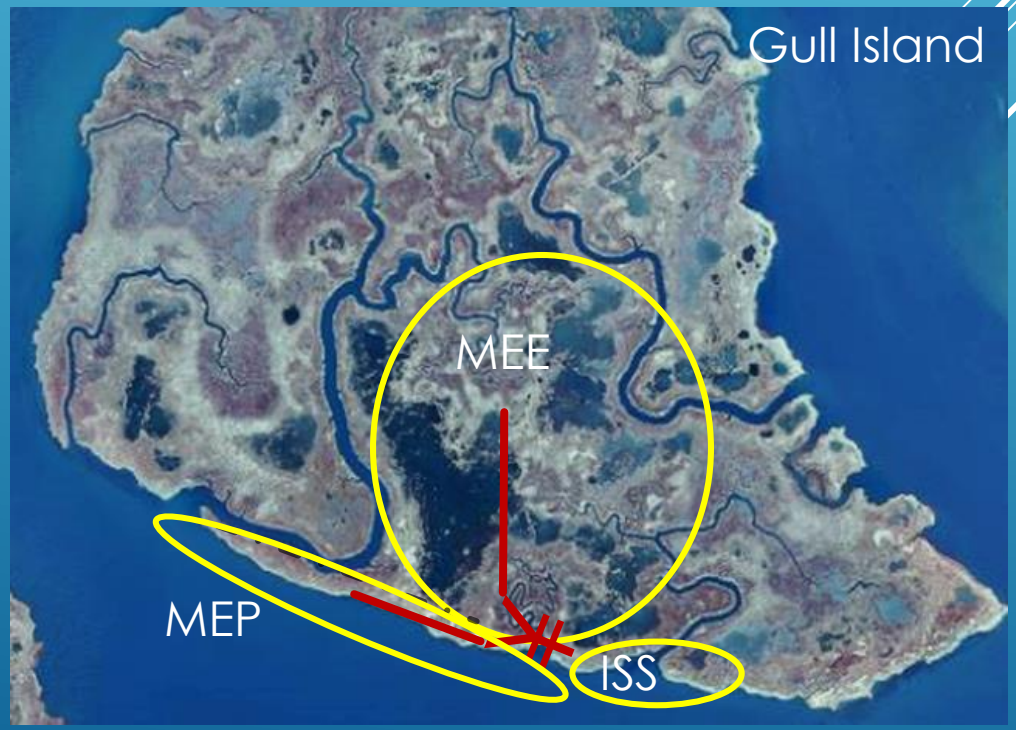
    - Intertidal Shoal to Marsh Edge Elevation (2.0'NAVD88)
  - Enhance Intertidal and Subtidal Shallows – Gull and Sturgeon Islands (ISS)
    - Target Elevations to MLLW Where Macroalgal Flats Transition from Sparse to Densely Vegetated (-1.0 MLLW – 0' MLLW)



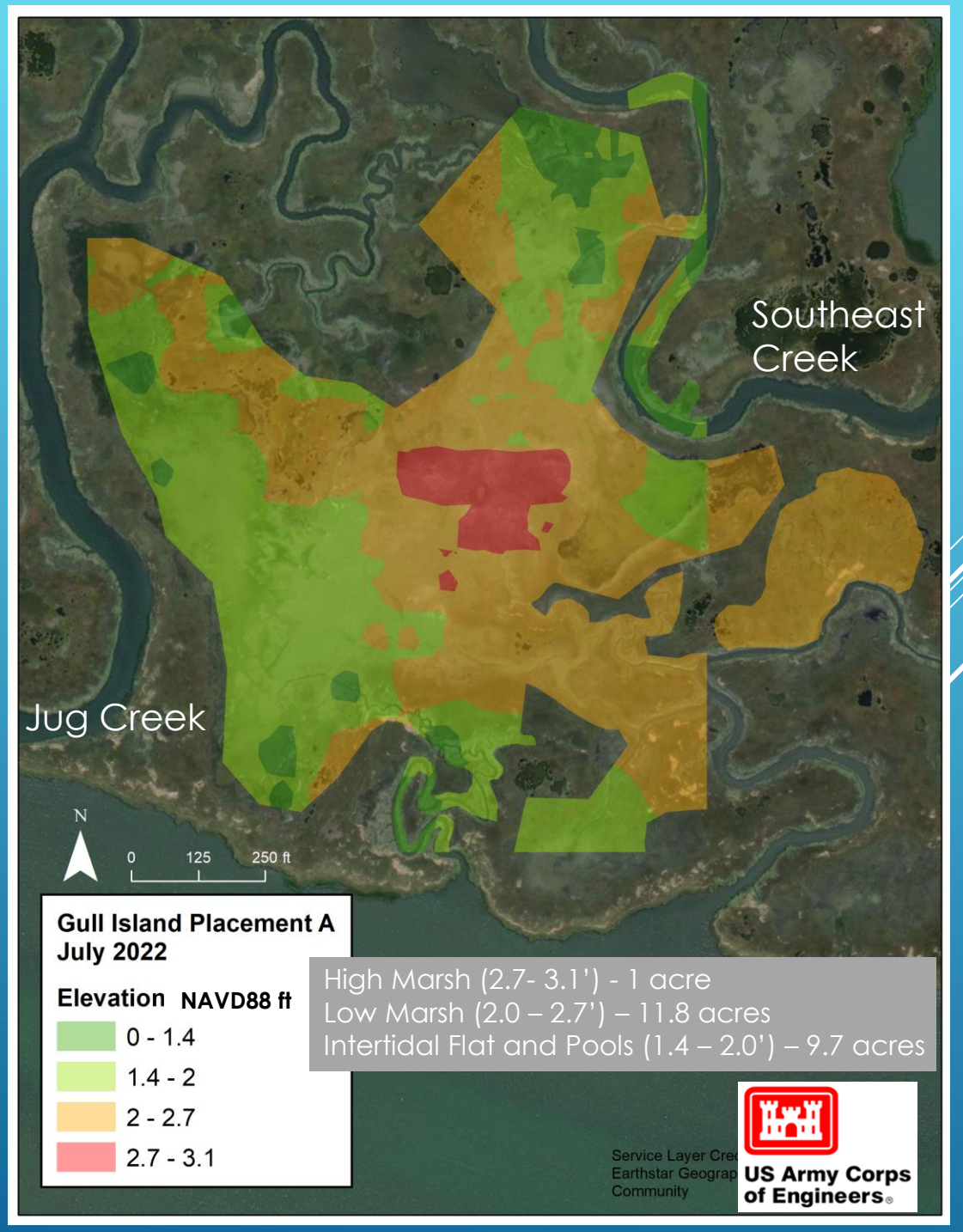
OUTCOMES GULL ISLAND PROJECTS

- September 2020
  - Placed 40,000 cubic yards of mixed fine sand and mud
- Marsh Elevation Enhancement (MEE)
  - ~22 acres of elevation lift
  - 3.9' NAVD88 grading down to 1.8' NAVD88
  - Excellent grass recovery
  - Migratory shorebird and sparrow use
- Marsh Edge Protection (MEP)
  - Built to marsh edge (2.0' NAVD88) grading down to MLLW
  - Intercepting wave energy
- Enhanced Intertidal Shallows (ISS)
  - Shallowed up to MLLW along southern island flank

- *Spartina alterniflora* recovery and expansion rapidly occurring during second growing season post-placement
- Especially at elevations below MHHW

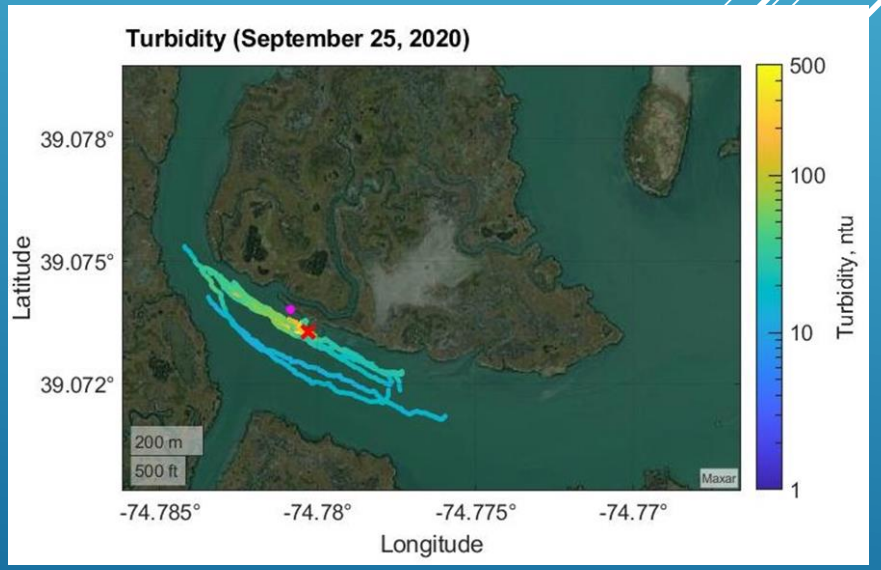
- Below target elevations for transitional wading bird habitat and only small area of high marsh
  - Acoustic monitoring detecting both Salt Marsh and Seaside Sparrows foraging on site
- Effectively created low marsh habitat and shallowed interior intertidal flats and pools
  - Avian surveys documenting more than 25 species utilizing placement area for foraging including several surveys with 500-1000 Semipalmated Sandpipers
- Vegetation recolonization and expansion proceeding well at 2 year post-placement timeframe
- Ecological benefits progressing along site evolutionary trajectory
- Return for additional uplift?

