U.S. ARMY CORPS OF ENGINEERS AND ENGINEERING WITH NATURE®

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EWN®

U.S.ARMY

US Army Corps of Engineers®

COASTAL & HYDRAULICS LABORATORY

OUTLINE

- What is the Corps of Engineers
- What is the Engineer Research and Development Center – Coastal and Hydraulics Laboratory
- Engineering With Nature® Initiative

US ARMY CORPS OF ENGINEERS

How to Pronounce Corps of Engineers

- Corps comes from the Latin word “corpus” – meaning body
- The p and s are silent because of the French origin
- Dictionary.com: Corps – a group of persons associated or acting together
- Other Corps:
  - US Marine Corps
  - Peace Corps
  - Diplomatic Corps
  - Press Corps

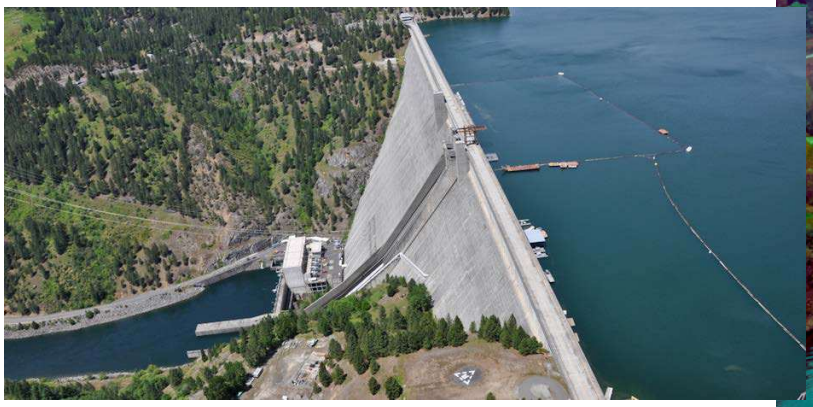
HISTORY – US ARMY CORPS OF ENGINEERS

- Founded in 1775
- Many politicians wanted the Corps to contribute to both military construction and works "of a civil nature."
- Throughout the 19th century, the Corps supervised the construction of coastal fortifications and mapped much of the American West.
- Constructed
  - Lighthouses
  - Jetties and Piers f
  - Mapped the Navig

US ARMY CORPS OF ENGINEERS

Key Civil Works Missions:

- Navigation
- Flood Risk Management
- Emergency Operations
- Ecosystem Restoration
- Water Operations

