Engineering with Nature for Coastal Resilience

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New York State Great Lakes Nature-Based Shorelines Workshop

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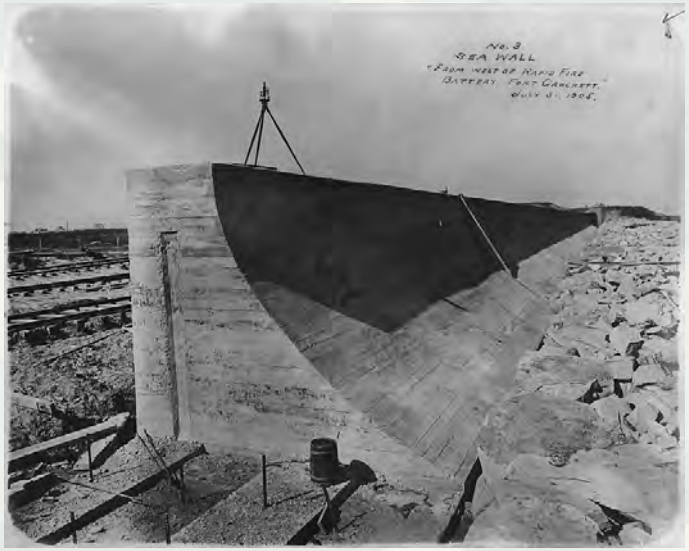
Coastal Resilience is Serious Business: Lives are at Stake

Galveston Hurricane (1900)

- Landfall 8 September 1900
- Estimated Category 4 Hurricane
  - 145 mph winds
- Estimated death toll: 6,000-12,000
- Galveston Seawall
  - Constructed:1902-1963
  - >10 miles long



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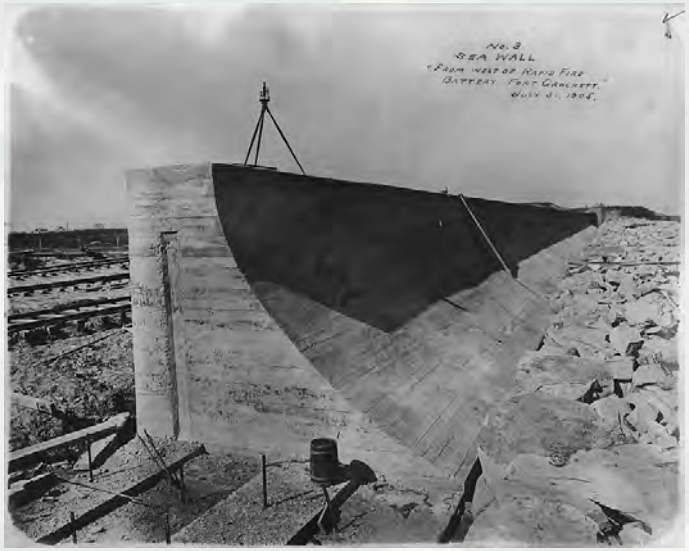
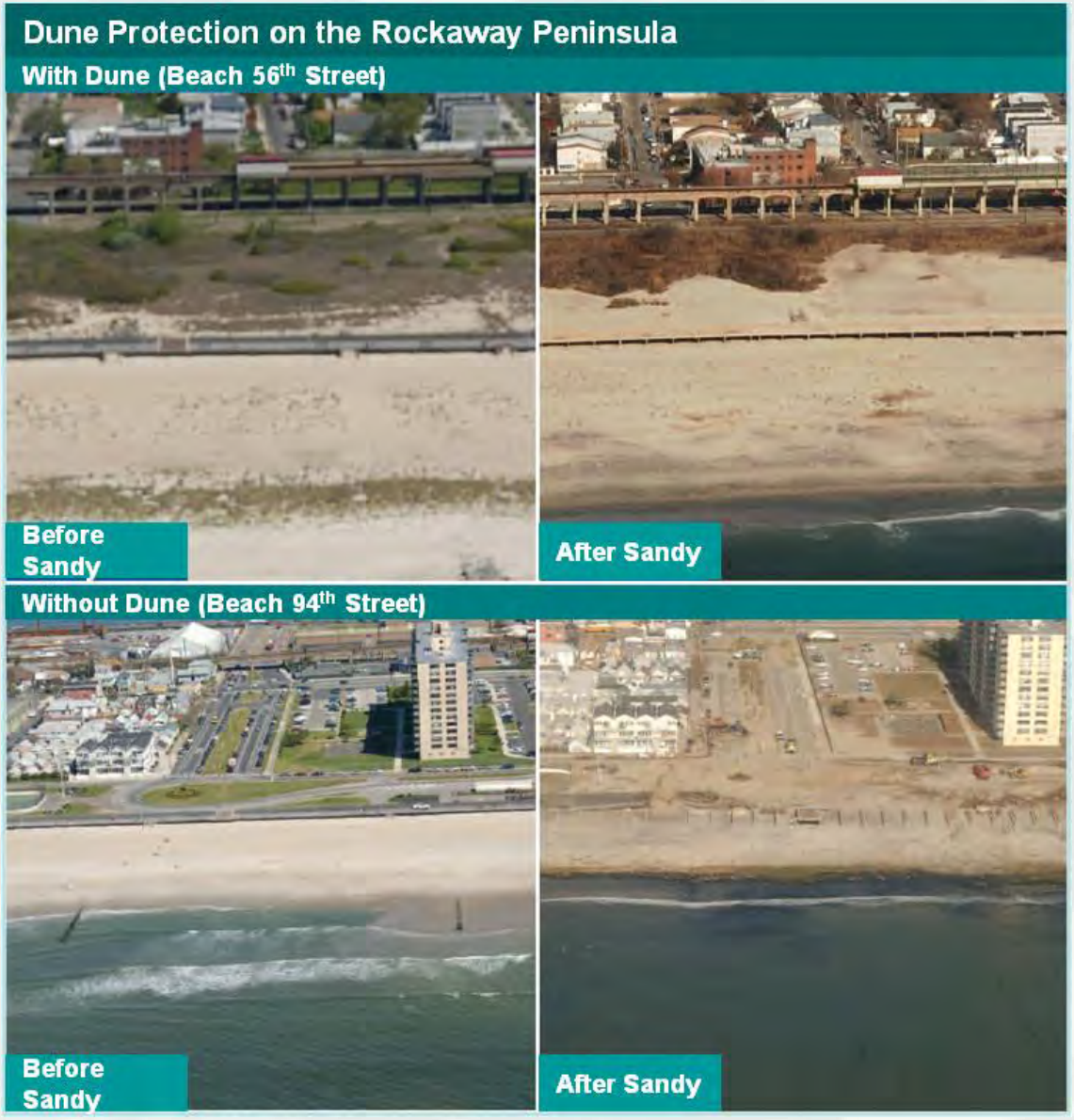
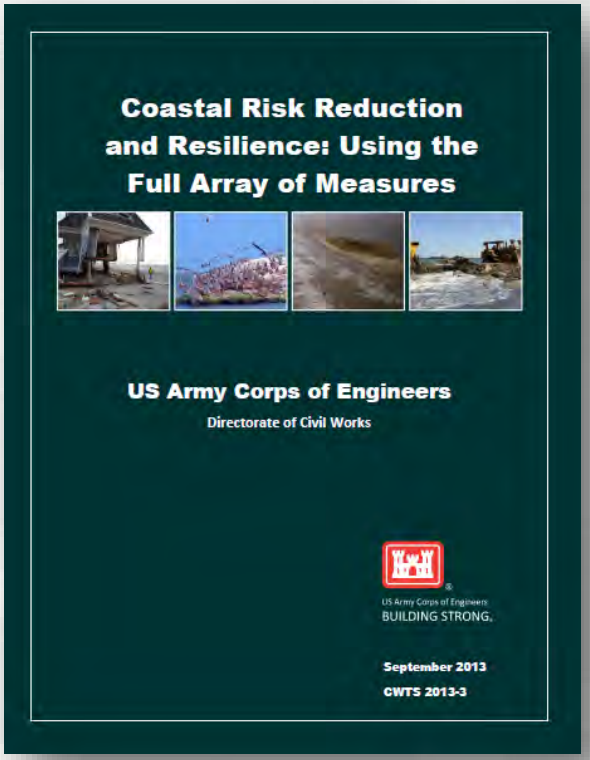
Nature-Based Features Perform During Hurricane Sandy (2012)

