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Environmental Enhancements and Navigation Infrastructure: Existing Practices, Innovative Ideas, and Research Needs

*by Thomas J. Fredette, Christy M. Foran, Sandra M. Brasfield,
and Burton C. Suedel*

PURPOSE: The concept that navigation infrastructure can serve as valuable habitat is not novel. However, the concept of designing navigation infrastructure with the specific intent of accomplishing both the engineering goal and specific environmental goals is, in most instances, a new idea for many planners and designers. The inclusion of environmental enhancements in navigation infrastructure represents both opportunities and challenges for project managers. The purpose of this document is to present an overview of the advantages, while addressing some of the implementation challenges, as seen by the current planning and engineering contingents. This study sought to (1) identify existing and potential navigation project features that were designed with the express intent of enhancing environmental benefit; (2) identify laws, regulations, and policies (formulation boundaries) that both support and hinder such design features; (3) identify opportunities for increasing environmental benefits for navigation projects within existing formulation boundaries; (4) propose potential changes to formulation boundaries that would further increase opportunities for environmental benefits; and (5) identify potential areas where research may increase the opportunity to integrate environmental features into future projects.



BACKGROUND: The genesis of the Environmental Enhancements and Navigation Infrastructure (EENI) project was in a position paper titled “Working with Nature” (PIANC 2008). The paper was prepared by the Environmental Commission of PIANC. The premise of “Working with Nature” was to “identify ways of achieving project objectives by working with natural processes to deliver environmental protection, restoration or enhancement outcomes.” Thus, “Working with Nature” provided the philosophical concept for this project, and U.S. Army Corps of Engineers (USACE) sought to investigate where and how that broad approach might actually be applied in practice, specifically in the context of navigation infrastructure.

Navigation infrastructure projects all involve human management of some aspect of the natural environment such as current flow, channel depth, or linkages between waterways (e.g., dredged channels, locks, jetties, canals). While minimizing unintended and adverse impacts from such endeavors is the goal of environmental assessment, there are also environmental enhancements that can be incorporated into the design of projects. When these potential features are identified early, they are more easily incorporated into the planning process. While it is USACE policy (USACE, 2002, 2010a, ASA-CW and USACE 2010b, USACE 2004) to incorporate environmental design features into USACE projects, realities associated with funding policies must also be factored into decisions.

Navigation infrastructure is a prominent feature of the nation’s waterways. The USACE is responsible for over 12,000 miles of navigation channel, 195 navigation locks, and hundreds of jetties, breakwaters, and anchorages. For example, in the New England District alone, there are over 130 breakwaters and jetties, with a total length of over 40 miles; over 2,000 acres of anchorage; and over 470 miles of channel. Few of these projects were designed with any specific features intended to support ecosystem services, yet with some advance planning, the opportunities for adding environmental attributes could be considerable. Each year, new projects are constructed and many more undergo some form of maintenance. As plans for the new infrastructure or maintenance of the existing ones are developed, planners, engineers, designers, and ecologists may be able to identify project design features that can be incorporated with little to no cost increase and that will better serve environmental services. Some design features may also serve the needs of other interested entities willing to cost-share the added budgetary burden. Additionally, the involvement of ecosystem-service-focused entities (e.g., the Fish and Wildlife Service, the National Oceanic and Atmospheric Administration (NOAA)-Fisheries, The Nature Conservancy, and others) creates a different project and review dynamic that, in turn, leads to projects that can be supported by a wider component of society due to the multifunctional purposes such projects serve.

This study collected information and personal experience from USACE and other federal agency personnel in response to questions such as the following: What is USACE doing to add environmental enhancements to navigation infrastructure? Are there any innovative yet untried approaches that would environmentally enhance navigation infrastructure? What are potential impediments to achieving increased environmental benefits? Are there concepts that need further research? These and other questions were posed in the context of new projects or maintenance of existing infrastructure.

APPROACH: The study was conducted via email, using webinars and an online survey. The project approach and survey was formulated after one-on-one interviews with environmental planners and navigation project managers to gauge initial reactions and explore ideas. These were followed by a briefing to the USACE Environmental Planning Chiefs' monthly conference call, a conference presentation at the Western Dredging Association (WEDA) Panama Chapter meeting, a presentation to the New England Regional Dredging Team (NERDT) (<http://www.nerdt.org/>), and a presentation to the *National Dredging Team* (NDT). An e-mail list containing over 300 contacts was developed from various sources, including the USACE Navigation Community of Practice, the Environmental Planning Community of Practice, and the most recent Dredged Material Assessment and Management seminar that was held in 2009. An internet-based webinar was presented on two separate occasions to a total of over 30 participants in an effort to provide a virtual presentation of the project concept, approach, information needs, and a request for individuals to participate in the survey. Participants were also asked to communicate information about the project to colleagues and staff. Through these efforts, over 400 individuals were introduced to the study and the survey.