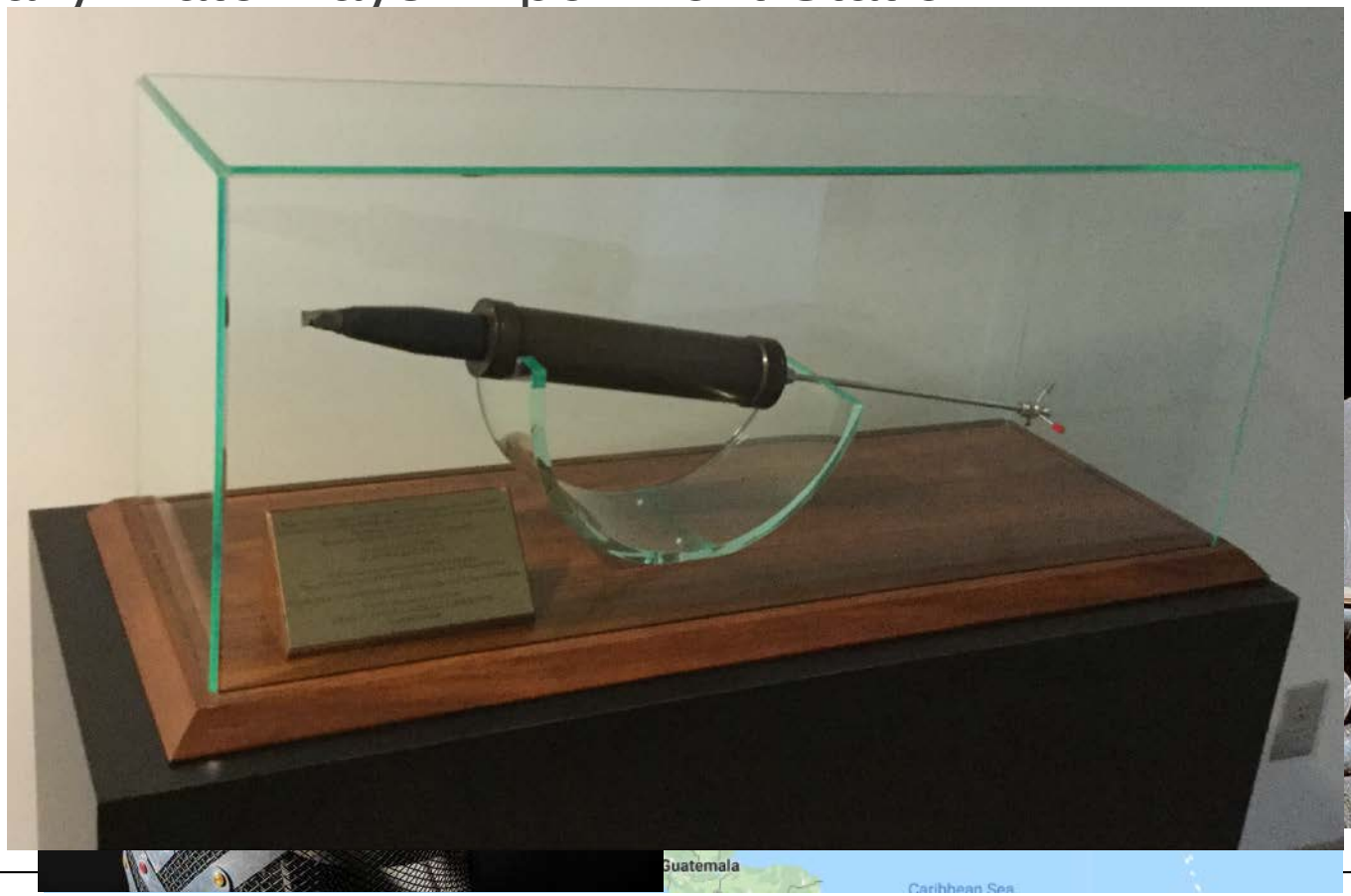


OUTLINE

- What is the Corps of Engineers
- **What is the Engineer Research and Development Center – Coastal and Hydraulics Laboratory**
- Engineering With Nature® Initiative

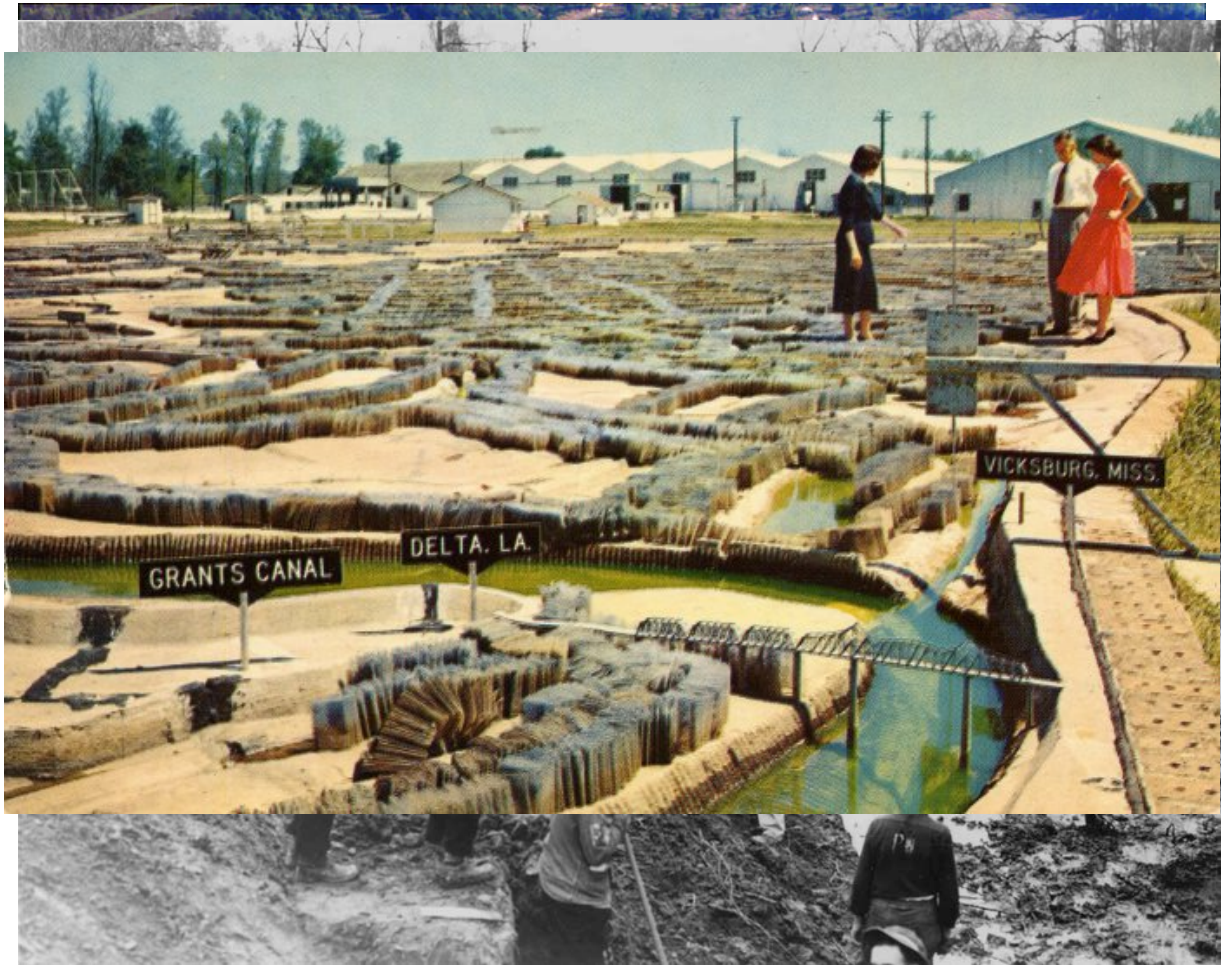
ENGINEER RESEARCH AND DEVELOPMENT CENTER

