External Perspective:
Engineering With Nature

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Engineering With Nature: Innovating for a More Resilient and Sustainable San Francisco Bay

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SF Bay Planning Coalition:
Dredging and Beneficial Reuse Workshop
18 October 2022
Thoughts about Innovation from Way Down Under…
Innovation in Medicine vs. Civil / Environmental Engineering

**Medicine**

1960
- Heart surgery/transplantation
1980
- Laser surgery
- Laparoscopic surgery / MIS
- HARRT
2000
- Human Genome Project draft complete
- Biologic treatments
- Artificial pancreas

**Civil Engineering**

1960
1980
2000
2020

**Environmental Management**

1960
- Laser surgery
- Laparoscopic surgery / MIS
- HARRT
2000
- Human Genome Project draft complete
- Biologic treatments
- Artificial pancreas
1900-2000: The Century of Infrastructure (US)

- 4,071,000 miles of roadway
  - 47,182 miles in the Interstate system
- 149,136 miles of mainline rail
- 640,000 miles of high-voltage transmission lines
- 614,387 bridges
- 90,580 dams
- >30,000 miles of flood levee
- 155,000 public drinking water systems
- ~5,000 military installations
- 926 ports, 25,000 miles of navigation channel

The San Joaquin Valley, California

California “Satellite” Image, ca. 1851 by Mark Clark
The San Francisco Bay of 1833
San Francisco Bay
The Multi-Hazard World

- Dust Bowl, 1930s
- San Francisco, 1906
- Mt. Saint Helens, 1980
- New Madrid Seismic Zone
- COVID-19, 2020
- HABs, Lake Erie; 2008-2017
- H1N1, 1918-1919
- Dust Bowl, 1930s
- Camp Fire; CA 2018
- Offutt AFB, 2019
- Three Mile Island, 1979
- Fukushima, 2011
- Deepwater Horizon, 2010
- Beirut, Lebanon; 2020
- Civil unrest, 2020
- Medfly “bio-attack”, CA, 1989
- Banqiao dam failure; China, 1975
- Hurricane Katrina, 2005
- Flood of 1927; Tallulah, LA
- Hurricane Harvey; landfall and Houston, 2017
- 2020 record-setting storm season
- 9/11
- Camp Fire; CA 2018
- MEGF TDR
- US Army Corps of Engineers • Engineer Research and Development Center
Engineering With Nature®

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

Key Elements:
- Science and engineering that produces operational efficiencies
- Using natural process to maximum benefit
- Increase and diversify infrastructure value
- Science-based collaboration to organize and focus interests, stakeholders, and partners

“We absolutely want to do more engineering with nature everywhere we work across the Corps, you have my commitment.”
— LTG Scott A. Spellmon, 55th Chief of Engineers, to the House Committee on Transportation & Infrastructure, Water Resources & Environment Subcommittee (24 June 2021)
Nature-Based Solutions: Conserving, restoring, and engineering nature for the benefit of people and nature

- **Coastal Storm Risk Management**; e.g., an island-wetland complex that attenuates storm surge and waves.
- **Inland Flood Risk Management**; e.g., a restored inland floodplain that provides space for high flows.
- **Surface Heat Reduction**; e.g., creation of green space, forest restoration.
- **Drought and Wildfire Resilience**; e.g., restored native vegetation + grazing + ‘slow-water’ interventions + ecological forest management.
- **Water Resilience**; a constructed freshwater wetland that absorbs excess nutrients and recharges depleted groundwater aquifers.
- **Climate Change Mitigation**; e.g., restored native grasslands / plant communities that sequester carbon in soils.
Leveraging Nature for Engineering Value: *Wetlands*

**Wetland Value During Hurricane Sandy:**
- Risk industry tools used to quantify the economic benefits of coastal wetlands
  - Temperate coastal wetlands averted 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%.
Engineering With Nature: *USACE Proving Grounds*

- Galveston District
- Buffalo District
- Philadelphia District
- Mobile District
- San Francisco District
- St. Louis District
- South Pacific Division
“Natural Infrastructure” in the Infrastructure Investment and Jobs Act 2021