SURVEY: A commercial, internet-based software tool (SurveyMonkey™ www.surveymonkey.com) was used to conduct a survey about attitudes, ideas, concerns, existing projects, unsuccessful projects, relevant laws and regulations, case studies, and participant demographics. Survey questions were drafted and an influence diagram was developed to visualize and identify the relationships between the study objective, consequences, and events. This made it easier to identify gaps in the survey questions, and to evaluate how the collected data would be analyzed (Figure 1). Survey questions were further refined following this influence diagram analysis (Table 1). Respondents worked for several federal agencies, including the US Environmental Protection Agency (USEPA), NOAA, and the USACE. One respondent worked for the Natural Resource Conservation Service (NRCS). Seventy-five (75) people began the survey and completed the first question (a required question to continue). Of those who responded, 39 (52%) completed all sections of the survey, while 41 (55%) individuals completed the survey through Section 6 and then declined to provide demographic information. Of the 75 people who answered question 1, 49 answered question 2; consequently, there appeared to be a certain curiosity/interest factor involved when 26 individuals decided not to complete the survey after initially viewing it.

DISCUSSION:

Existing Projects and Innovative Ideas. The concept of EENI appeared to be relatively new to many individuals, but was viewed by 95% of the respondents as an activity for which there is considerable opportunity. Through the survey, webinars, and personal communication we identified a considerable number of ideas and projects for which EENI has been implemented or may be possible. These infrastructure ideas and projects include breakwaters, river training structures, locks and dams, channels, and anchorages (Table 2). In particular, the Upper Mississippi River Restoration Environmental Management Program (UMRR-EMP) has been developing and implementing EENI approaches for over two decades and — even though it is focused on riverine environments — it should be considered further for ideas and guidance (USACE 2010b) by planners and environmental engineers working in any ecosystem. This