- Conducts R&D for the Corps of Engineers
- Headquartered in Vicksburg, Mississippi
- Originally Waterways Experiment Station



MISSISSIPPI RIVER BASIN MODEL

200 acres
1:100 vertical
1:2000 horizontal
Network of nearly
  13 km of streams
Constructed 1943
Partially constructed by German POW's



COASTAL AND HYDRAULICS LABORATORY FACILITIES

- 1.5 million square feet (140,000 m^2)
  - 1 Main Building
  - 14 Hangars

1) 3 Real-time Ship Tow Simulators
2) Full-Scale Levee Breach Facility
3) 3 main wave basins:
   - 2 Fixed-angle Wave Generators
   - Directional Spectra Wave Generator
4) 5 wave flumes (0.3-3 m)
5) 12+ hydraulic flumes (0.5-6 m)
6) Numerous basins for rivers, dams, and harbor models

CHL FACILITIES (CONT.)

7) Recently purchased from Texas A&M:
   - Directional Spectra Wave Generator
   - Dredge carriage
8) Mobile: SEDFlume - estimate gross erosion rates
9) Remotely: Field Research Facility in Duck, NC
   - 30+ years of continuous hydrodynamic and bathymetry measurements
   - 560 m pier to ~7m contour

OUTLINE

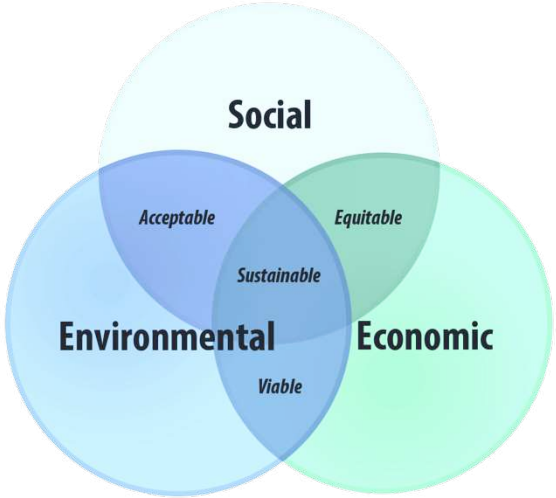
- What is the Corps of Engineers
- What is the Engineer Research and Development Center – Coastal and Hydraulics Laboratory
- **Engineering With Nature® Initiative**

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® OVERVIEW

Engineering With Nature initiative started within USACE Civil Works program in 2010