- Billions invested in nature-based solutions
- 17+ references to “natural infrastructure” in the bill
- USACE: ~$17B in appropriations, including:
  - $2.5B for CSRM, $1B for multi-purpose
  - $2.5B for inland FRM, $750M for multi-purpose
- DOT, surface transportation NI
- DOE, hydropower and FRM NI
- BoR, Western Water Infrastructure NI
- Other supporting investments with NRCS, FEMA, NOAA, EPA, USFWS, Bureau Indian Affairs
Executive Order on Strengthening the Nation’s Forests, Communities, and Local Economies

Sec. 4. Deploying Nature-Based Solutions to Tackle Climate Change and Enhance Resilience:
“To further amplify the power of nature, including its ability to absorb climate pollution and increase resilience in all communities, today’s Executive Order calls for the following:”
1) Report on Nature-Based Solutions
2) Guidance on Valuing Nature
3) First U.S. National Nature Assessment
Beneficial Use Innovation: *There’s something for everyone to do!*

- Government Agencies Doing Dredging: Doing business differently
- Ports / Navigation Sector: Multi-purpose projects
- Regulatory Agencies: Efficiently pursuing win-wins
- Dredging / Engineering Companies: Innovative engineering and operations
- Environmental NGOs: Facilitating P3s

**The Key: Affordability, Affordability, Affordability**
Beneficial Use: Status and Opportunities

“Beneficial use” is using dredged sediment to achieve additional benefits beyond its removal from a channel/waterway, including other economic, environmental or social benefits.

- **USACE has a long track record of BU**
  - ~30% of dredged material beneficially used over last 20 years (60 out of 200 mcy/yr)
    - >1.5 billion cy used in beach construction over last 100 years
    - 25,000 acres of wetlands created in south Louisiana since 1970s

- **BU supports:**
  - Climate change adaptation thru Engineering With Nature®
  - Habitat for fish and wildlife
    - Tribal equities, Threatened and Endangered Species
  - Social value to enhance resilience of communities and vulnerable/underserved populations

- **BU challenges:**
  - Budget constraints
  - Federal policies/regulations/business practices
  - State policies/regulations/business practices
The “Federal Standard” and WRDA Section 125

*Federal standard* means the dredged material disposal alternative or alternatives identified by the Corps which represent the *least costly* alternatives consistent with *sound engineering practices* and meeting the *environmental standards* established by the 404(b)(1) evaluation process or ocean dumping criteria. 33 CFR 335.7

**WRDA 2020, SEC. 125: BENEFICIAL USE OF DREDGED MATERIAL**

• It is the policy of the United States for the Corps of Engineers to maximize the beneficial use, in an environmentally acceptable manner, of suitable dredged material...

• the Secretary shall consider—(i) the suitability of the dredged material for a full range of beneficial uses; and (ii) the economic and environmental benefits, efficiencies, and impacts...

• The economic benefits and efficiencies from the beneficial use of dredged material considered by the Secretary under subparagraph (A) shall be included in any determination relating to the “Federal standard”…
Applying the Full Range of Beneficial Use

Sediment "Recharge" via Dredging

Direct Wetland "Nourishment"

Wetland Creation

Island Enhancement or Restoration

Strategic Placement

Thin-Layer Placement for Bottom Contouring

Beach and Dune Construction

New Island Construction
**Barrier Island: Deer Island, Biloxi, MS**

- **Biloxi Harbor Navigation Project** – 3.65 m (12 ft) deep navigation channel

- Sediment beneficial use to restore marsh, create terrestrial and aquatic habitat, provide a more resilient shoreline for future storm events, create long term disposal capacity

- Hurricanes over time destroyed forests, significantly eroded shoreline, and left elevations too low to support marsh vegetation

- Filled breach in west end of the island

- 1.5 mcm dredged material to restore southern shoreline using 4 km long wave barrier

- Strategic vegetation plantings (625,000+ plants)

- Construction of a 0.76 mcm lagoon for BU dredged material from navigation channels