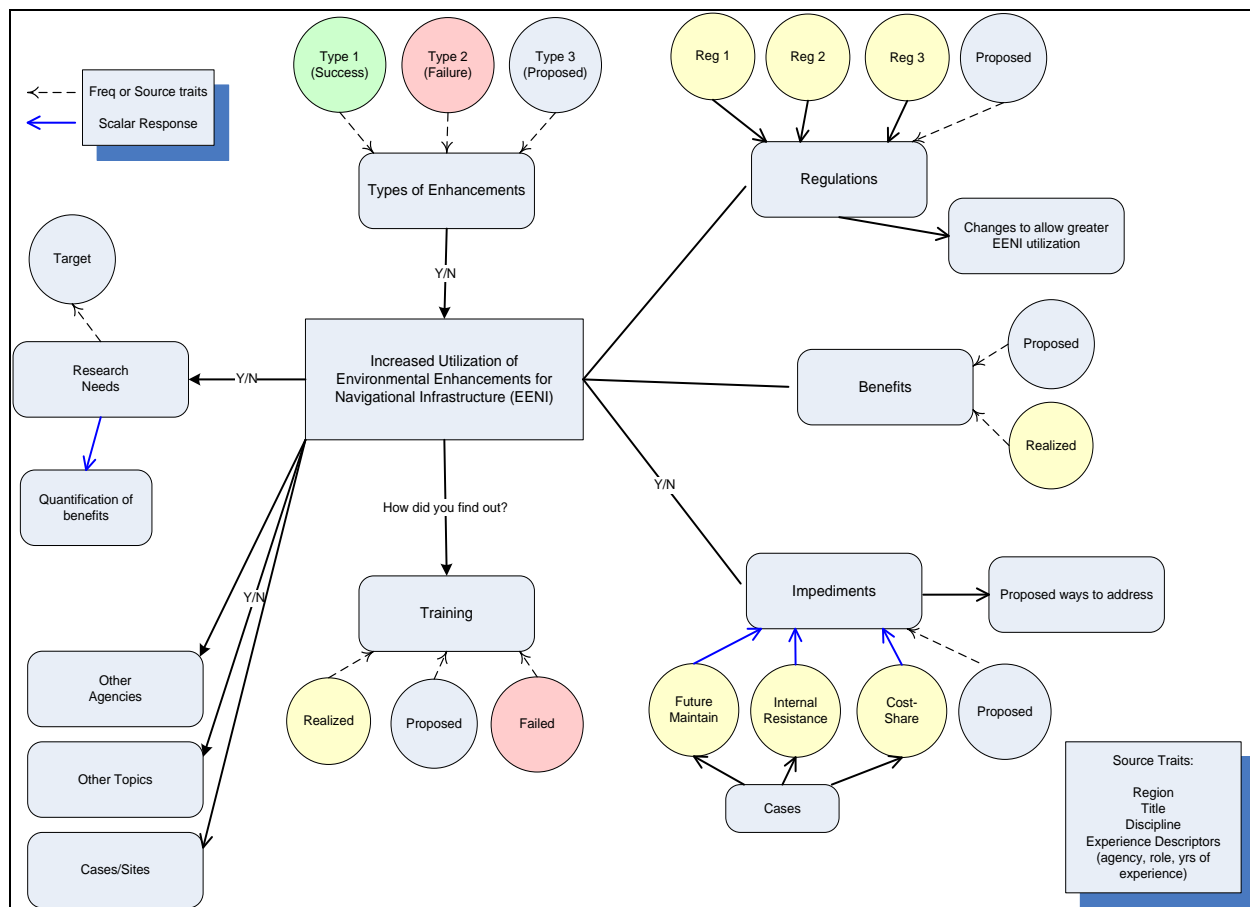


Figure 1. EENI Survey Question Influence Diagram. The rectangle in the left center of the figure is the study objective node, consequence nodes are represented by rounded rectangles, and circles represent event nodes.

survey represented multiple federal agencies with the greatest representation coming from the main target group, the USACE. Within the USACE, 19 Districts were represented. Survey respondents represented a wide cross-section of experience and expertise. Over 56% of those who took the survey had more than 15 years of experience with navigation infrastructure projects and over 28% had more than 25 years of experience. Respondents included good representation from all of the principle Corps office elements, Operations (33%), Planning (39%), Regulatory (18%), Engineering (26%), Construction (5%), and Project Management (13%).

Laws, policies, regulations. There are numerous laws and regulations, both federal and state-specific, which require compliance in the implementation of EENI. When presented with a list of potential laws, nearly 60% of the survey respondents were unsure whether or not the list was complete. This lack of clarity about the policies that may impact the implementation of EENI has the potential to be a significant obstacle to the inclusion of these enhancements in projects. Early consultation by project managers with individuals possessing expertise in environmental law and policy is a paramount step towards achieving success.

Table 1. Environmental Enhancement of Navigation Infrastructure (EENI) Survey Questions.	
Question #	Survey Questions by Section
Environmental Enhancements: Present and Potential	
1	Do you believe there are opportunities to improve the environmental attributes of existing or future navigation infrastructure projects?
2	Are you familiar with any projects in which environmental enhancements have been considered or incorporated?
3	Please identify any relevant project(s), the environmental enhancement(s) and provide links to references as appropriate.
4	How did you find out about designing and implementing these features? What process(es) enabled their consideration?
5	At what stage of the project(s) were these enhancements considered and why? (e.g. problem formulation, reconnaissance study, generation of alternatives, feasibility study, comparison of alternatives, selection of a plan)
6	In cases where these features were incorporated, what were the ultimate benefits to the project? Was there any post-construction monitoring and reporting? Please describe and cite, where possible.
7	In cases where these features were not incorporated, what was the reason?
8	What agencies and stakeholder groups were involved in the investigation and evaluation of these features? How did you work with them? What expertise did they contribute? Was it a collaborative effort?
9	What other specific projects would be helpful to investigate for this survey?
10	Are there (other) environmental enhancements that you believe might be possible to incorporate into existing or future navigation infrastructure projects?
11	If Yes, please describe any environmental enhancements that you envision and on what type of project. Be creative.
12	What information/training would facilitate incorporating these or other environmental enhancements?
13	What training/information or programs have we tried that didn't work? Why do you think it didn't work?
Laws, Policies, and Regulations	
14	Does this appear to be a correct and complete list?
15	If No, please provide additional citations for those you feel need to be added or identify any other problems with the list.
16	What state or local regulations/mandates affect the consideration or inclusion of EENI in your region?
17	If you added information above, why do you think it is important?
18	What other policies, attitudes or approvals (formal or informal) need to be reconciled in considering environmental enhancements?
19	What potential changes in laws or regulations would allow greater use of environmental enhancements?
Impediments to Use	
20	How high of an impediment do you believe cost sharing is to EENI?
21	Can you describe an experience in which cost sharing was the reason an enhancement was not considered?
22	If you believe cost sharing is an impediment, please describe any potential solutions that you can think of to reduce the impediment.
23	How high of an impediment do you believe institutional resistance is to EENI?
24	Can you describe an experience in which resistance within the USACE was the reason an enhancement was not considered?