- Engaging across USACE Districts (23), Divisions, HQ; other agencies, NGOs, academia, private sector, international collaborators
  - Workshops (>20), dialogue sessions, project development teams, etc.
- Guided by a strategic plan
- Informed by focused R&D
- Demonstrated with field projects
- Advanced through partnering
- Shared by strategic communications
- Marking progress
  - 2013 Chief of Engineers Environmental Award in Natural Resources Conservation
  - 2014 USACE National Award-Green Innovation
  - 2015, 2017 WEDA Awards; 2017 DPC Award

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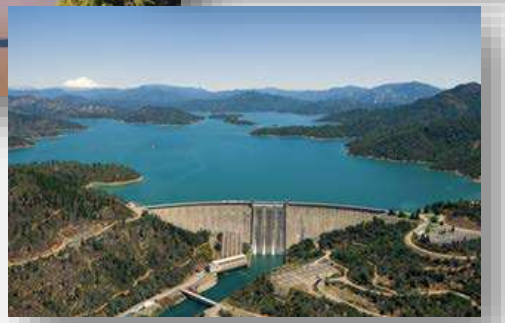
EWN® ACROSS USACE MISSION SPACE

Navigation
- Strategic placement of dredged material supporting habitat development
- Habitat integrated into structures
- Enhanced Natural Recovery

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 and connectivity



USE OF NATURAL SYSTEMS TO SUPPORT FLOOD RISK MANAGEMENT

Following Hurricane Sandy:

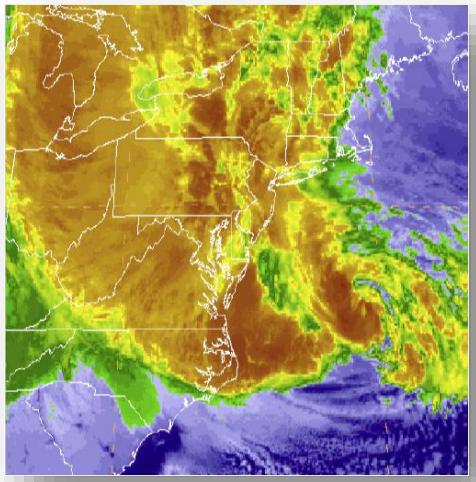
- Risk industry-based tools used to quantify the economic benefits of coastal wetlands
  - Temperate coastal wetlands saved more than $625 million in flood damages.
  - In Ocean County, New Jersey, salt marsh conservation can significantly reduce average annual flood losses by more than 20%.

COASTAL WETLANDS AND FLOOD DAMAGE REDUCTION

Using Risk Industry-based Models
to Assess Natural Defenses in the Northeastern USA

October 2016

UNIVERSITY OF CALIFORNIA SANTA CRUZ
The Nature Conservancy
Wildlife Conservation Society
LLOYD'S TERCENTENARY RESEARCH FOUNDATION



ENGINEERING PERFORMANCE: NATURE-BASED FEATURES WORK IN DIFFERENT WAYS

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

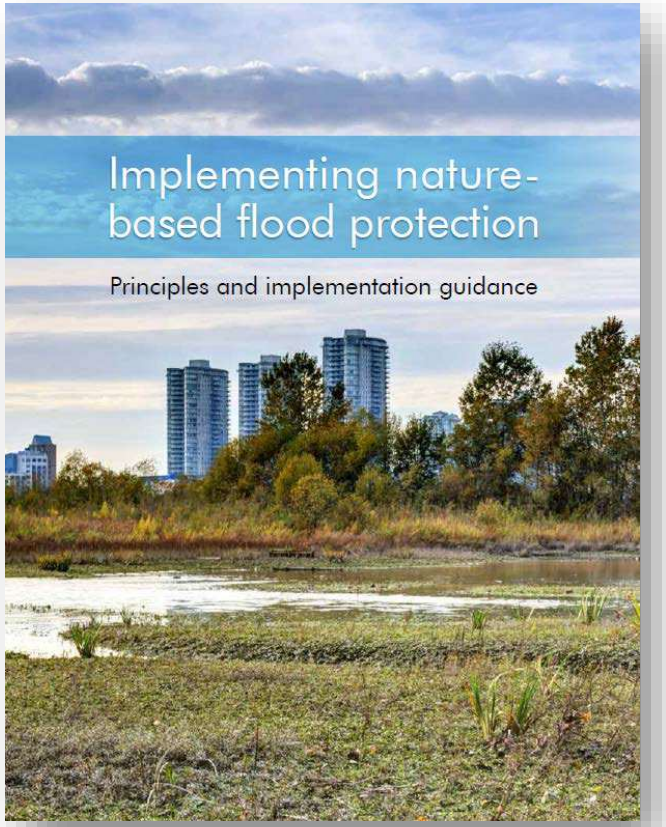
Forest dimension

Sediment composition

Platform elevation

INTERNATIONAL COLLABORATION: WORLD BANK GUIDANCE FOR NATURE-BASED FLOOD PROTECTION

NBFP Workshop, 11-13 April 2017



https://www.gfdrr.org/sites/default/files/documents/Brochure%20Implementing%20nature-based%20flood%20protection_voor%20web.pdf