- Providing significant environmental, coastal storm, and recreational benefits
Empowering Partnership: Swan Island


US Army Corps of Engineers  •  Engineer Research and Development Center
Facilitating Field Implementation: *SMIIL*

Seven Mile Island Innovation Laboratory

- Collaboration and partnership that is building first-of-their-kind NBS projects in coastal New Jersey
  - Began in conversation
  - Accelerated by a storm (Sandy)
  - Progressed through piloting
  - Now in full-scale implementation
Mobile Bay: *Innovation thru Science-Informed Collaboration*

**The Problem:** WRDA86
- Place all dredged sediments in ODMDS
- 4.0 mcy/yr, hopper dredge, 20+miles
- Tripled maintenance costs

**The Solution:** 2014, *decision reversed*
- EWN approaches and demonstration
- RSM Interagency Work Group

**The Benefits:** $12M reduced operational costs + more BU!
- Thin Layer Placement in Mobile Bay
- Sand Island Beneficial Use Area (SIBUA)
  - Downdrift benefits to Dauphin Island
  - Protect lighthouse
- Fill dredge holes
  - Brookley Hole, Oyster Holes
- Gaillard Island
  - Marsh Creation, biodegradable containment, Brown Pelican
- Future in-Bay placement:
  - TLP for 1000-acre emergent marsh
Documenting NBS Benefits: Horseshoe Bend Island, Atchafalaya River, Louisiana, USA

Project Awards:
- 2015 Western Dredging Association Award for Environmental Excellence
- 2017 Western Dredging Association Award for Climate Change Adaption
- 2017 Dredging and Port Construction Award for Engineering with Nature
- 2020 USACE Green Innovation Award
Evaluating Benefits: BCA Policy Research

Current federal alternative evaluation process does not comprehensively value economic, environmental, and social benefits. These constraints screen out or exclude Nature-Based Solutions (NBS) and could lead to outcomes inconsistent with the Administration’s priorities around community resilience and equity.

Approach:
- **Summarize** historical and current alternative evaluation policies and practices
- **Identify** 6 historical planning studies that considered NBS alternatives suitable for case study analysis
  1. Jacksonville Harbor (NAV, South East)
  2. Jamaica Bay Reformulation (CSRM, North East)
  3. Southwest Coastal (CSRM, Gulf Coast)
  4. South Platte River and Tributaries (FRM, North West)
  5. West Sacramento (FRM, Pacific)
  6. South San Francisco Bay Shoreline (FRM, Pacific)
- **Review** updated valuation methods and planning frameworks that incorporate environmental and social benefits
- **Analyze** case studies using updated methods and exploratory analysis to look beyond current policy constraints

[https://ewn.erdc.dren.mil/?p=7841](https://ewn.erdc.dren.mil/?p=7841)

National Summit: Measuring What Matters
November 30, 2022; Washington D.C.
Sustainability: Sustainability is achieved by efficiently investing resources to create present and future value

The National Environmental Policy Act (1969): “create and maintain conditions under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic and other requirements of present and future generations.”

What value and for whom?
- Economic development
- Natural capital
- Biodiversity
- Human well-being
- Social equity
- Etc.
The Science of Nature-Based Solutions: Using Multiple Lines-of-Evidence

- Physical Modeling
- Numerical Modeling
- Natural Analogs
- Scaled Demonstrations
- Experience
  - Project Monitoring
  - Traditional Ecological Knowledge
  - Engineering Judgment

Huamantanga, Peru. People use and maintain 1,400-year-old amunas, canals. Credit: Diego Pérez/Forest Trends
Developing Guidance: *International Guidelines on Natural and Nature-Based Features for Flood Risk Management*