GULL ISLAND OUTCOMES 2 YEARS POST PLACEMENT



- Turbidity Monitoring
  - Turbidity plume localized, only extending ~50 m off marsh edge and <200 m along shore.
  - Was at similar levels (250-380 ntus) to those measured during passage of Nor'easter and southerly wind events (>5 m/s).
- Berm Monitoring
  - Placed ~9000 cy and ~8700 cy on two subtidal features and gained 1 – 2.5' of elevation
  - Documented ~4700 and ~4100 cy after 16 months and 1-1.5' of elevation gain so ~50% reduction in volume
  - Measured wave height and energy reduction along marsh edge during May Nor'easter (Perkey et al.)


Main Indirect Placement – Intertidal Shallows Enhancement – 1 Month Post-Placement



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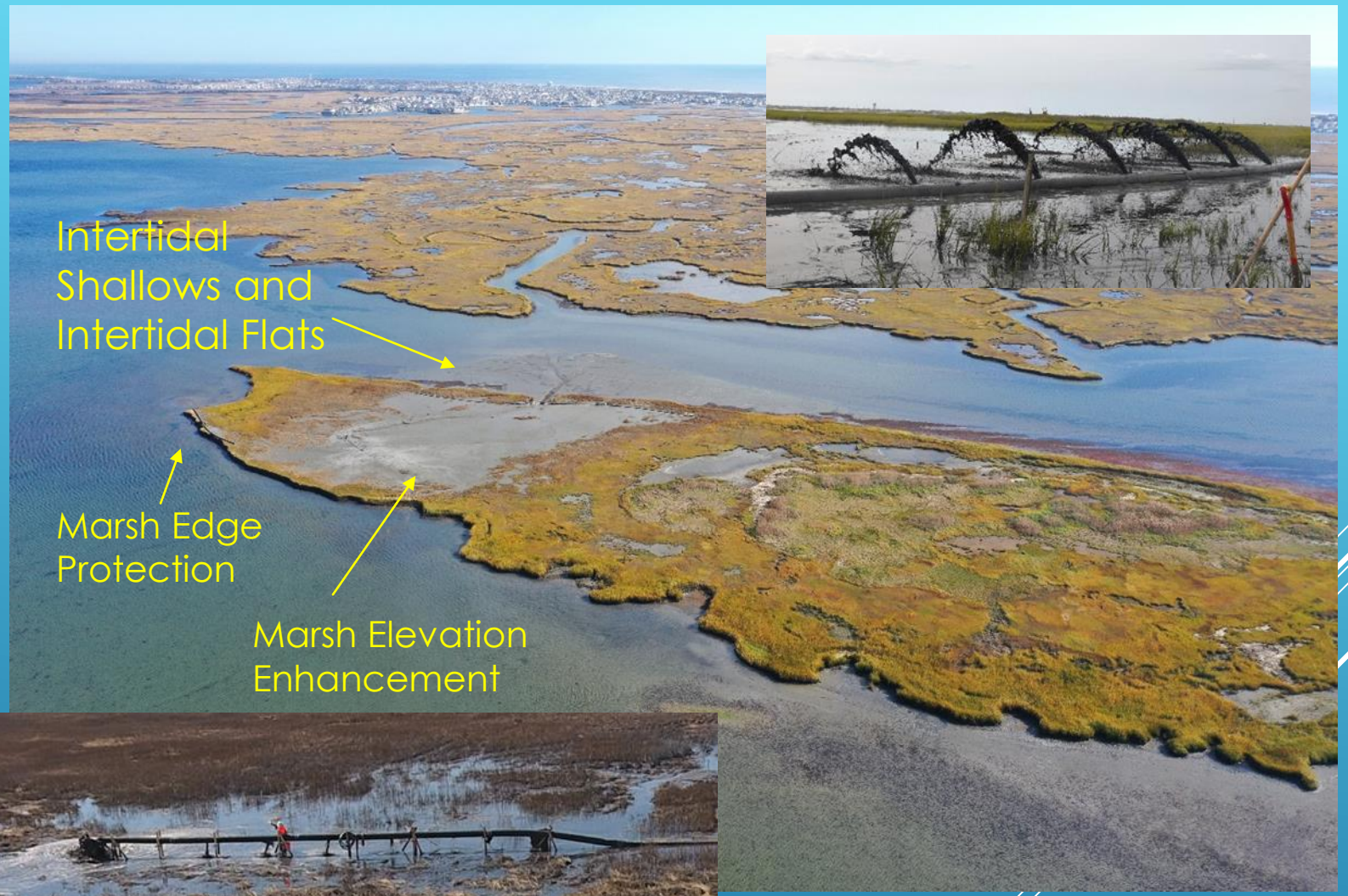
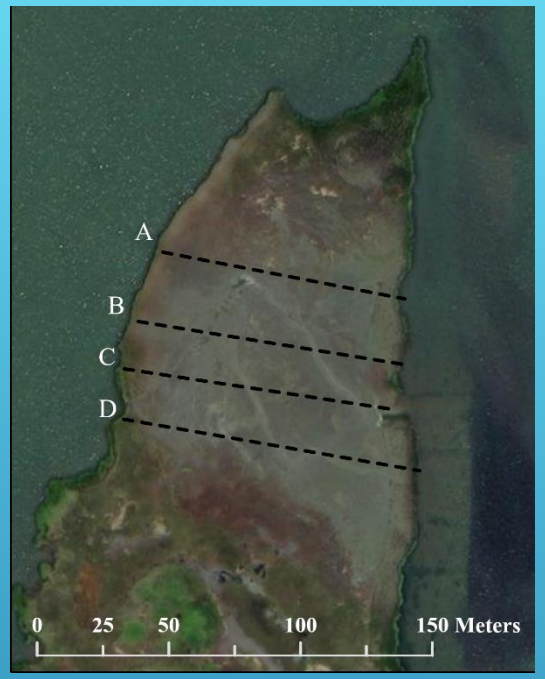
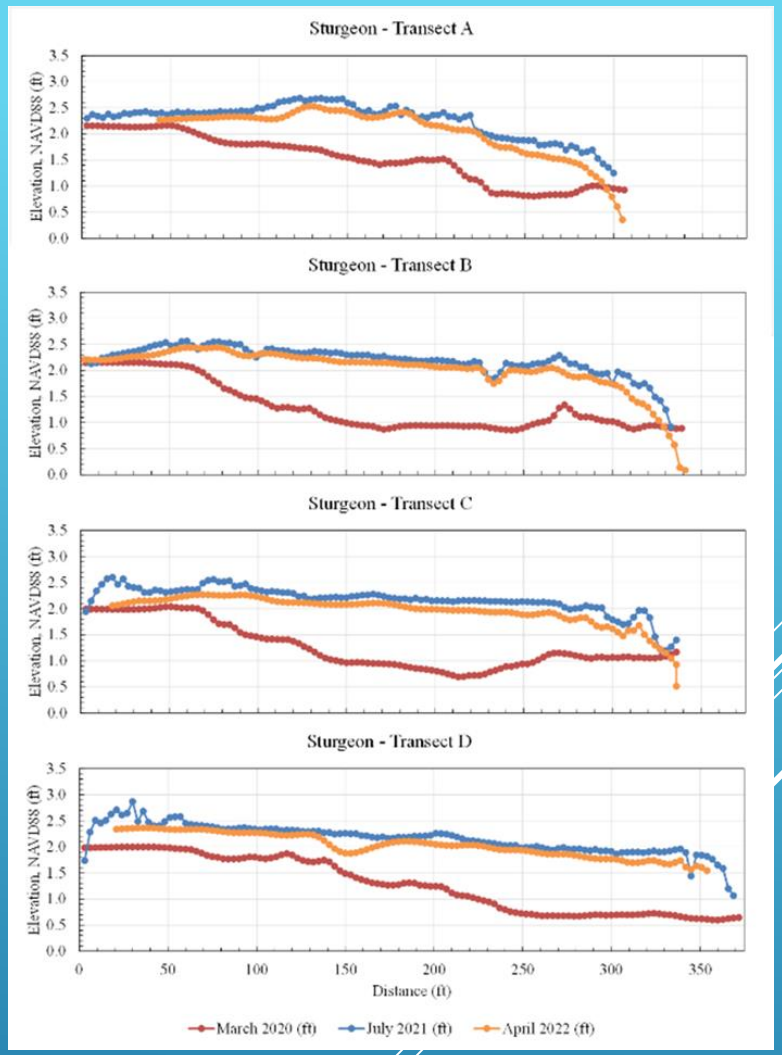
(Fall et al., 2022)

STURGEON ISLAND PLACEMENTS

- Placed in Two Phases in 2020
  - March 2020
    - 4,200 cubic yards
  - September 2020
    - 15,000 cubic yards
  - Mixed fine sand and mud
- Marsh Elevation Enhancement (MEE)
  - 3.5 acres of enhancement
  - 3.0' NAVD88 grading down to 1.9'
- Marsh Edge Protection (MEP)
  - Placed small sand ridge along toe of erosional slope
- Enhanced Intertidal Shallows (ISS)
  - Shallowed above MLLW along eastern island to extend flats northward
- Returned in Fall 2022 for Phase 3







- 2020 uncontained placement achieved 1.5 – 2.5' of marsh elevation enhancement
- Vegetation recolonization is rapidly occurring naturally via seed bank in year 2

Courtesy of Harris et al.