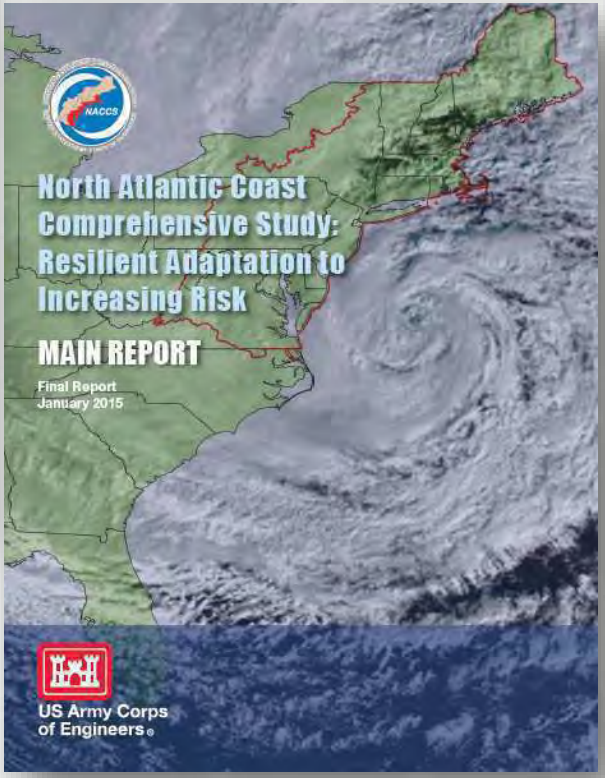


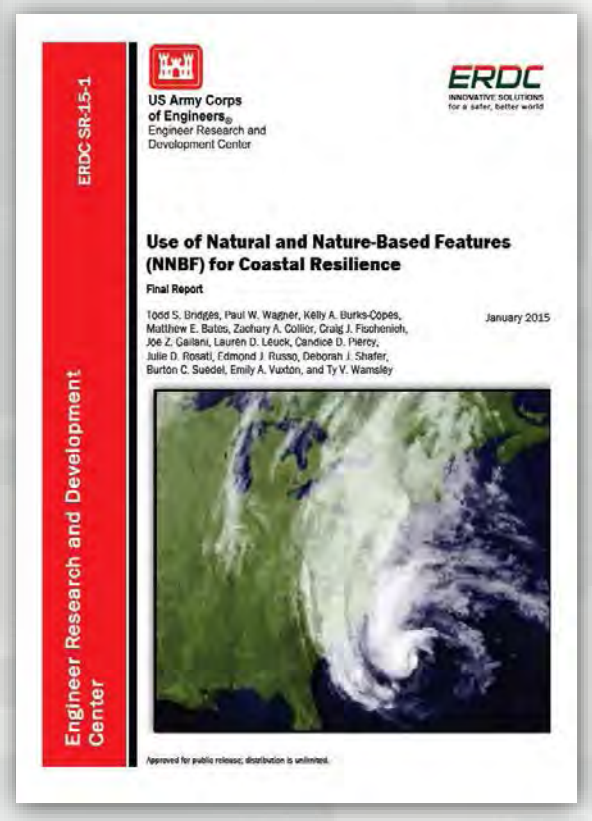


http://www.nyc.gov/html/sirr/html/report/report.shtml

The North Atlantic Coast Comprehensive Study







Engineering Performance: Nature-Based Features Work in Different Ways

Natural and Nature-Based Infrastructure at a Glance

GENERAL COASTAL RISK REDUCTION PERFORMANCE FACTORS:
STORM INTENSITY, TRACK, AND FORWARD SPEED, AND SURROUNDING LOCAL BATHYMETRY AND TOPOGRAPHY

Dunes and Beaches

Benefits/Processes

Break offshore waves

Attenuate wave energy

Slow inland water transfer

Performance Factors

Berm height and width

Beach Slope

Sediment grain size and supply

Dune height, crest, width

Presence of vegetation

Vegetated Features: Salt Marshes, Wetlands, Submerged Aquatic Vegetation (SAV)