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25	If you believe institutional resistance is an impediment, please describe any potential solutions that you can think of to reduce the impediment.
26	Inclusion of environmental enhancements may be believed to constrain/complicate future maintenance operations of navigational infrastructure. How important of an impediment do you think this belief may be to consideration of EENI?
27	Can you describe an experience in which these future maintenance concerns were the reason an enhancement was not considered?
28	If you believe future maintenance concerns are an impediment, please describe any potential solutions that you can think of to reduce the impediment.
29	Do you believe there are other impediments that we have not considered?
30	If Yes, please describe those impediments.
31	Can you describe potential ways to minimize these other impediments?
Research Needs	
32	Do you believe new or additional information would be useful in promoting consideration of environmental enhancements when maintaining, designing, and constructing navigational infrastructure?
33	Please describe information that would be useful.
34	Who do you anticipate would use this information and how?
35	How valuable are measured or predicted benefits for considering the incorporation of an environmental enhancement in infrastructure design?
36	If the benefits resulting from environmental enhancements were to be measured, what measurements do you feel would be most important?
37	Are there other EENI-related items which you believe need further research?
38	What research is needed?
39	Of the research topics mentioned, what do you believe is the most important for promoting consideration of these enhancements?
Is There Anything We Missed?	
40	Do you think we have covered all of the major issues related to this topic?
41	If No, please describe additional issues we need to consider.
42	Is there any other relevant information that would be helpful to identify ways that the USACE could increase environmental enhancement incorporation into either existing or future navigation infrastructure projects?
Invite Others	
43	Is there anyone else you feel might be able to provide useful information for this survey?
44	Please either provide contact information, or if they are Federal employees provide them with a link to this survey.
Information About You	
45	Name
46	Agency
47	Title
48	Discipline
49	What USACE district do you primarily work with?
50	Office
51	How many years of experience do you have with navigational infrastructure projects?
52	Briefly describe your personal experience.
53	Email optional: (only if you don't mind giving us the opportunity to follow-up with you, if needed)

Table 2. List of Existing and Innovative EENI Projects Identified through the Survey, Webinars, and Personal Communications with Survey Participants.	
Navigation Infrastructure Type and List of Projects and Ideas	Project (P) or Idea (I)
Breakwaters, Jetties, Groins	
Placed pea gravel on stone toe for fish spawning habitat. Rochester Harbor, NY Wave Surge Reduction Project	P
Notched some of the continuous breakwater protecting a shore line to pump behind, create a wetland, and provide tidal flushing	P
Use different sizes of stone (i.e., increase surface complexity) or cross-sectional modifications placed around other coastal structures like groins and revetments to enhance habitat	I
Other materials could be placed or anchored at the toe either inside or outside the protected area, to create areas attractive to fish	I
Partially or completely convert older breakwaters into rubble mound structures, using the original structure as the core	I
Place underwater reef segments/prefabricated reef modules, either extending linearly from the ends of breakwaters, piers, and jetties, or placed in concentric arcs near the ends	I
Use rubble mound reef structures to intercept sediment, providing a shallow water area further from shore while reducing dredging needs by pushing littoral and movement into deeper waters	I
Use boxes to enhance fish spawning and habitat for structures such as breakwaters	I
Create living reefs, shorelines (see for example, http://ccrm.vims.edu/livingshorelines/index.html)	I
Glue live oysters or mussels to rock jetties and breakwaters to encourage larval settlement and reef creation	I
Encourage shellfish reefs to create self-sustaining biological filters	I
Adding salt marsh or eelgrass habitat behind a spur jetty	I
Provision of terrestrial habitat for birds on offshore breakwaters	I
Add sand to toe of hard features (e.g., inside of hurricane barriers, breakwaters, or jetties) to encourage tern nesting	I
Energy generating features added to structures (wind turbines, wave turbines) - indirect environmental benefit (less fossil fuel use)	I
Locks & Dams	
Hard structures are "scratched" to enhance the settlement of aquatic insects	P
Nature-inspired fish ladders such as rock arch rapids. http://www.saw.usace.army.mil/Wilmington-Harbor/EA_Fish_passage_at_LD1_4_Mar_%202010_WILLETT_15-MAR.pdf	P
River Channel Training Structures	
Adding channel chutes/notches and river dike modifications. Missouri River Recovery Program, Bank Stabilization and Navigation Project Sioux City, IA to Rulo (BSNP) http://www.moriverrecovery.org/mrrp/f?p=136:4:1482385506379213	P
River dike notching, hardpoint, and chevron construction in addition to grooving the surface of Articulated Concrete Revetment. Recent projects are Island 63 back channel, Kangaroo Point, and Below Ludlow dikes	P