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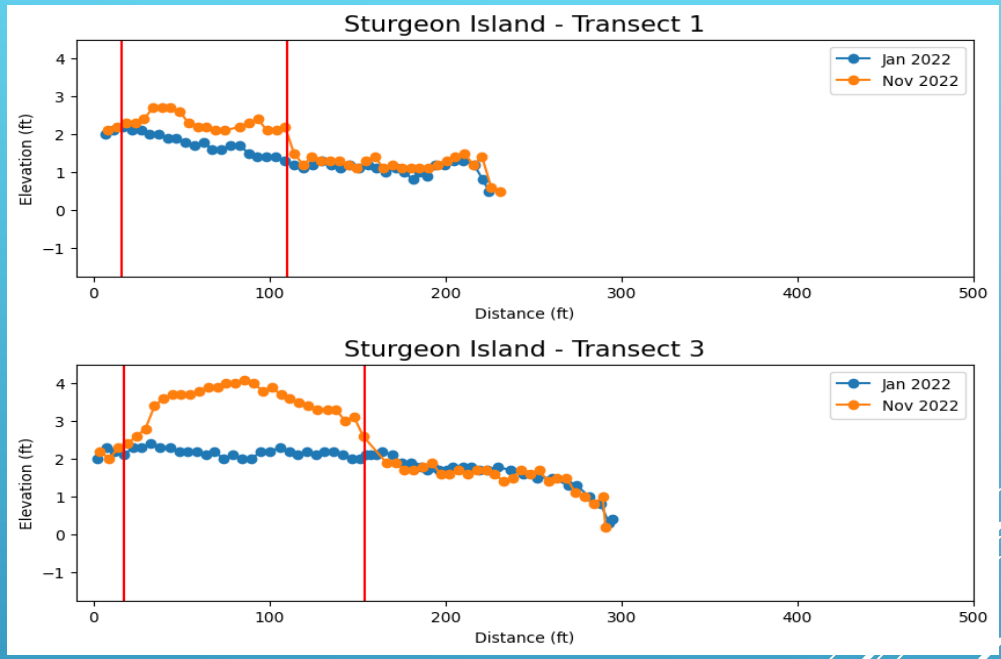
STURGEON ISLAND PHASE 3 – FALL 2022

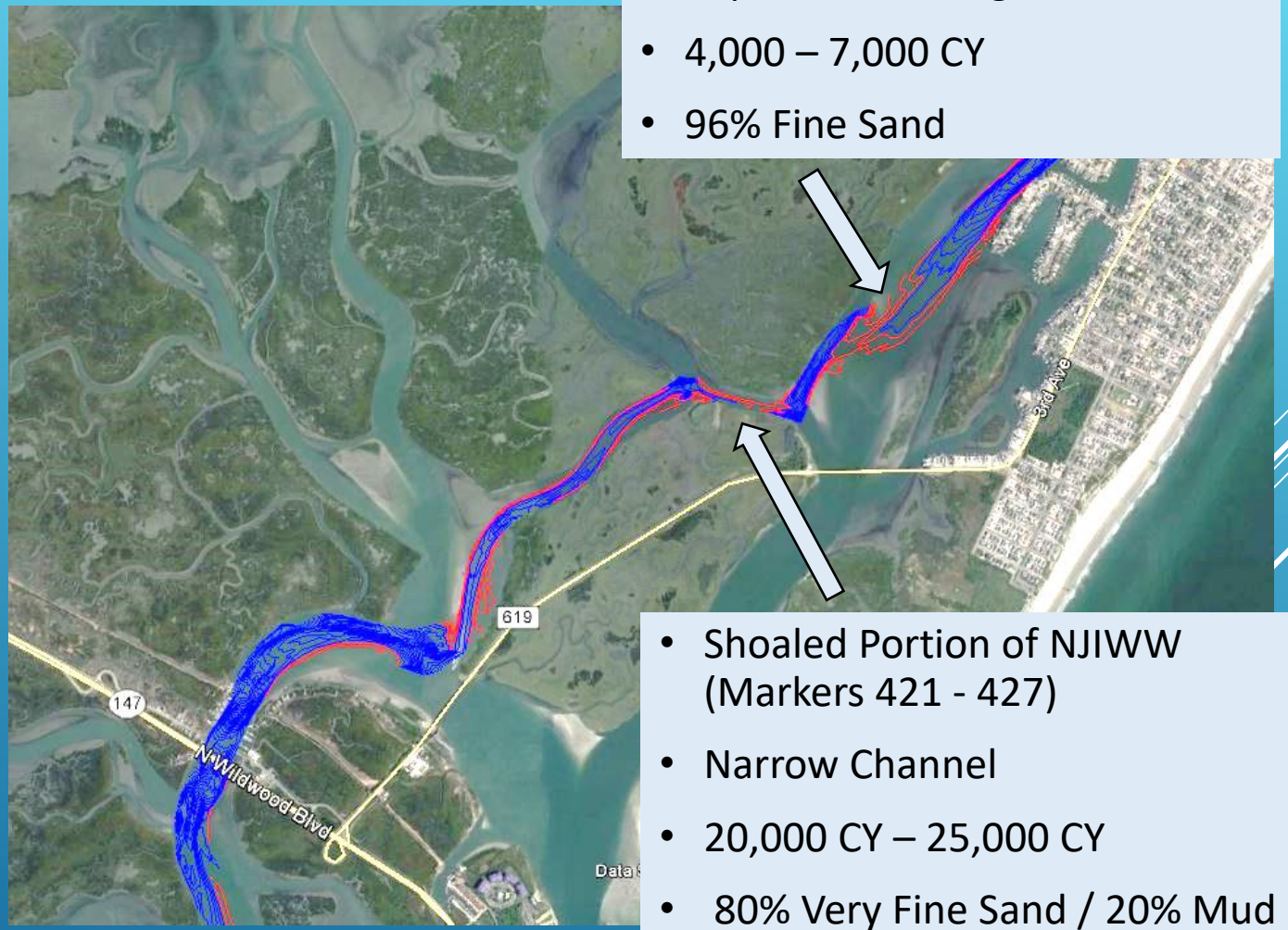
- Placed 24,000 CY of fine sand to create sandy marsh edge protection features
  - Intercepting wave energy
- Used containment to elevate 0.4 acre for elevated bird nesting habitat
  - Placed more than 3' of material
  - Built to 4.0' NAVD88
- Employed Y-valve to switch between containment and subtidal features
  - Maintain dredging efficiency
  - Allow time for contained area to dewater
  - Slow and manage flow volumes and velocities



SOUTHERN SMIIL NJIWW MAINTENANCE DREDGING

- NJIWW Dredging Need (USACE/USCG)
  - Repetitive Dredging – Small Volumes
    - Sandy Sediments (95%+) in Shoal Areas Southern SMIIL
  - Larger Project – Recurrence Interval Unknown
    - Shoaled Channel Very Fine Sandy/Mud
- Repetitive Beneficial Use Projects
  - Ring Island (2014)
    - USACE, NJDEP, TNC, Greenvest, TWI – NFWF Hurricane Sandy Grant
  - Ring Island (2018)
    - USACE, NJDEP, TWI – USACE Maintenance Dredging
  - Great Flats (2018/2021)
    - USACE, NJDEP, TWI – USACE Maintenance Dredging

- Shoaled Portion of NJIWW (Markers 419-421)
- Repetitive Infilling Small Shoals
- 4,000 – 7,000 CY
- 96% Fine Sand