Benefits/Processes

Break offshore waves

Attenuate wave energy

Slow inland water transfer

Increase infiltration

Performance Factors

Marsh, wetland, or SAV elevation and continuity

Vegetation type and density

Oyster and Coral Reefs

Benefits/Processes

Break offshore waves

Attenuate wave energy

Slow inland water transfer

Performance Factors

Reef width, elevation and roughness

Barrier Islands

Benefits/Processes

Wave attenuation and/or dissipation

Sediment stabilization

Performance Factors

Island elevation, length, and width

Land cover

Breach susceptibility

Proximity to mainland shore

Maritime Forests/Shrub Communities

Benefits/Processes

Wave attenuation and/or dissipation

Shoreline erosion stabilization

Soil retention

Performance Factors

Vegetation height and density

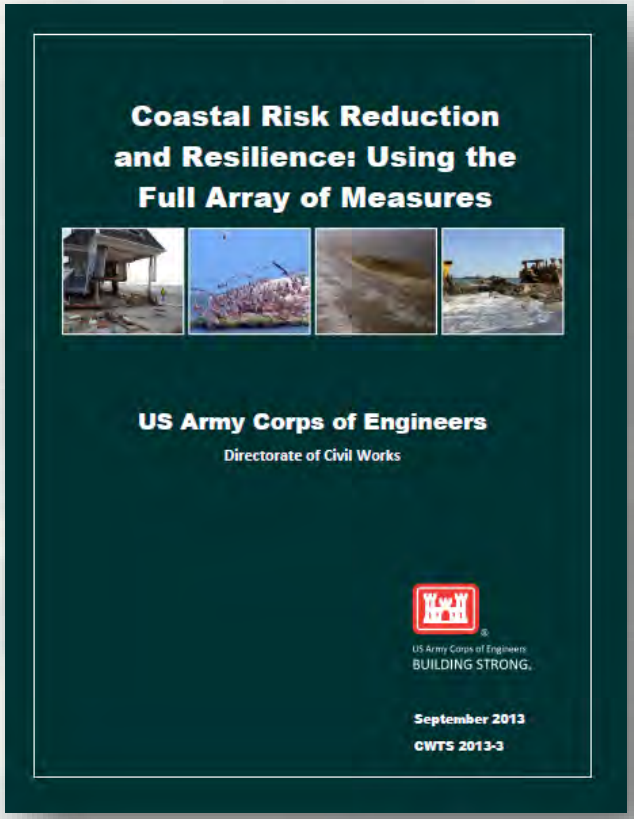
Forest dimension

Sediment composition

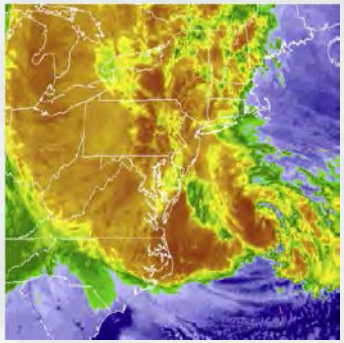
Platform elevation

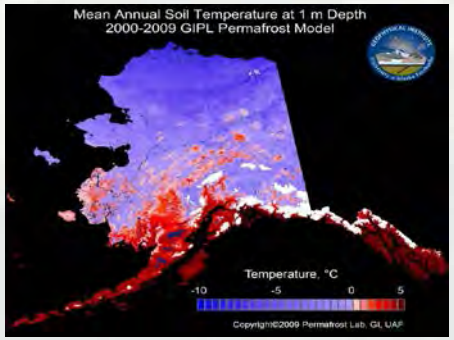
A Systems Approach: Coastal Risk Reduction and Resilience

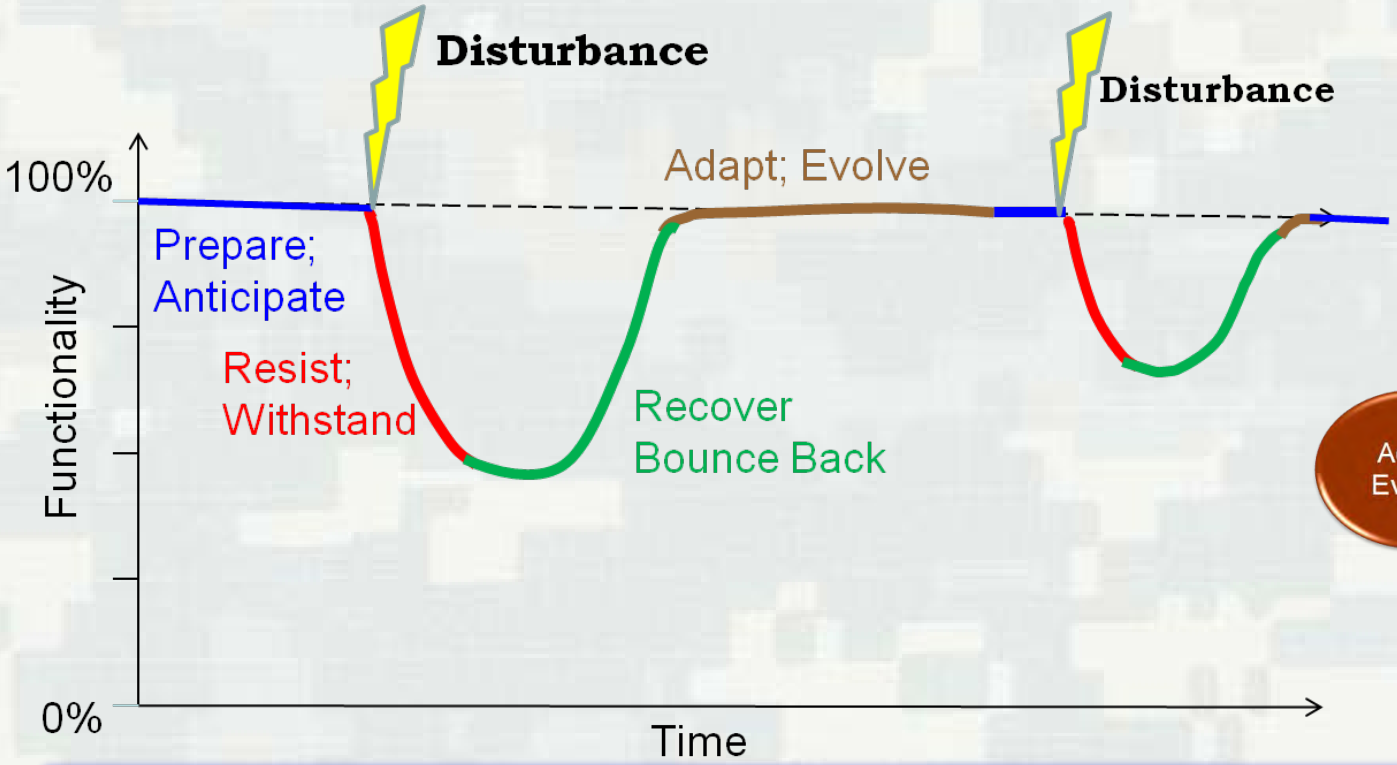
"The USACE planning approach supports an ***integrated approach*** *to reducing coastal risks and increasing human and ecosystem community resilience through a combination of* ***natural, nature-based, non-structural and structural measures****. This approach considers the engineering attributes of the component features and the dependencies and interactions among these features over both the short- and long-term. It also considers the* ***full range of environmental and social benefits*** *produced by the component features."*



http://www.corpsclimate.us/docs/USACE_Coastal_Risk_Reduction_final_CWTS_2013-3.pdf







Resilience: the ability of a ***system*** to **Prepare for**, **Resist**, **Recover**, and **Adapt** to achieve functional performance under the stress of disturbances through time.

In the Context of Coastal Resilience…

- What opportunities are there for achieving better alignment of natural and engineered systems?
  - Can improved alignment reduce risks to life and property?
  - What range of services can be produced through such alignment?
  - What are the science and engineering needs in order to achieve better alignment?