INTERNATIONAL GUIDELINES ON THE USE OF NATURAL AND NATURE-BASED FEATURES FOR SUSTAINABLE COASTAL AND FLUVIAL SYSTEMS

Purpose: Develop guidelines for using NNBF to provide engineering functions relevant to flood risk management while producing additional economic, environmental and social benefits.

- Publish NNBF technical guidelines by 2020:
  - Multi-author: government, academia, NGOs, engineering firms, construction companies, etc.
  - Addressing the full project life cycle
  - Guidelines in 4 Parts
    - Overarching
    - Coastal Applications
    - Fluvial Applications
    - Conclusions

EWN ELEMENTS

Four major elements are key to applying EWN to develop infrastructure projects:

Engineering With Nature

Producing Efficiencies

Using science and engineering to produce operational efficiencies

Using Natural Processes

Using natural processes to maximize benefit

Broadening Benefits

Increasing the value provided by projects to include social, environmental, and economic benefits

Promoting Collaboration

Using collaborative processes to organize, engage, and focus interests, stakeholders, and partners

GALVESTON BAY EWN PROVING GROUND

Producing Efficiencies

Finding ways to use BU in Galveston Bay within the Federal Standard while maintaining placement area capacities

Using Natural Processes

Natural dissipation of constructed features like berms can be used to increase the long-term sustainability of wetlands

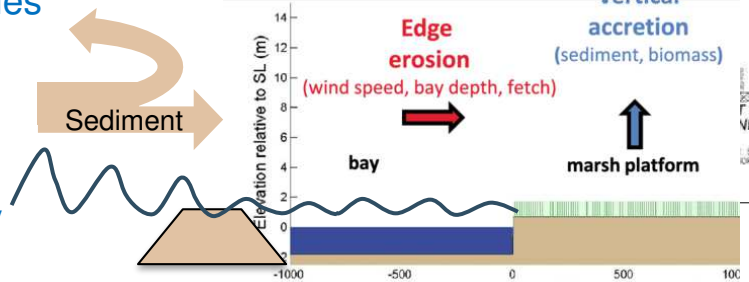
Broadening Benefits

Utilizing Galveston Bay dredged sediments beneficially increases wetland area and improves wetland resiliency

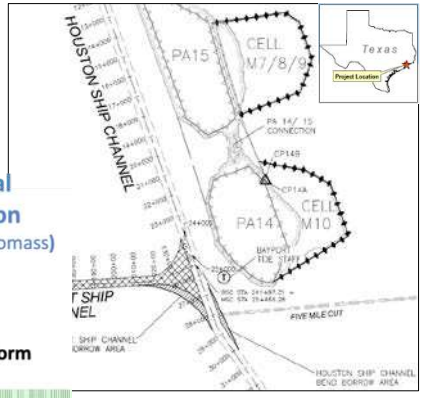
Promoting Collaboration

The Galveston EWN proving ground unites multiple research program efforts to meet District needs and facilitates engagement with regional stakeholders