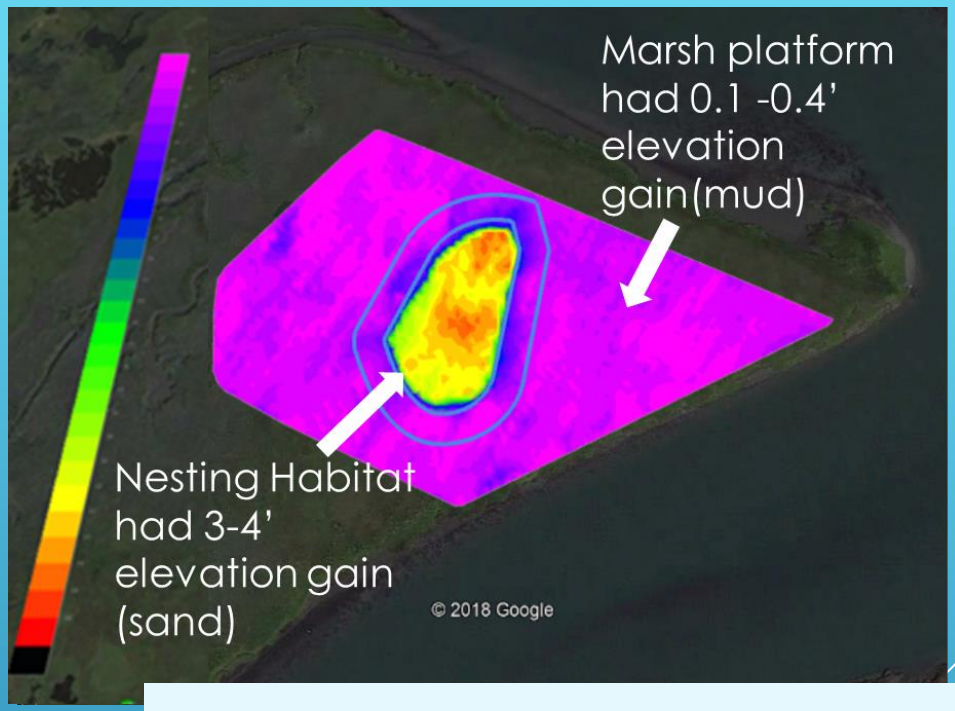


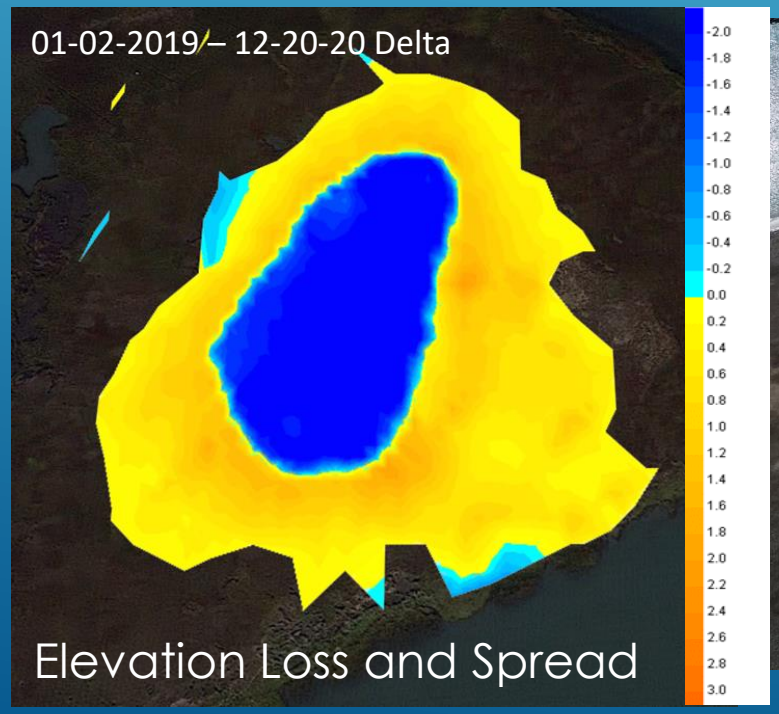
- Shoaled Portion of NJIWW (Markers 421 - 427)
- Narrow Channel
- 20,000 CY – 25,000 CY
- 80% Very Fine Sand / 20% Mud

NESTING HABITAT CLUSTERS: MIMICKING NATURE AND MANAGING NAVIGATIONAL NEEDS

- Dredging Need
  - Sandy Shoaled Portion of NJIWW
- Ecologic Value
  - Create Network of Nesting Sites for Several Beach-Nesting Species at Different Stages of Succession
    - Black Skimmer
    - Common and Least Terns
    - American Oystercatcher
  - Separate Populations for Resilience
  - Ecological Value During Site Evolution Trajectory
- Dredging Value
  - Provides for Repetitive Placement Cycles
  - Matches Ecological Goals with Dredging Goals
  - Minimizes Permitting and Reduces Costs

2018 Placement





Elevation Loss and Spread

2021 Placement

Construction then Repetitive Adaptive Management

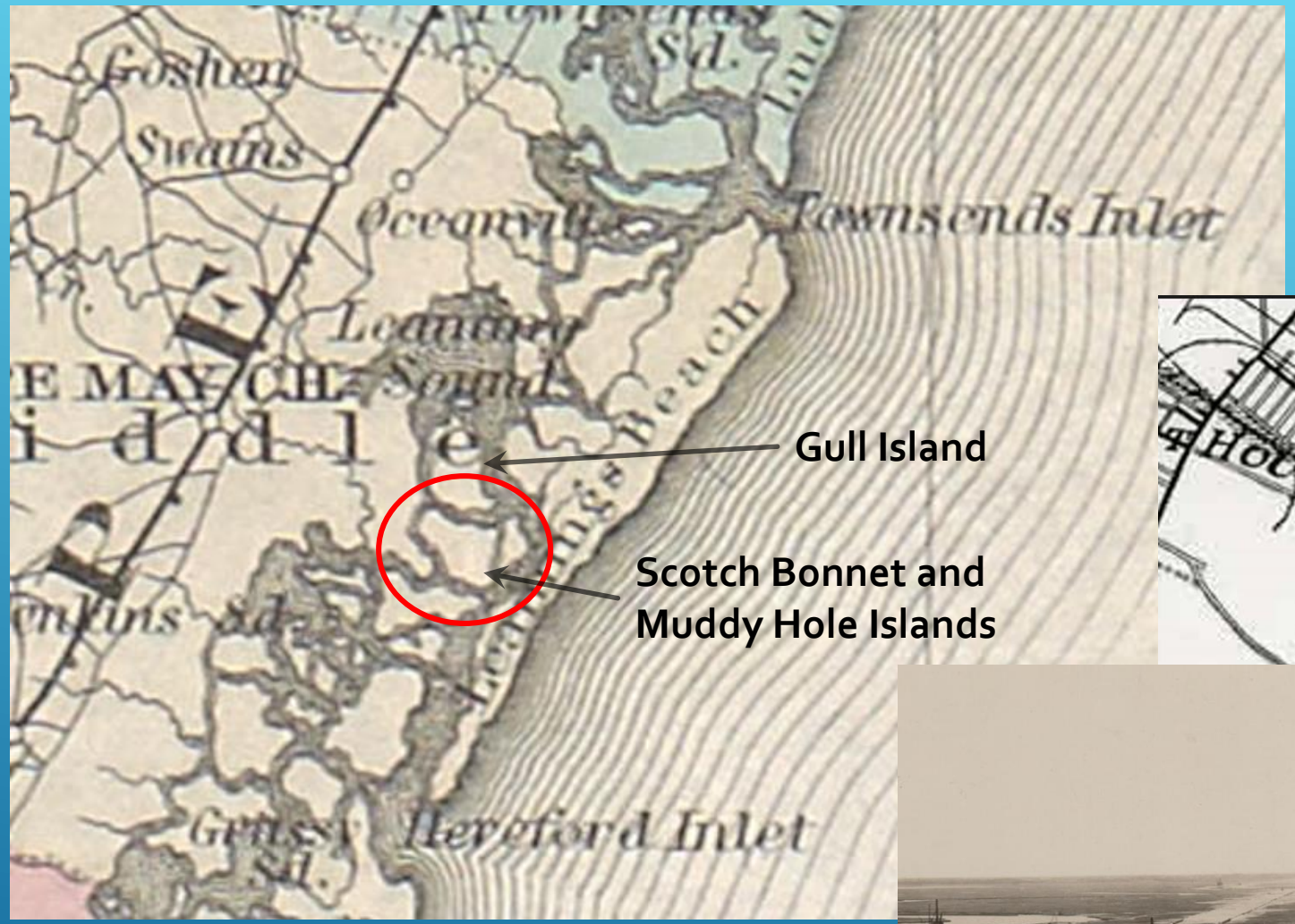
- 1 acre sites – 6,000 CY initial placement
- 3 year return cycle refurbished with 4,000 CY each time
- Free pump until enough material to create containment berms
- Match maintenance dredging of small sandy shoals with ecological goals for at risk species

BUILDING RESILIENCE FOR CAPE MAY WETLAND WILDLIFE MANAGEMENT AREA AND THE WETLANDS INSTITUTE

Wetland Ecosystem and Ecological Landscape

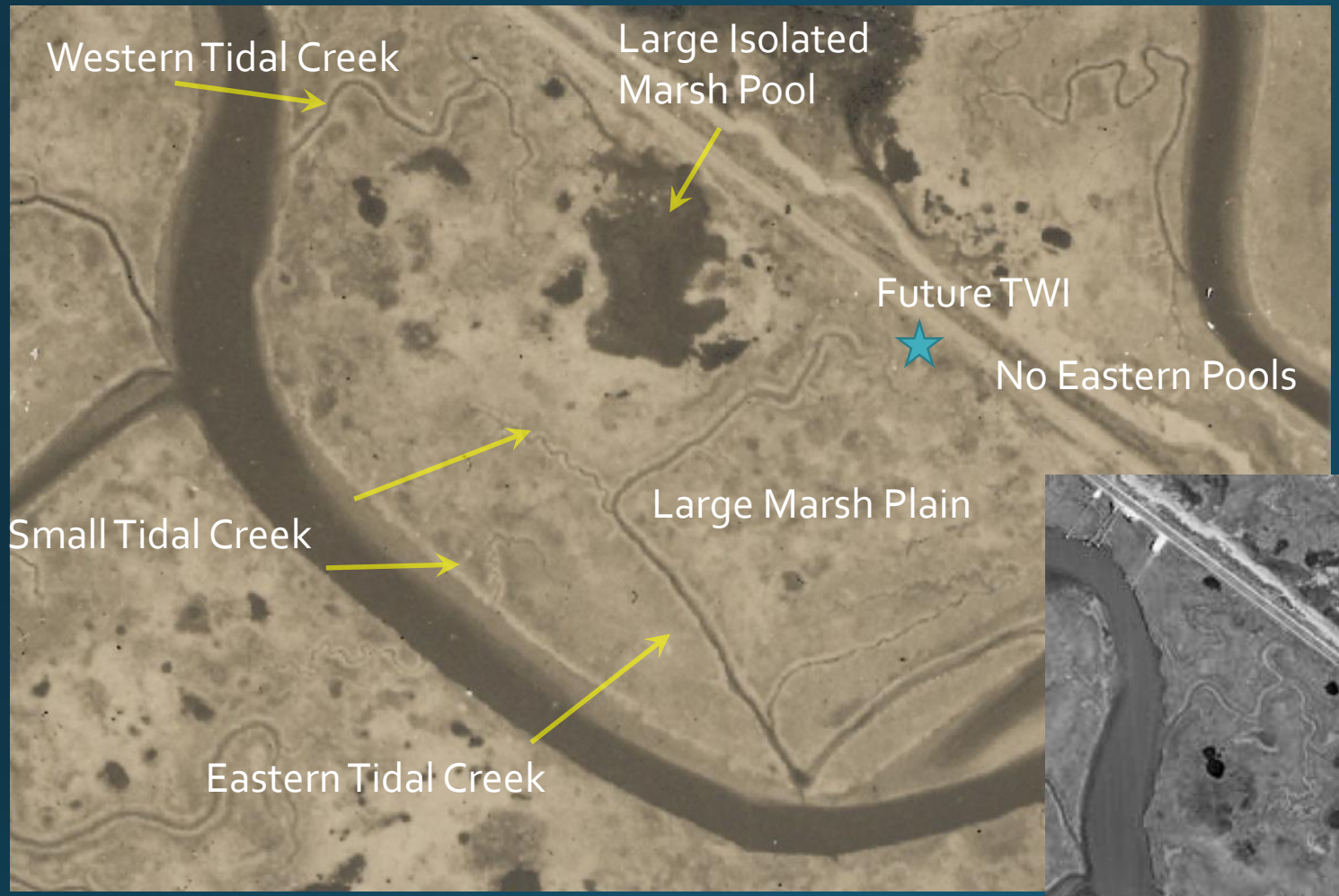
- Sea Level Rise Rates Altering Marsh Ecosystem
- Increasing Storm Risk Impacts and Uncertainties