Sustainable Solutions Vision: "Contribute to the strength of the Nation through innovative and environmentally sustainable solutions to the Nation's water resources challenges."

Natural and Nature-Based Features Evaluation and Implementation Framework

ORGANIZATIONAL ALIGNMENT

EVALUATION

IMPLEMENTATION

Iterate as Needed

Identify and Organize Stakeholders, Partners and Authorities

Define Physical and Geomorphic Setting

Assess Vulnerability and Resilience

Identify NNBF Opportunities
- Formalize NNBF Objectives
- Identify NNBF Alternatives
- Define NNBF Performance Metrics

Evaluate NNBF Alternatives
- Tier 1
- Tier 2
- Tier 3

Advance through Tiers as Appropriate

Select NNBF Alternatives

Design Implementation Plan: Elaborate Operational and Engineering Practices

Implement NNBF Alternative

Monitor for Performance and Assess Ecosystem Goods and Services

Feedback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DEPARTMENT OF THE INTERIOR


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FEMA


MDE


USGS
science for a changing world


BOEM
Bureau of Ocean Energy Management


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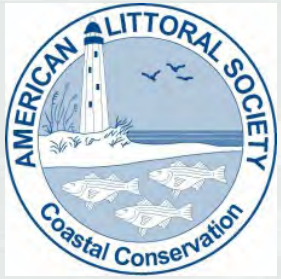
UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY


The Nature
Conservancy


COMMONWEALTH of MASSACHUSETTS
DIVISION of FISHERIES & WILDLIFE


DELAWARE DIVISION
FISH & WILDLIFE


AMERICAN LITTORAL SOCIETY
Coastal Conservation


NATIONAL
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NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE


U.S. DEPARTMENT OF THE INTERIOR
MARCH 3, 1849


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American Society of Civil Engineers