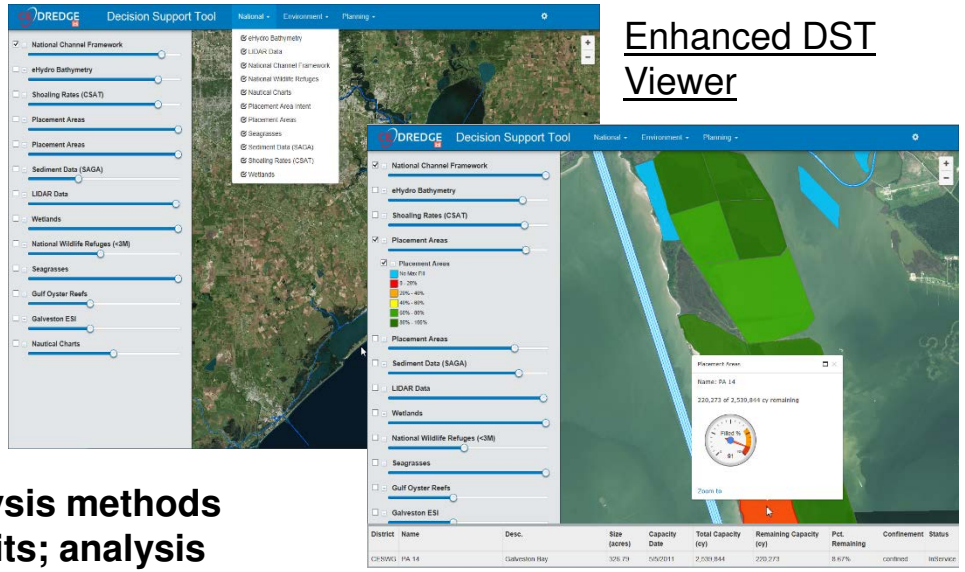
Coupling mixed-sediment berms with constructed wetlands



Modified from Kirwan et al., 2016



Enhanced DST Viewer



R&D NEED: Holistic life-cycle benefit-cost analysis methods able to account for multiple categories of benefits; analysis methods for including in project life-cycles features that are designed to evolve.

RESERVOIR SEDIMENT MANAGEMENT
(FLUSHING AND BYPASSING)

Producing Efficiencies

Innovative methods to bypass reservoir sediments.

Using Natural Processes

Provide means to allow sediments to follow natural transport patterns and pathways through the river system.

Broadening Benefits

Innovative methods to reduce reservoir sedimentation, increase water storage capacity, and improve sediment management; Utilize sediments to improve down river environment.

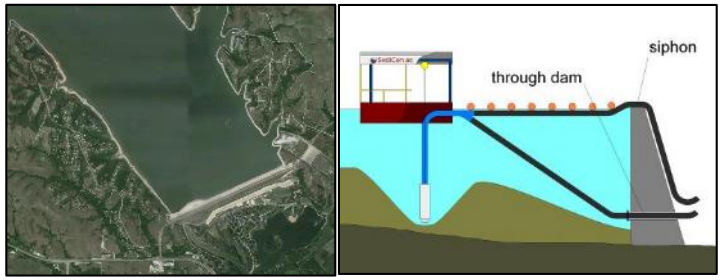
Promoting Collaboration

Industry, Government agencies, Districts, Stakeholders.

R&D NEED: Enhance numerical models and tools for predicting reservoir flushing, and impacts/benefits above and below the reservoir. Innovative technologies(Water Injection Dredging and bedload interceptor) to bypass sediments, prediction and management tools.

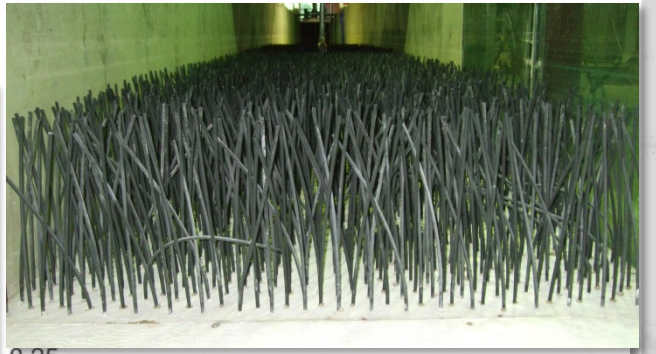
Reservoir Flushing

Reservoir Bypassing



Bedload Interceptor

PHYSICAL MODELING: VEGETATION TO MITIGATE COASTAL FLOODING



Producing Efficiencies

Reduce cost and/or risk by including attenuation benefits of vegetation in project evaluations.
Reduced O&M for integrated structural measures.