Morgan Hand Jr
1912 Cape May County Map



1878 Colton Map

~1910 Photo of Bridge to Stone Harbor

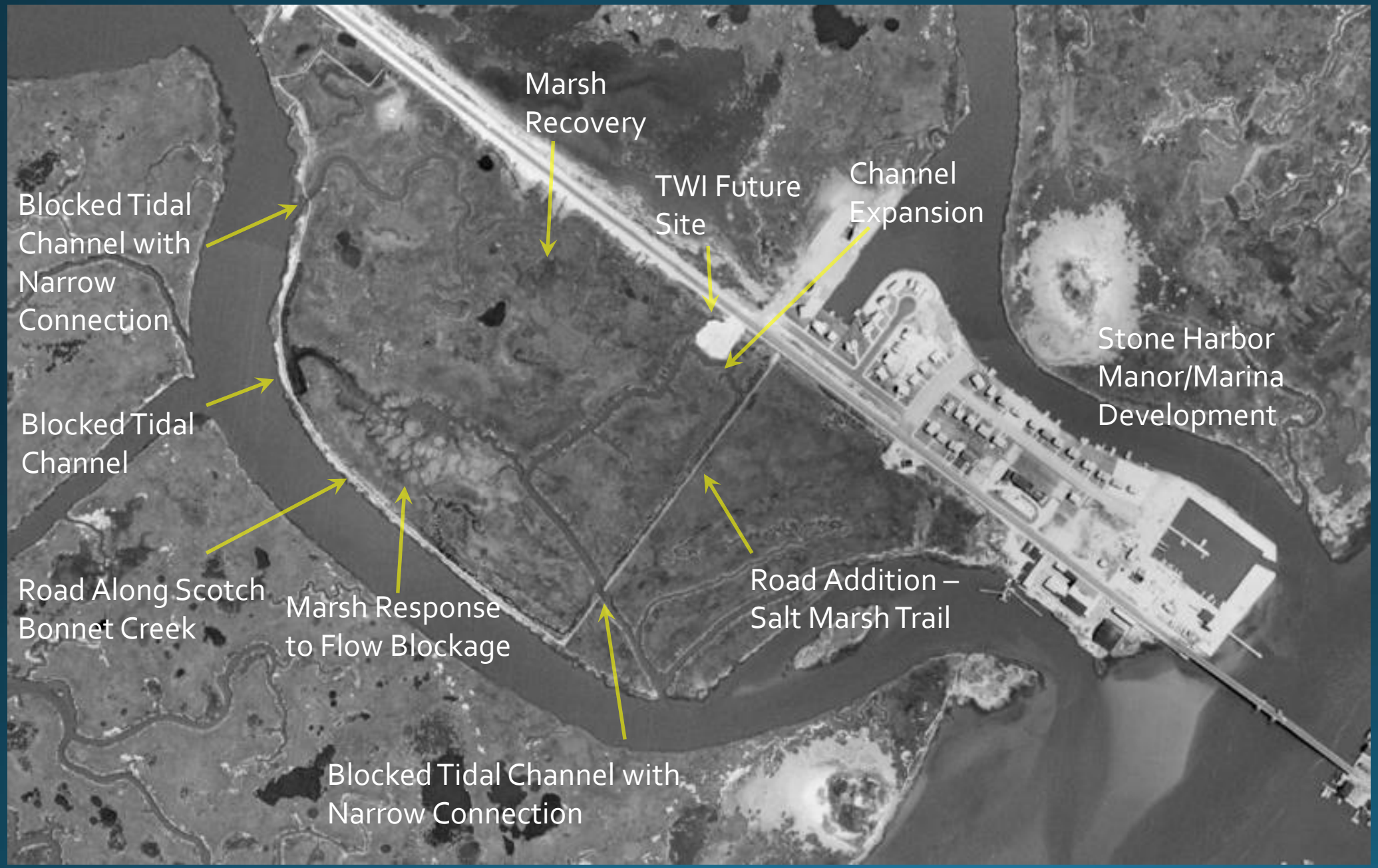


1941

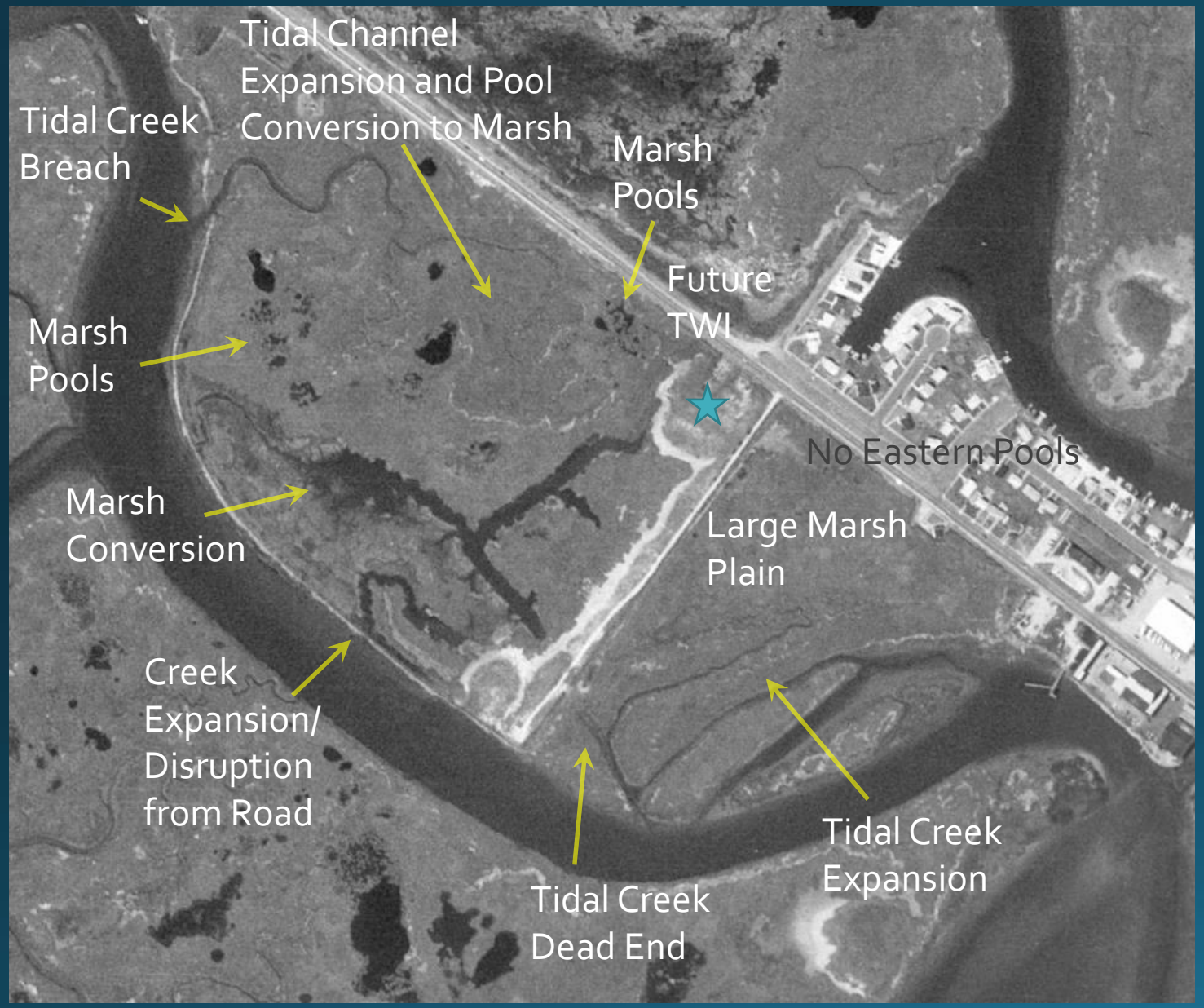
Tidal Channel Expansion and Pool Conversion to Marsh and Mudflat

Fresh Placement and Early Fill

1956


Marsh Recovery
TWI Future Site
Channel Expansion
Blocked Tidal Channel with Narrow Connection
Stone Harbor Manor/Marina Development
Blocked Tidal Channel
Road Along Scotch Bonnet Creek
Marsh Response to Flow Blockage
Road Addition – Salt Marsh Trail
Blocked Tidal Channel with Narrow Connection

1963


Tidal Creek Breach
Tidal Channel Expansion and Pool Conversion to Marsh
Marsh Pools
Future TWI
Marsh Pools
No Eastern Pools
Marsh Conversion
Large Marsh Plain
Creek Expansion/ Disruption from Road
Tidal Creek Expansion
Tidal Creek Dead End