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MARYLAND
DEPARTMENT OF
NATURAL RESOURCES

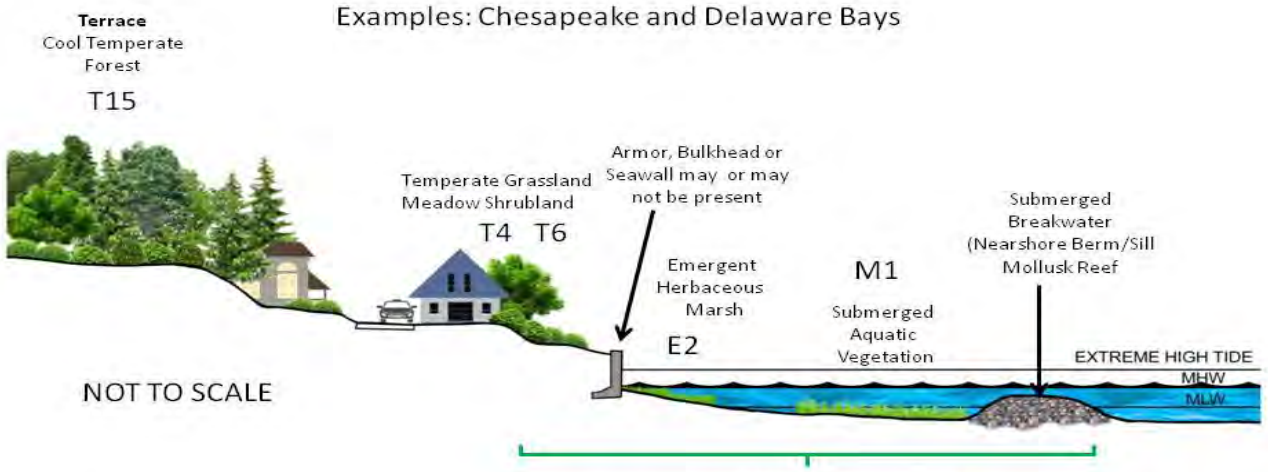

D·E·M


MASSACHUSETTS OFFICE OF
COASTAL ZONE MANAGEMENT


THE PORT AUTHORITY
OF NEW YORK & NEW JERSEY

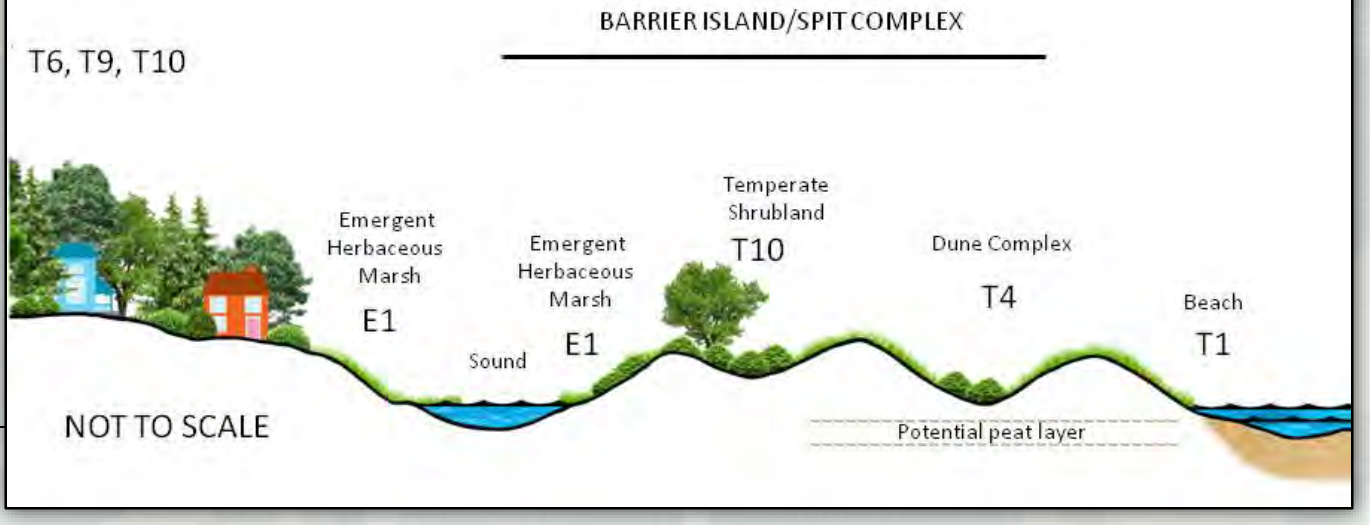
1 A 1-1. Drowned River Valley

Examples: Chesapeake and Delaware Bays



II B 1. Marine Depositional Barrier Coast

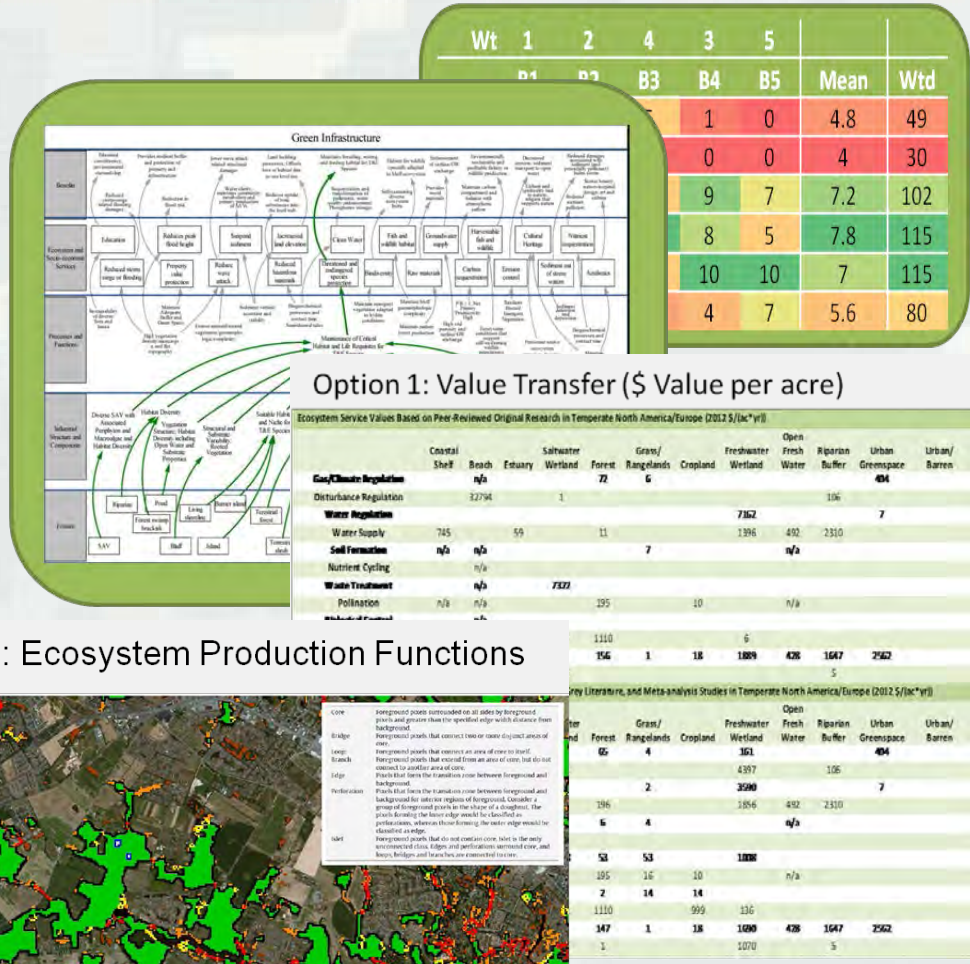
Examples: Virginia coast



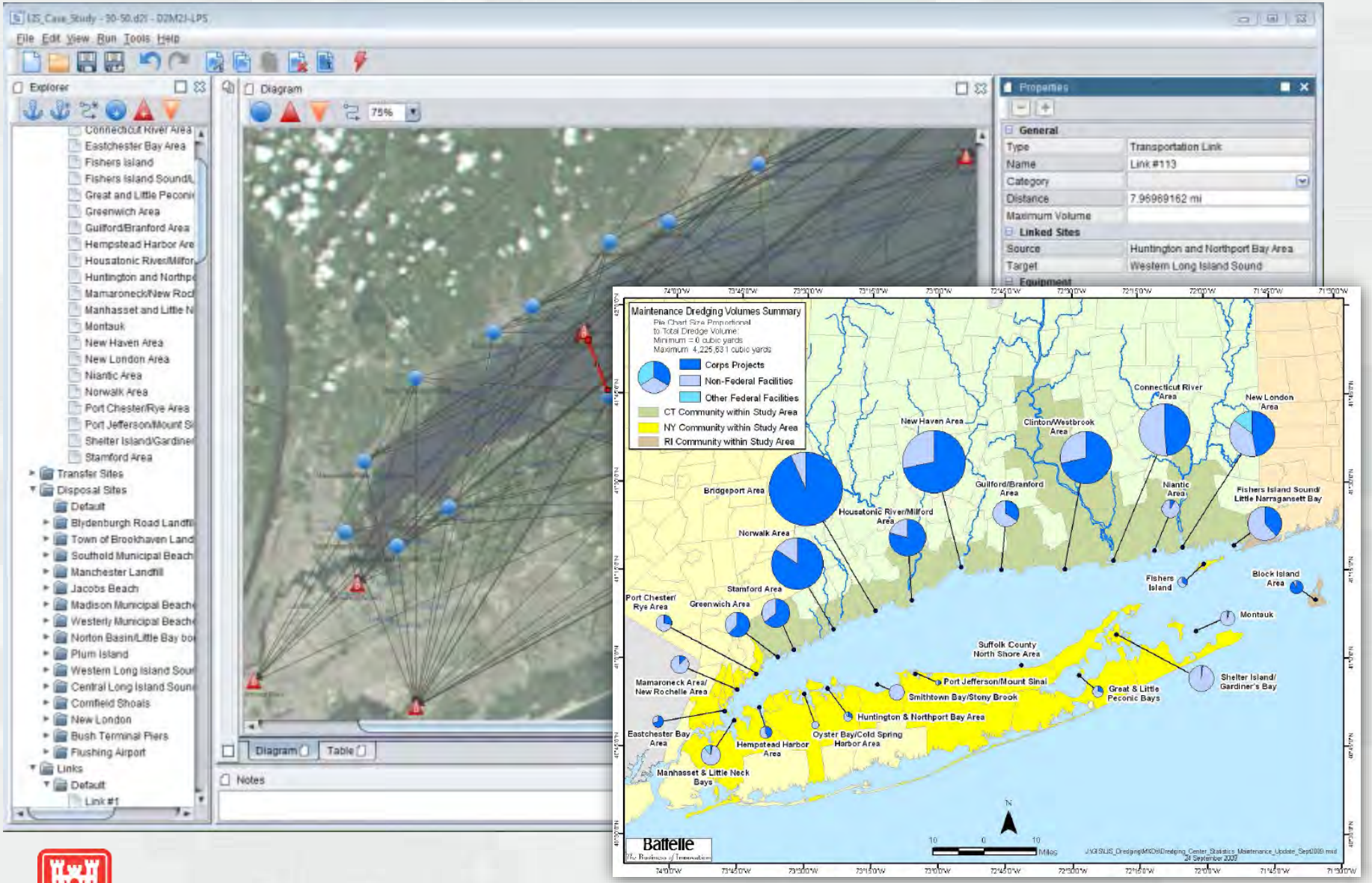
System Performance Evaluation

- **Level 1** – Qualitative characterization of performance
- **Level 2** – Semi-quantitative characterization of performance
- **Level 3** – Quantitative characterization of performance