**NNBF Guidelines Table of Contents**

- Chapter 1. Introduction
- Chapter 2. Principles, Frameworks, and Outcomes
- Chapter 3. Community Engagement
- Chapter 4. Systems Approach
- Chapter 5. Performance
- Chapter 6. Benefits and Costs of NNBF
- Chapter 7. Adaptive Management
- Chapter 8. Introduction to Coastal Systems
- Chapter 9. Beaches and Dunes
- Chapter 10. Coastal Wetlands and Intertidal Areas
- Chapter 11. Islands
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- Chapter 16. Fluvial Systems and Flood Risk Management
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**Winner, Environment Agency Flood & Coast International Excellence Award, 2022**

https://ewn.erdc.dren.mil/?page_id=4351

"The guidelines do not contain or represent the policy commitments or policy positions of the organizations that participated in their development. Policy development is the sole purview of each organization and the laws and procedures that govern their activities." Pages xi-xii.
Natural infrastructure is the practice of using naturally occurring aspects of the landscape and nature-based solutions that use or imitate natural processes (e.g., wetlands, living shorelines, municipal green infrastructure) to support natural hazards mitigation, climate change adaptation, and other benefits to people and environments. Recognition of the multiple benefits of natural “green” infrastructure has increased over the past several decades, and alone or in combination with built “gray” infrastructure solutions, such as seawalls and levees, many potential opportunities remain untapped. On May 10-11, 2022, the National Academies Program in the National Academies of Sciences, Engineering, and Medicine (the National Academies) convened a workshop to explore opportunities to link the benefits of natural infrastructure across geographic scales and multiple objectives. Sponsored by the U.S. Army Corps of Engineers (USACE) and hosted by the Institute for Resilient Infrastructure Systems at the University of Georgia (IRIS), the hybrid workshop was targeted to the engineering community, as well as stakeholders, policy makers, planners, and others involved in designing, developing, and funding natural infrastructure.

Supporting People and Communities

• Science says that nature directly supports human wellbeing!
  • Physical health
    ▶ Blood pressure
    ▶ Healing
    ▶ Immunity
    ▶ Etc.
  • Mental health
    ▶ Cognitive function
    ▶ Anxiety
    ▶ Depression
    ▶ Socialization
    ▶ Etc.

Nature experience reduces rumination and subgenual prefrontal cortex activation

Gregory N. Bratman, J. Paul Hamilton, Kevin S. Hahn, Gretchen C. Daily, and James J. Gross
PNAS July 14, 2015 112 (28) 8567-8572; first published June 29, 2015 https://doi.org/10.1073/pnas.1510459112

Scientific reports
Urban street tree biodiversity and antidepressant prescriptions
Melissa R. Marselle1,2,3,4, Diana E. Bowler2,3, Jan Watzema1,4, David Eichenberg1,2,3, Toralf Kirsten1,4 & Aletta Bonn1,4

“It is a scientific fact that the occasional contemplation of natural scenes... is favorable to the health and vigor of men…” Frederick Law Olmsted (1822-1903)
“Revolutionizing” Practice Through Nature-Based Solutions

- Policy development
  - Engagement with policymakers
  - Policy/procedure “modernization”
- Engagement, partnering, and teaming
  - Within USACE, e.g., EWN Proving Grounds
  - With other organizations inside and outside government
- Innovation
  - Creating a vision of the future
  - Establishing goals, targets and conditions
  - New science and engineering and tools for delivery
- On-the-ground projects and demos
  - Across the spectrum of applications and project development (i.e., from planning to operations)
  - Scaling up nature-based solutions
- Strategic communications
  - Individual research papers
  - Communication tools, e.g., EWN Atlas Vol 1 and 2
  - Education, e.g., academic curricula, training
  - Good Storytelling
Sparking Conversation, Thinking, and New Ideas

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The changes in surgical endoscopy leading up to 1988 were, in fact, gradual and evolutionary. For any major change or progress to take place, many factors must fall into place. In the case of laparoscopy, dramatic technical innovations were required. Additionally, there is a season for any change, requiring a favorable and supportive philosophical environment. Authoritative institutions must be convinced of the safety and efficacy of the changes relative to the comfortable status quo. Momentum always favors inertia. Fears must be overcome: fear of making mistakes, fear of failure, fear of established procedures becoming obsolete, and fear of established authorities losing control. Successful change requires timing and a force more powerful than the status quo. The strongest force for sustainable change is a worthy goal.”