1970

>1972


Marsh Pool Expansion
Marsh Conversion
Tidal Creek Breach and Connection
SCOTCH BONNET
Marsh Pool Expansion


Wetlands Institute

Low Tide Image So Waterways Show as Mudflats

Tidal Creek Widening and Expansion

Pool Expansion

Significant Pool Expansion/New Pool Development and Marsh Loss

Creek Reestablishment

Tidal Creek Widening and Expansion

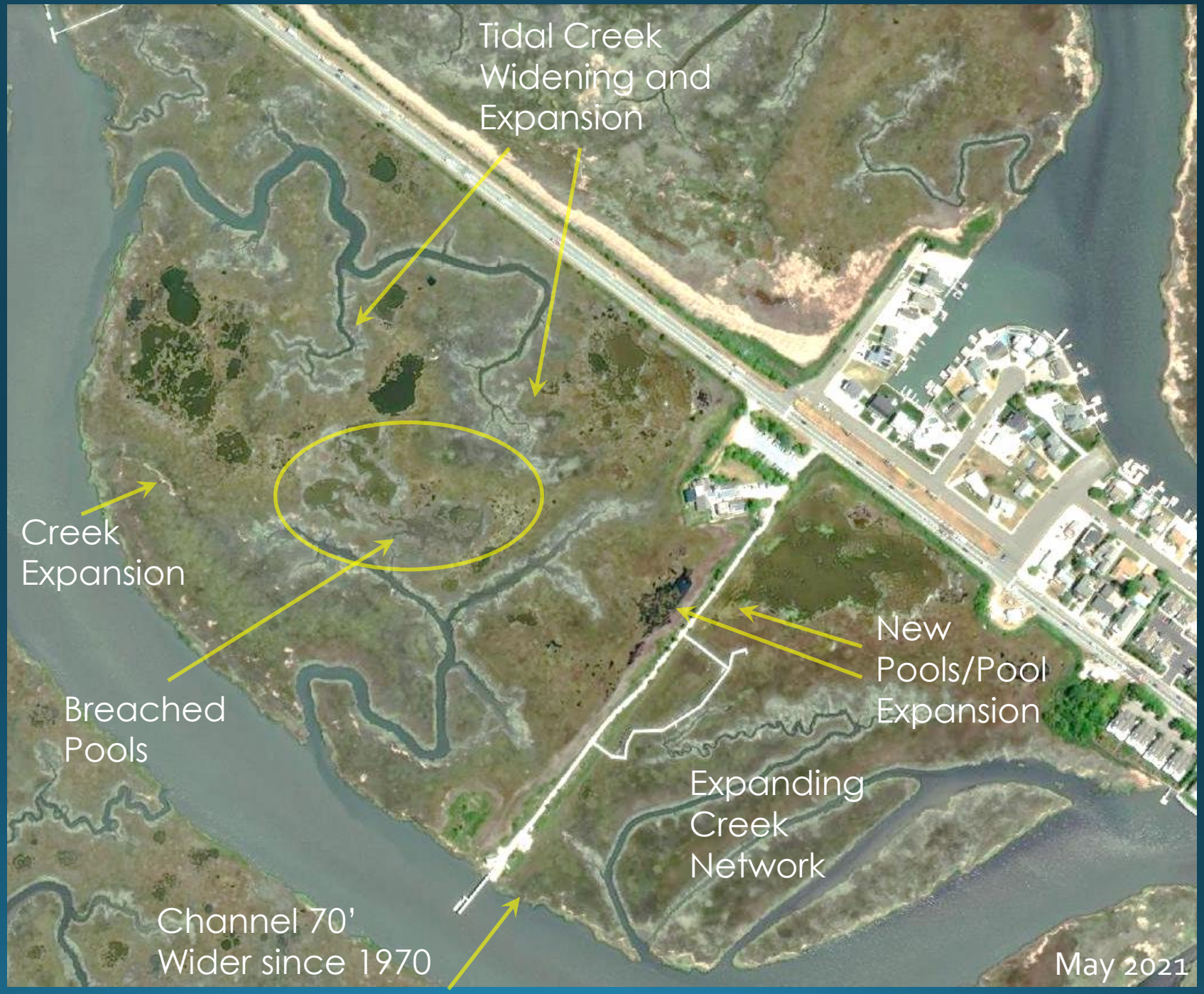
Highly Dissected Marsh Plain

Pool Expansion

5/2009

Current Marsh Platform Conditions

- Highly dissected marsh platform
- Continued rapid expansion and extension of tidal creek network
- Creek expansion creating connection to larger creek network
- Recent breach of pools and rapid deepening
- New pool formation and expansion of eastern pools – beginning to establish connection to expanding creek network
- Entire marsh complex is at lower elevation of *S. alterniflora* growth



SEA LEVEL RISE FRAMEWORK

		2030	2050	2070		
				Emissions		
	Chance SLR Exceeds	feet	feet	Low	Mod.	High
Low End	>95% Chance	0.3	0.7	0.9	1.0	1.1
Likely Range	>83% Chance	0.5	0.9	1.3	1.4	1.5
	~50% Chance	0.8	1.4	1.9	2.2	2.4
	<17% Chance	1.1	2.1	2.7	3.1	3.5
High End	<5% Chance	1.3	2.6	3.2	3.8	4.4

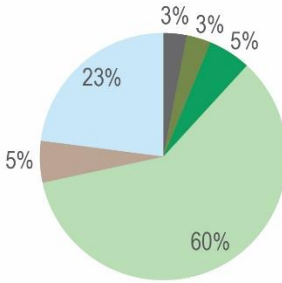
- Utilizing SLR Predictions from Rutgers University
  - Values are above the year 2000 (1991-2009 average) baseline
  - 2000 – 2022 (2001-2019 average) Observed 4" (0.3')
- Evaluated 50% and <17% Chance of Exceedance – Planning based on <17% Chance
- Focused on 2030 and 2050 Time Horizons

2020 Existing Condition- 2018DEM (1m)

Legend (SLAMM)

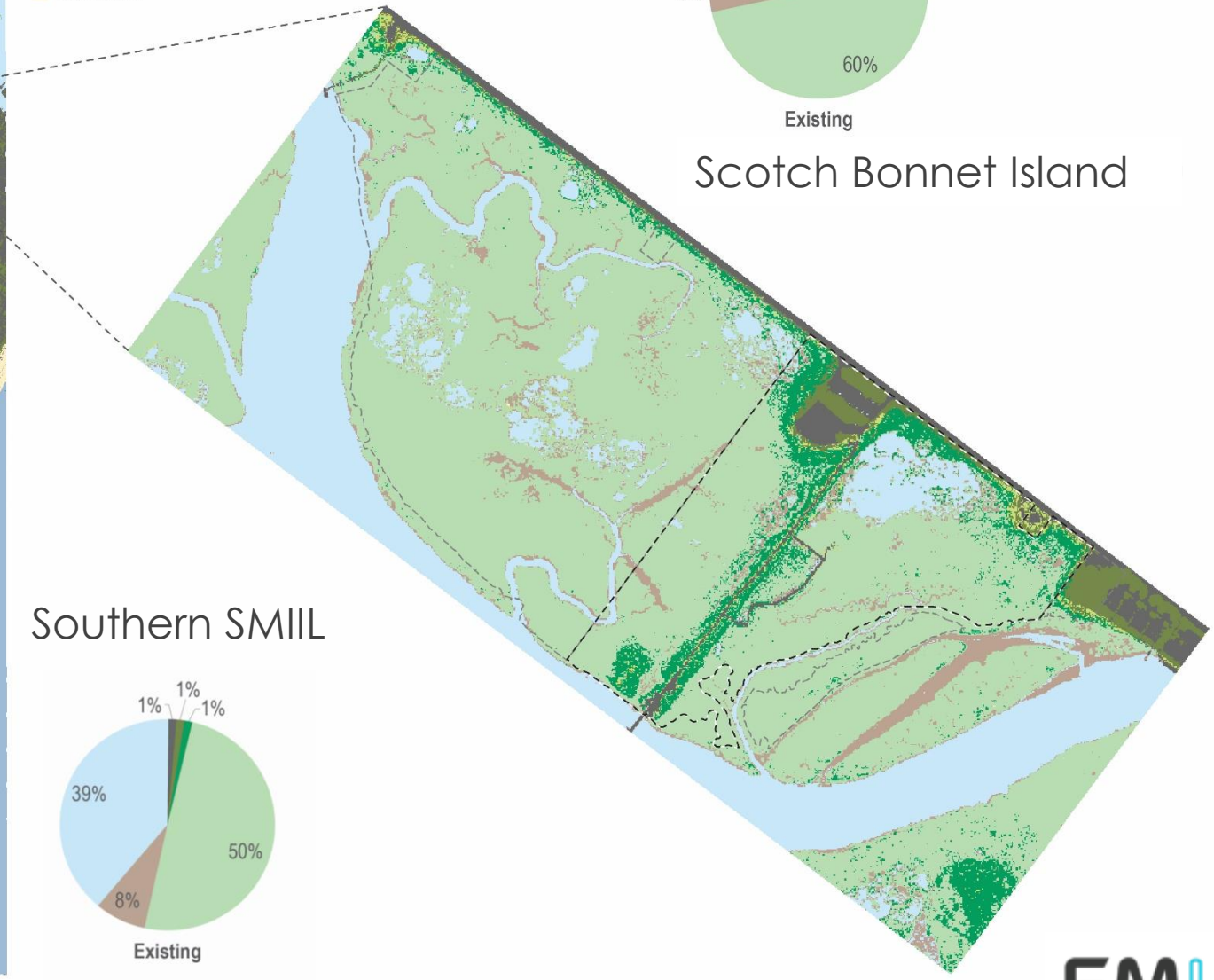
- Open Ocean
- Estuarine Water
- Developed Dry Land
- Undeveloped Dry Land
- Shrub/ Scrub
- Regular Flooded Marsh (Low Marsh)
- Irregular Flooded Marsh (High Marsh)
- Tidal Flat
- Ocean Beach