72 individual performance metrics identified for NNBF



D2M2: Dredged Material Management Decisions

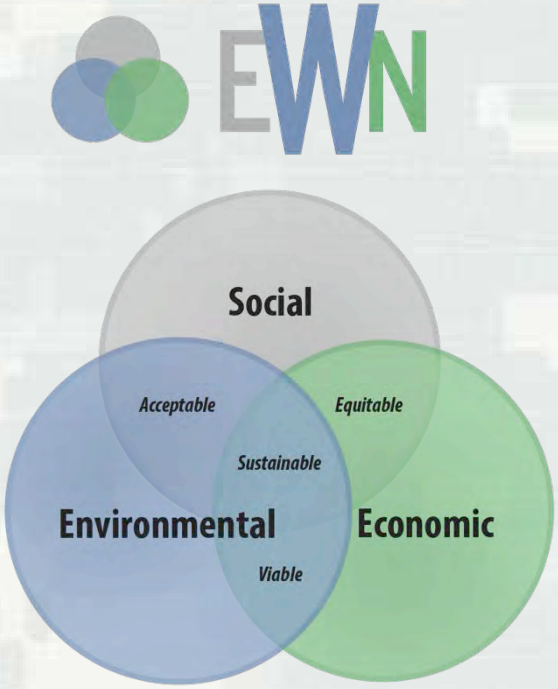


Engineering With Nature…

…the intentional alignment of natural and engineering processes to efficiently and sustainably deliver economic, environmental and social benefits through collaborative processes.

Key Elements:

- Science and engineering that produces operational efficiencies
- Using natural process to maximum benefit
- Broaden and extend the benefits provided by projects
- Science-based collaborative processes to organize and focus interests, stakeholders, and partners



EWN Across USACE Mission Space

- Navigation
  - Strategic placement of dredged material supporting habitat development
  - Habitat integrated into structures
- Flood Risk Management
  - Natural and Nature-Based Features to support coastal resilience
  - Levee setbacks
- Ecosystem Restoration
  - Ecosystem services supporting engineering function
  - “Natural” development of designed features
- Water Operations
  - Shoreline stabilization using native plants
  - Environmental flows

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EWN Status

- *Engineering With Nature* initiative started within USACE Civil Works program in 2010. Over that period we have:
  - Engaged across USACE Districts (23), Divisions, HQ; other agencies, NGOs, academia, private sector, international collaborators
    - Workshops (>20), dialogue sessions, project development teams, etc.
  - Implementing strategic plan
  - Focused research projects on EWN
  - Field demonstration projects
  - Communication plan
  - District EWN Proving Grounds established
  - Awards
    - 2013 Chief of Engineers Environmental Award in Natural Resources Conservation
    - 2014 USACE National Award-Green Innovation

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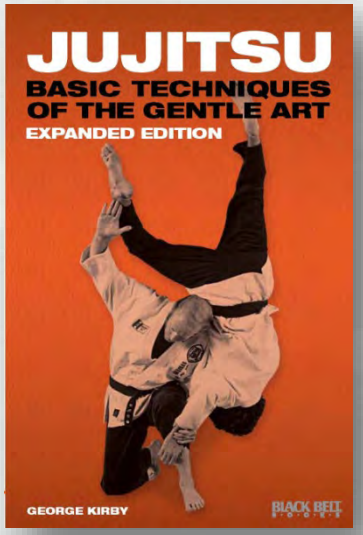
Opportunities to *Engineer With Nature*

- **Key Factors, the 4 Ps**
  - ► Processes
    - Physics, geology, biology…
    - Foundation of “coastal engineering Jujitsu”
  - ► Programmatic context
    - Planning, engineering, constructing, operating, or regulating
  - ► Project scale
    - Individual property owner to an entire coastal system
  - ► Performance
    - Configuring the system
    - Quantifying the benefits



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Strategic Sediment Placement: Nearshore Berms

Small Dispersive Placements

Shark River Inlet (NAN)

Positive Recreational Feature

Huntington Beach (SANDAG)

Assateague Island, MD (NAB)

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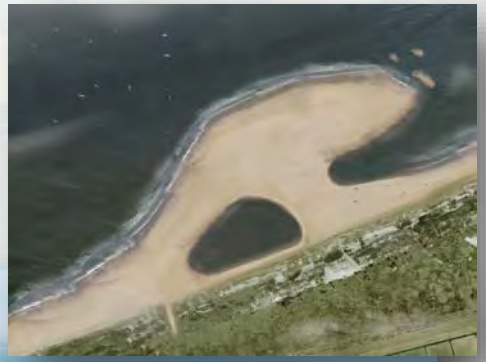
Dutch Sand Engine

- 2011 construction
- 21.5 mcm of sand



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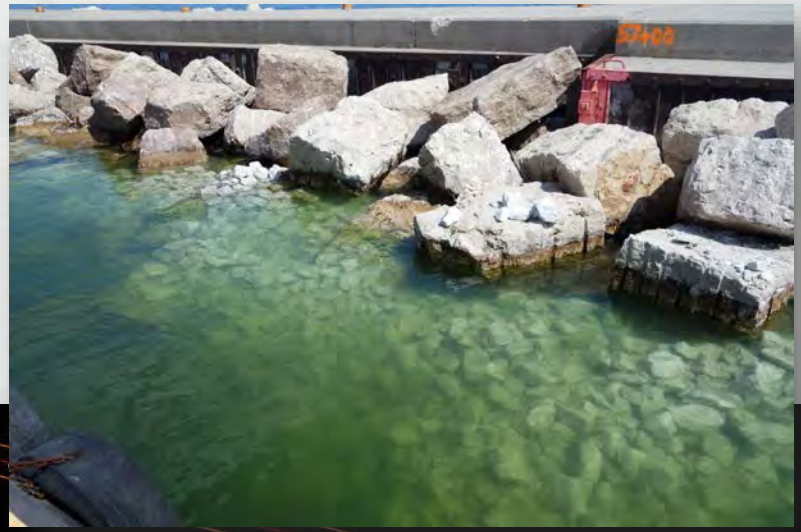
Horseshoe Bend, Atchafalaya River