Using Natural Processes

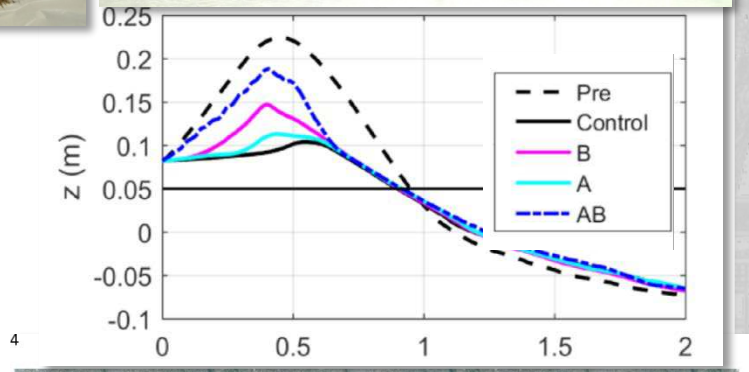
Vegetation contributes significant resistance to flow and reduces coastal dune erosion. Supports elevation by stabilizing sediments.

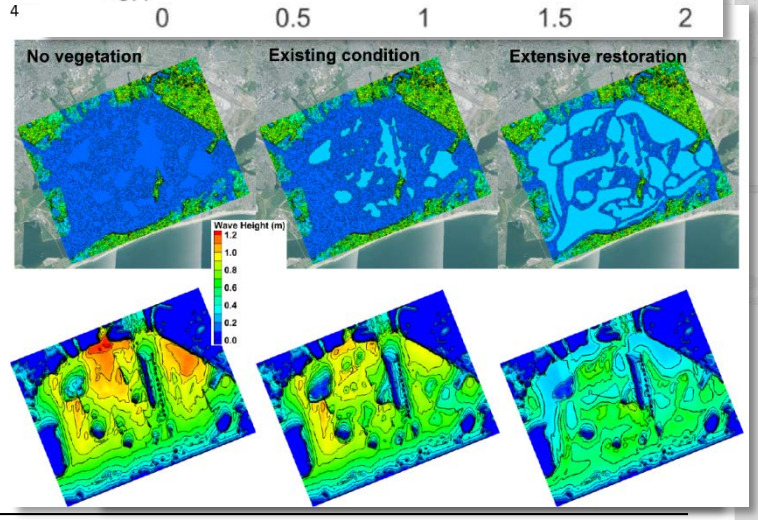
Broadening Benefits

Environmental and recreational benefits; restoration of degraded systems; reducing dune nourishment costs; more cost-effective, sustainable conventional solutions.

Promoting Collaboration

ERDC partnered with TAMU and UL Lafayette regarding plant metrics.





R&D: Long term field campaigns to study performance during storm events and the time-scales to observe measurable benefits.

MONITORING TOOLS FOR IMPROVED COASTAL PROJECT MANAGEMENT

Producing Efficiencies

Utilize robust, efficient technologies that reduce risks, manpower, and costs to monitor projects, making up-to-date data readily available.

Using Natural Processes

Improved monitoring helps operational understanding of the state of the system – are natural processes functioning how we expect?

Broadening Benefits

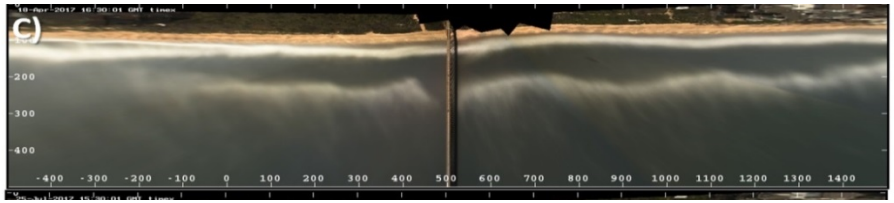
These tools help quantify benefits:

- monitoring shoreline evolution onshore of nearshore placements (e.g. LRC RSM project);
- monitoring pre/post-storm condition of infrastructure, beach projects, and ecosystems (SAC, SAJ Pilot Projects)
- monitoring beach project evolution (SAJ Pilot Project at Ponce Inlet)
- quantifying regional sediment dynamics (NAP RSM Project)

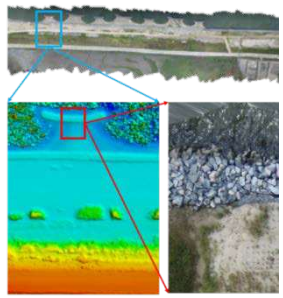
Promoting Collaboration

- Technology develop through CIRN (ERDC/USGS/NRL/Delft/Academic/Industry)
- Joint CHL/EL/GRL effort;
- Multi-agency, Lab, Academic, Industry Experiment
- Coupling observations to USACE Numerical Models for realtime, accurate risk assessment and management


Low-cost monitoring – mini-Argus Stations




Unmanned Aerial Systems



R&D NEED: Robust tools (hardware & software) which do not require a SME to run to allow for quick and efficient interpretation and utilization of data in coastal project management (ecosystem health; sediment management; infrastructure condition, etc)

NEARSHORE BERM RESEARCH, GUIDANCE, TOOLS

Producing Efficiencies

Development of Sediment Mobility Tool allows engineers to quickly site placement of sediment in the nearshore.