Elevation-derived habitat distributions via SLAMM*:



Existing

Scotch Bonnet Island



Southern SMIIL

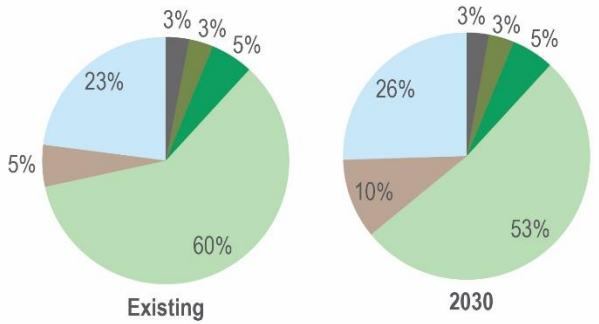
Existing

2030, 1.1ft SLR (<17%) SLAMM Simulation- 2018DEM (1m)

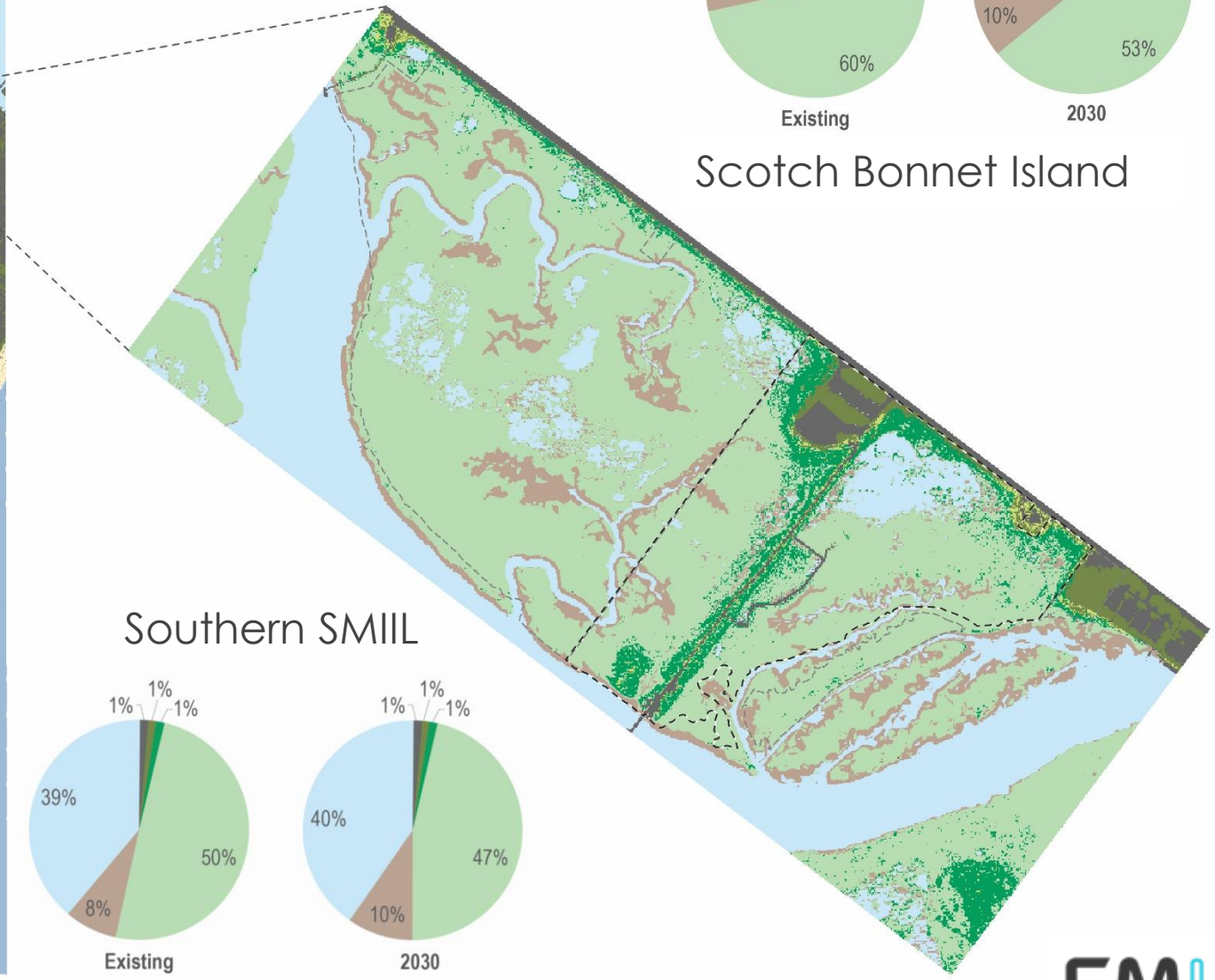
Legend (SLAMM)

- Open Ocean
- Estuarine Water
- Developed Dry Land
- Undeveloped Dry Land
- Shrub/ Scrub
- Regular Flooded Marsh (Low Marsh)
- Irregular Flooded Marsh (High Marsh)
- Tidal Flat
- Ocean Beach

Elevation-derived habitat distributions via SLAMM:



Scotch Bonnet Island



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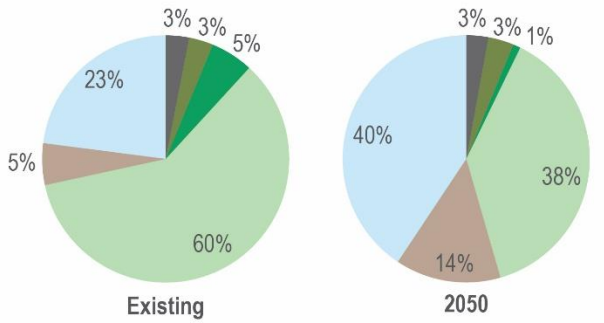
2050, 2.1ft SLR (<17%) SLAMM Simulation- 2018DEM (1m)

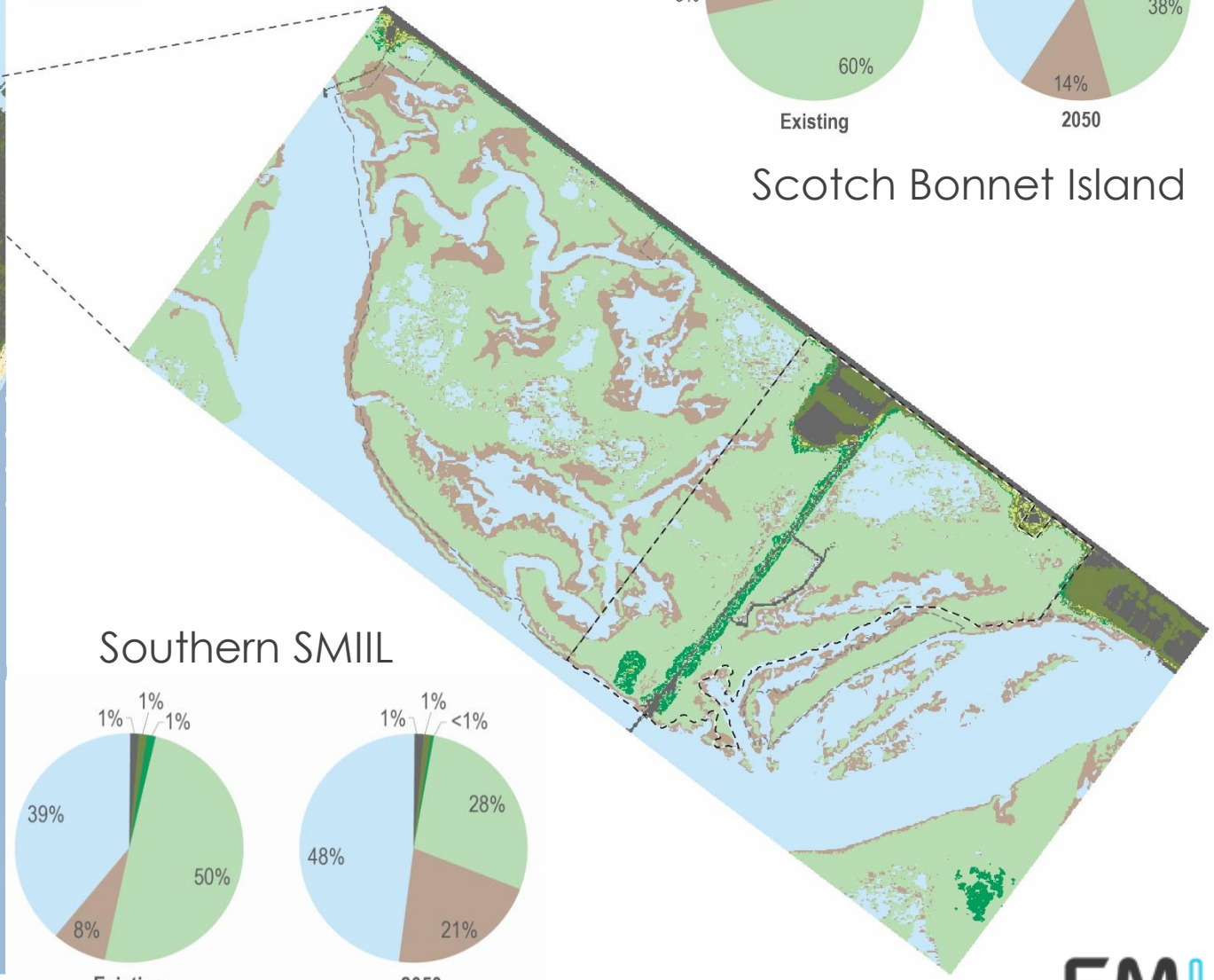
Legend (SLAMM)