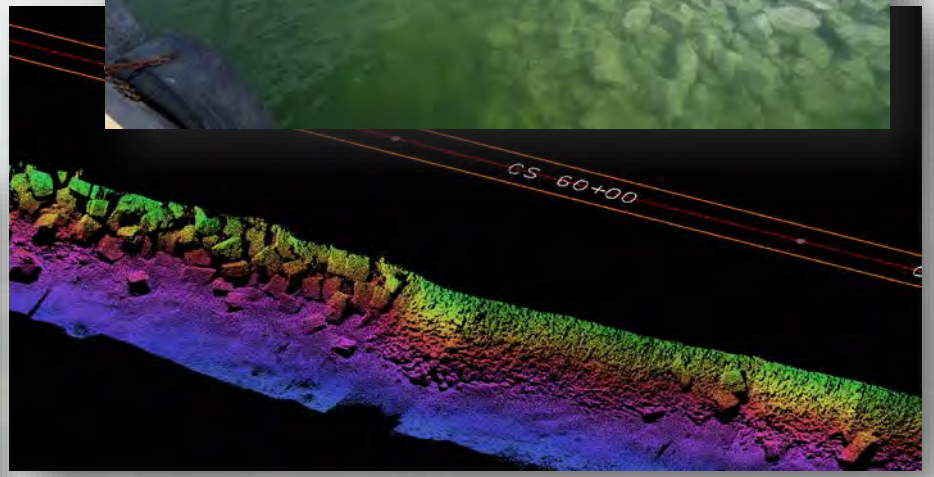
- Options for managing dredged material via shore-based wetland creation were exhausted
- Strategic placement of sediment (0.5-1.8 mcy/1-3 yrs) was used to create a ~35 ha island
- Producing significant environmental and engineering benefits
- Project won WEDA's 2015 Award for Environmental Excellence

Example EWN Solutions: Green Breakwaters

Ashtabula Harbor

Milwaukee Harbor





Deepening of Boston Harbor

- Project anticipates generating 10+ MCY of clay/till and 0.5 to 1 MCY of rock
- Evaluating potential beneficial use:
  - Capping of offshore radioactive waste disposal site
  - Nearshore placement of rock to create reefs and berms to attenuate waves and support habitat development

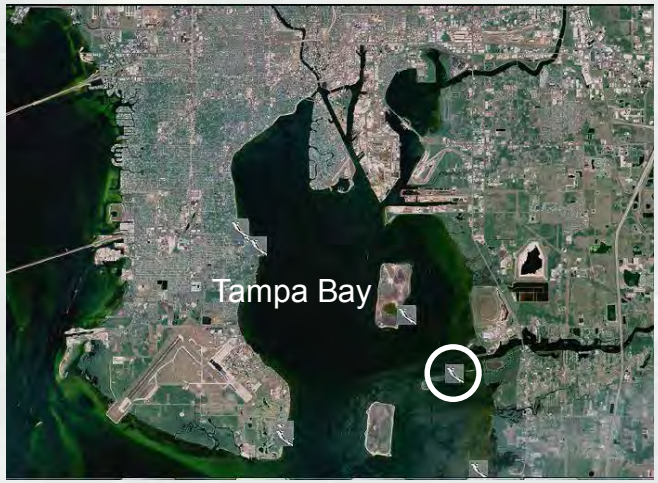
Beaches Provide Critical Habitat

- Many rare and/or endangered species depend on beaches for foraging and breeding
- Example:
  - 685 miles of SE Atlantic and Gulf beaches designated as critical habitat for loggerhead sea turtles
- A current need: defining engineering approaches that integrate shoreline protection and habitat requirements

Coastal Dunes

Alafia Banks Bird Sanctuary, FL

- 8000 lb reef module breakwaters (930 ft)
- Shore protection for Audubon bird sanctuary islands
- Help restore oyster populations
- Provide habitat



www.reefball.org

USACE Galveston and Buffalo Districts: EWN "Proving Grounds"

- EWN Proving Ground Kick-Off Workshops
  - October (SWG) and December (LRB) 2014
  - ~70 participants
  - SWG, SWD, LRB, ERDC, IWR and HQ
- Identified opportunities to implement EWN within current and future programs and projects
- Emphasis on solution co-development