Using Natural Processes

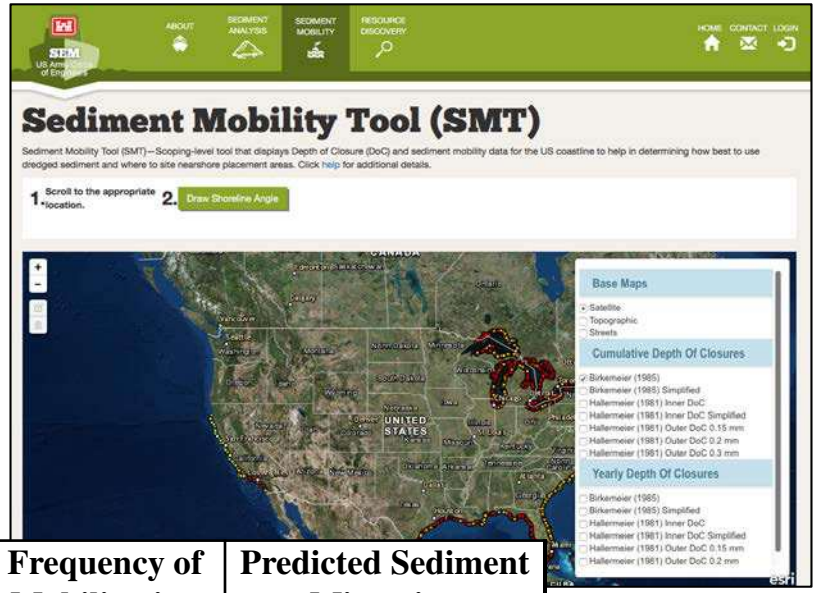
Placement of sediment in the nearshore allows natural processes to transport sediment within the system.

Broadening Benefits

NNBF, TLP, and nearshore placement provide multiple benefits to what have historically been single purpose projects.

Promoting Collaboration

There is increasing interest in this type of beneficial use of dredged material. Several Districts have been involved in the research projects, as well as stakeholder involvement



d_{50} (mm)	Frequency of Mobilization	Predicted Sediment Migration
0.1	16 – 38%	83% Offshore
0.2	14 – 30%	60% Onshore
0.3	12 – 26%	84% Onshore

R&D NEED: More research is needed to determine where sediment will move, effects on adjacent shorelines, and how long sediment will take to move from the placement site; expansion to other strategic placement opportunities, e.g., wetlands, tidal flats, etc.

NEXT STEPS FOR SCIENCE AND ENGINEERING…

- What processes and engineering requirements are critical to engineering performance and resilience?
- How will integrated solutions and systems evolve over time in dynamic environments?
- How can integrated systems be assembled to reduce long-term O&M costs in order to sustainably deliver resilience?
- How can field-scale demonstration projects be used to accelerate progress?

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SCIENCE, ENGINEERING, TECHNOLOGY RESEARCH TARGETS

1. **Fundamental processes**
   - Sediment transport through and around NNBF
   - Long-term engineering and environmental performance of features
   - Environmental Services provided by engineered features and structures
   - Processes contributing to system-scale resilience
2. **Modeling systems that support broad-scale application**
   - Planners, stakeholders and decision-makers
   - Engineering design
   - Operations and maintenance
3. **Reliable, cost-efficient monitoring technologies**
   - Measuring system evolution
   - Infrastructure/feature performance
4. **Demonstration/pilot projects to innovate, evaluate, and learn at relevant field scales**
   - Facilitate necessary collaboration
   - Evolve organizational culture and practice
   - Produce credible evidence of success
   - Fuel the “power of the story”

BUILDING ON MOMENTUM

- Opportunities to scale-up progress?
- How leverage partnerships across sectors and interests?
- How to consider the diverse benefits provided projects and systems?
- How to evaluate, design for and adaptively manage the engineering performance of projects?
- What form of guidance is needed for different functional areas?
- How to incentivize, institutionalize and codify progress?

THANK YOU!

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