- Open Ocean
- Estuarine Water
- Developed Dry Land
- Undeveloped Dry Land
- Shrub/ Scrub
- Regular Flooded Marsh (Low Marsh)
- Irregular Flooded Marsh (High Marsh)
- Tidal Flat
- Ocean Beach

Elevation-derived habitat distributions via SLAMM:



Scotch Bonnet Island



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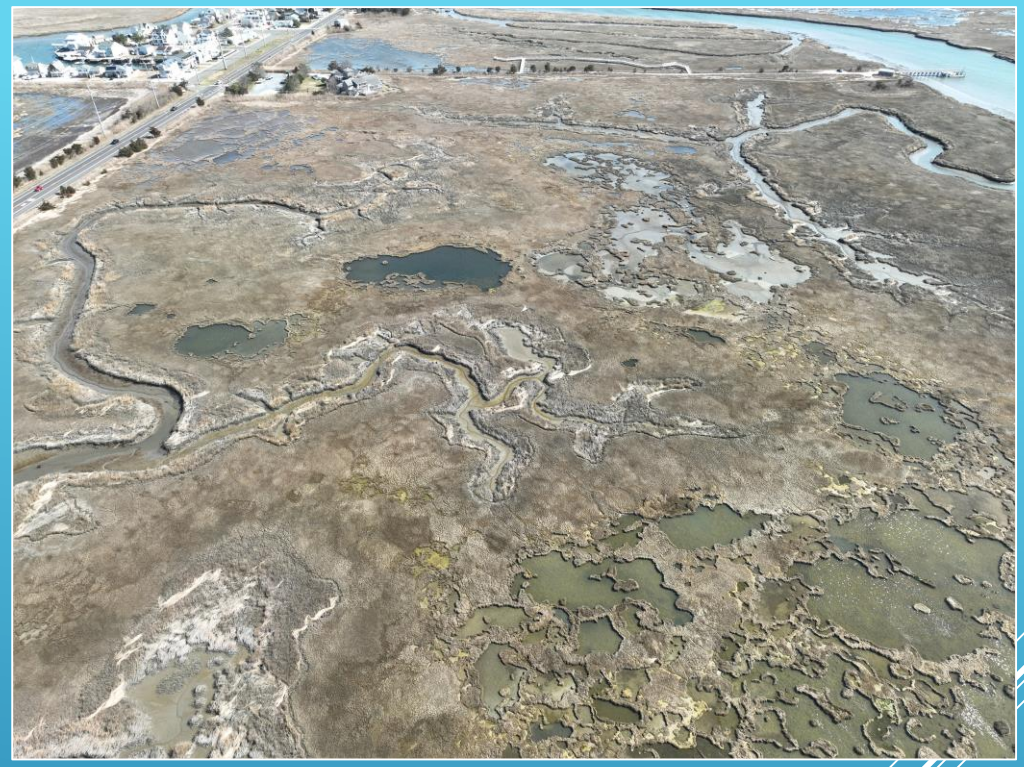
SCOTCH BONNET ISLAND MARSH ELEVATION ENHANCEMENT PROJECT

- Goals
  - Stabilize Failing Marsh Platform
    - Infill Expanding Pools
    - Slow Marsh Dissection
  - Reverse Marsh Acreage Loss
    - 1941 to 2019 Lost 34% of Marsh Area (30 acres)
    - Projections to 2050 – Lose Additional 33% (20 acres)
- Ecological Targets
  - Increase Marsh Platform Resiliency by Raising Marsh Elevation into Low Marsh Elevation Range
    - Currently at the Lower Limit of Low Marsh (2.3'NAVD88) near Mudflat Boundary (<2.3' NAVD88)
    - Target 2030 Low Marsh Elevations (2.8' – 3.5' NAVD88)
  - Increase Low Marsh Acreage by Up to 8 acres
  - Slow and Reverse Tidal Channel Widening and Expansion



EVOLUTION OF HABITAT ELEVATION RANGES

	2019 TWI		2030 Rutgers		2050 Rutgers	
SLR	n/a		0.8 - 1.1		1.1 - 2.1	
	Elevation Range					
Habitat	Low	High	Low	High	Low	High
UP	3.281	-	3.961	-	4.893	-
HM	2.953	3.281	3.493	3.961	4.275	4.893
LM	2.297	2.953	2.857	3.493	3.417	4.275
MF	0.656	2.297	1.616	2.857	2.116	3.417
OW	-	0.656	-	1.616	-	2.116

- Habitat maintenance over time requires increasing elevations
- Presumes salt marsh habitat is primarily guided by elevation related to sea level
- TWI elevations determined via direct elevation measurements and USACE 2018 DEM via LIDAR
- Future habitat elevation ranges are via SLAMM (Sea Level Affecting Marsh Model) to account for sea level rise, accretion, and subsidence via published resources

LESSONS LEARNED AND SOME GUIDING THOUGHTS

- Don't over engineer projects
- BUDM projects are water management projects
  - Flow velocities from 24" dredge pipe are 22,000 gals/min and 80% water
- Sediment containment is challenging, expensive, and often creates its own negative feedback loops
  - Unconfined placement allows material to spread over wide areas and for maintenance/development of tidal flushing
  - Building elevation may require multiple lifts or partial containment
- Adaptive management during dredging and placement is challenging
  - Placement sites are inaccessible / Pipe movements extremely difficult
- Dredging efficiency and effectiveness of placements enhanced by:
  - Using Y-valves and other tools to allow placement in multiple sites easily and switching between sites
  - Can help control flow velocities and provide resting and settling times for placed material
  - Allows for placement in different areas based on tides
- Plan for placement at multiple sites to manage changing dredge material composition

LESSONS LEARNED AND SOME GUIDING THOUGHTS

- Ecological Need and Goals Underpin Projects
  - Driven by material type and location
  - Marsh need is great so marrying need with material availability feasible
  - Understanding progress towards construction/ecological goals during placement difficult and ultimate goal attainment evolves as site evolves.
  - Structure project goals to include habitat and species benefits during site evolution
- Vegetation recovery takes ~two growing seasons to initiate
  - Recovery has been almost entirely by new seeding from the seedbank
  - Planting should be delayed for at least two growing seasons if needed at all
  - Balance placing in thin layers to preserve existing vegetation (rare) vs thicker placement for more ecological uplift
- Consider role of monitoring and keep focused on adaptive management or to advance practices

RELEVANT PUBLICATIONS

- Beardsley, Welp, Harris, McFall, Tyler, and Savant (2022): Sediment Distribution Pipe: Modeling Tool and field Application. WEDA Journal of Dredging, v. 20 (1) 16-37.
- Chasten, Goldberg, Pasquale, Piercy, Welp, and Golden (2016): Recent Experience with Channel Dredging and Placement to Restore Wetlands In New Jersey, WODCON XXI PROCEEDINGS.
- Chasten, M., Tedesco, L., and Kopkash, G. (in press). "Advancing Sediment Solutions in the Seven Mile Island Innovation Lab," Proceedings, 37th International Conference on Coastal Engineering, December 2022, Sydney, Australia.
- Chasten, M., Tedesco, L., Kopkash, G. (in press). "Seven Mile Island Innovation Laboratory: Advancing Beneficial Use Practices to Support Coastal System Resilience," Proceedings, Coastal Sediments 2023, April 2023, New Orleans, LA.
- Collins, Ferguson, Morey, and Tedesco (2021): Cape May Wetlands Wildlife Management Area Habitat Restoration Monitoring and Evaluation, https://wetlandsinstitute.org/wp-content/uploads/2022/11/FG19-057_TWI_2019-2021_FINAL.pdf
- Ecoshape (2018): Living Lab for MUD Brochure, www.ecoshape.org.
- Fall, Perkey, Tyler, and Welp (2021): Field Measurement and Monitoring of Hydrodynamic and Suspended Sediment with the Seven Mile Innovation Laboratory, New Jersey, ERDC/CHL TR-21-9, https://permanent.fdlp.gov/gpo185925/ERDC-CHLTR-21-9(1).pdf
- Fall, Perkey, Tedesco and Chasten (2022): Impact of Strategic, Unconfined, Dredged Material Placement on Turbidity Within a Shallow Back Bay System: observations from Seven Mile Island Innovation Laboratory, NJ, WEDA Journal of Dredging, v. 20 (1) 38-49.
- Rochette, Chasten, Tedesco, and Kopkash (2019): Seven Mile Island Innovation Laboratory, Overview and Purpose Fact Sheet, www.nap.usace.army.mil.
- Tedesco, Chasten, Ferguson, Collins, and Davis (2021): Using Dredged Sediments to Uplift Marshes, Build Subtidal Shallows and Provide Marsh Edge Protection in the Seven Mile Island Innovation Lab, Delaware Estuary Science and Environmental Summit, https://delawareestuary.org/delaware-estuary-science-and-environmental-summit/

ADVANCING SCIENCE AND PRACTICE AT THE SEVEN MILE ISLAND INNOVATION LABORATORY

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