US Army Corps of Engineers
Buffalo District
BUILDING STRONG®

Coastal NJ, Philadelphia District

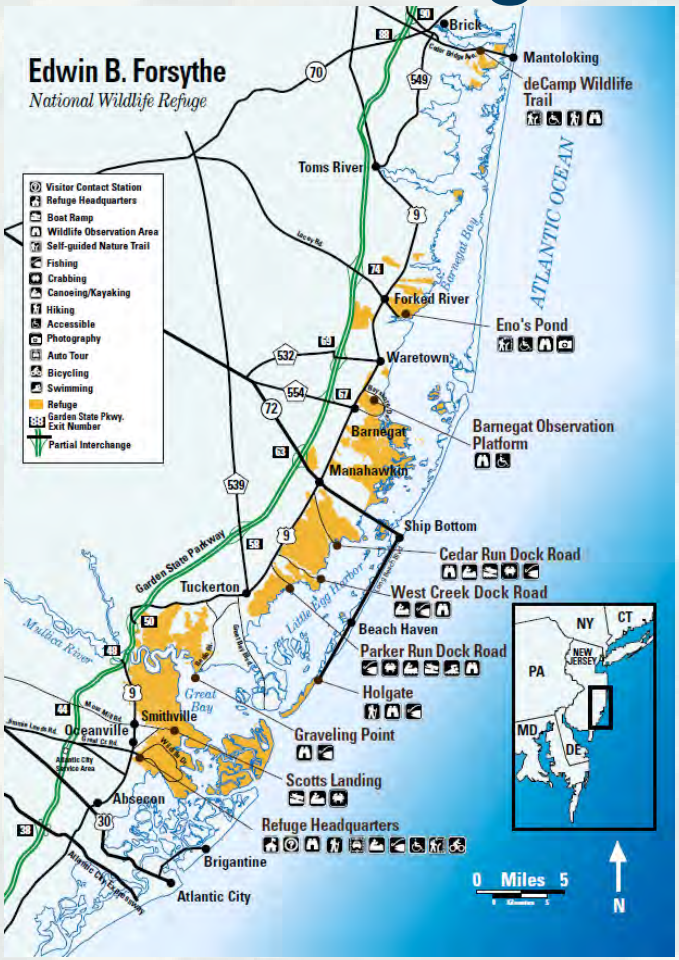
December 2014

Stone Harbor

Avalon

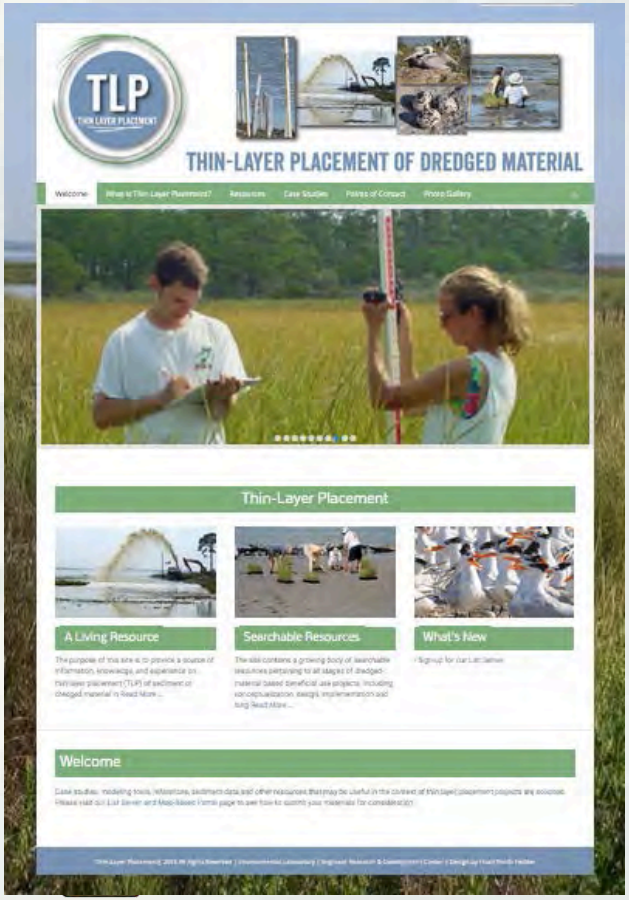
US Fish and Wildlife Service
Forsythe National Wildlife Refuge

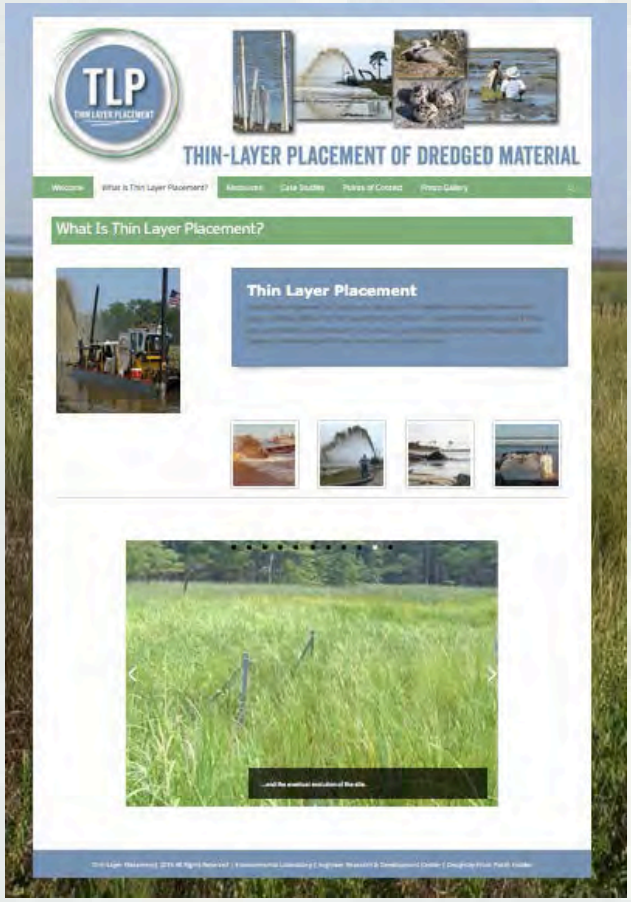
- Forsythe NWR: >40,000 acres of wetlands and other habitat in coastal NJ
- Collaboration objective: Enhance ecosystem resilience through engineering and restoration
- Means: Smart use of sediment resources and EWN principles and practices

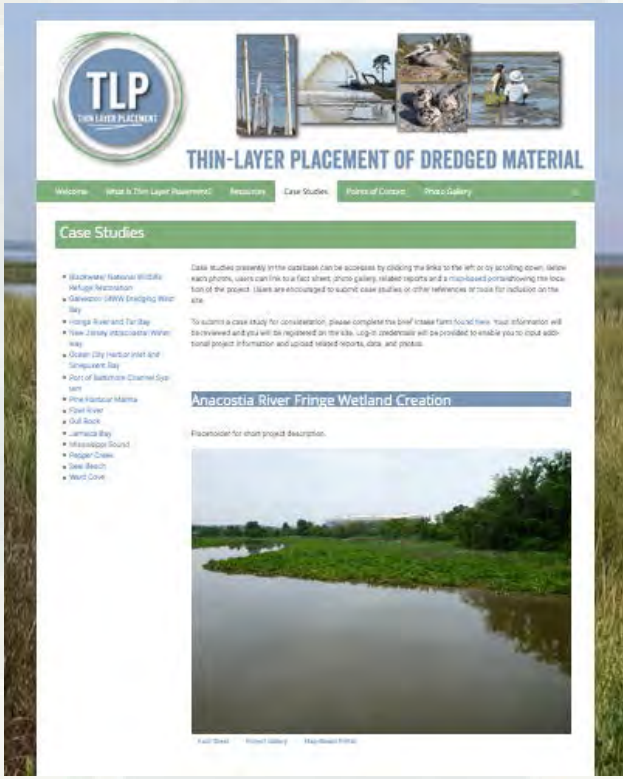


Thin-Layer Placement Website

Coming soon to www.engineeringwithnature.org







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EWN Action Demonstration Projects, 1

- Sediment Retention Engineering to Facilitate Wetland Development (San Francisco Bay, CA)
- Realizing a Triple Win in the Desert: Systems-level Engineering With Nature on the Rio Grande (Albuquerque, NM)
- Atchafalaya River Island and Wetlands Creation Through Strategic Sediment Placement (Morgan City, LA)
- Portfolio Framework to Quantify Beneficial Use of Dredged Material (New Orleans and New England)
- Engineering Tern Habitat into the Ashtabula Breakwater (Ashtabula, OH)
- Living Shoreline Creation Through Beneficial Use of Dredged Material (Duluth, MN)
- A Sustainable Design Manual for Engineering With Nature Using Native Plant Communities

EWN Action Demonstration Projects, 2

- Landscape Evolution of the Oil Spill Mitigation Sand Berm in the Chandeleur Islands, Louisiana
- Guidelines for Planning, Design, Placement and Maintenance of Large Wood in Rivers: Restoring Process and Function (Collaboration with BoR)
- The Use and Value of Levee Setbacks in Support of Flood Risk Management, Navigation and Environmental Services (a strategy document)
- Strategic Placement of Sediment for Engineering and Environmental Benefit (an initial guide to opportunities and practices)
- Use of Activated Carbon to Manage Contaminant Exposures Associated with Open-Water Placement

Next Steps for Science and Engineering…

- How will integrated infrastructure systems evolve over time in dynamic coastal environments?
- What processes and engineering requirements are critical to performance?
- How can integrated systems be assembled to reduce long-term operations and maintenance?
- How can field-scale demonstration projects be used to accelerate progress?

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High Points

- Develop a coherent vision!
  - And stories to make it tangible
- Focus energy to facilitate innovation in both technical and business processes
- Elevate communication about advancing practice
- Accelerate progress through co-development of solutions
  - Across government
  - Between government and industry
  - Among government, industry, academia, and NGOs