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Creation of islands that maintain flow in the main channel, create habitat diversity on the non-channel side, and are CDFs	P
Changing rock size to allow for more interstitial spaces for habitat	I
Islands	
Oyster shell added to the surface of a dredged material island to promote nesting of least terns at Barren Island	P
Enhancements include use of shore protection works to develop improved habitats and wetlands, management of operations to preserve and enhance least tern nesting areas. Craney Island Dredged Material Management, Portsmouth, VA	I
Plant and/or seed shellfish and native species	I
Design island creation to incorporate features to promote native vegetation and wildlife productivity	I
Channels & Anchorages	
Eelgrass planting in anchorages	P
Excavation of back channels in river systems	P
Shellfish planting in federal anchorages/channels seldom dredged	I
Create shallow terraces or steps outside the channel footprint to enhance shallow water habitat (photic zone) for submerged aquatic vegetation, macroalgae, and oysters	I
Intracoastal Waterway. Typically the bank is hardened. If lower structures were stepped out from the bank to break wake-waves this would provide shallow vegetated and unvegetated habitat between the structure and the bank and a more natural system. Structures could be clutched with shell to increase natural systems	I
Add structural modifications such as large woody debris and additional rock to provide habitat depth/velocity/substrate	I
Seeding dredged areas with native species to give head start over invasive species	I
Create deep holes in the navigation channel to provide habitat diversity	I
Piers & Wharves	
Marina in Canada incorporated vegetation and shaped breakwaters to accommodate habitat	P
Coral enhancement projects for a new wharf on Guam	P
The inclusion of light transmitting materials used for docks and stationary structures as a modification which allows vegetative colonization of areas beneath the structures	P
Design hard structures to facilitate better seaweed recruitment	I
Provide aquatic habitat features on the sides of piers, jetties, and breakwaters	I
Place spurs on jetties	I
Create lay-down/haul-out areas for marine mammals such as seals at jetties that could be incorporated onto existing structures	I
Construct nesting platforms for ospreys and other shore birds	I

Impediments. As with any project, there are challenges or impediments that will need to be addressed. Respondents provided a number of insights relative to potential EENI projects. Cost sharing was viewed as a strong impediment to the implementation of EENI, as it is for beneficial use of dredged sediments or habitat restoration. Respondents did, however, recommend solutions — such as the creation of a special appropriation for such projects — similar to the Section 227 program for erosion control projects. It was also suggested that the USACE, either separately or in coordination with the NDT, develop goals for increasing the application of EENI on a national or division basis. This could be in the form of annual goals and a broader 5- or 10-year target. A model for establishing sustainability goals that could be emulated is the USACE Strategic Sustainability Performance Plan (ASA-CW and USACE 2010a).

While there were some fairly strong concerns about EENI hampering the future maintenance of infrastructure projects (particularly as expressed by respondents in a number of the narrative responses), there also appeared to be an openness to considering the concept, as institutional resistance was not viewed as a very high or even a high impediment by a majority (63%) of those surveyed. The main concern with future maintenance is rooted in the potential environmental restrictions that may result from the enhancement. Survey respondents identified a number of projects in which they believed future maintenance concerns had resulted in an EENI concept not being adopted. Project managers fear that in the process of “doing good” they will be hindering future ability to properly and efficiently maintain the project. Interagency agreements, such as the Memorandum, of Understanding (MOU) can address this concern. The MOU could stipulate that the enhancement would be disturbed by maintenance and could also specify that, barring that willingness to accept the periodic disturbance, the enhancement would not exist at all.

One important potential impediment that the survey did not directly address and that was mentioned in narrative comments was the potential effect of EENI on the structural integrity or on the primary navigation function of the infrastructure. This certainly should be a key focus of any environmental enhancement proposal and the subject requires careful consideration as part of the overall project review and planning.

Recommendations for reducing impediments were strongly focused on the need for both increased coordination and education activities. One frequent recommendation was that the EENI concept be strongly promoted, because it is a relatively new concept for many individuals. It was also believed that the act of simply introducing the idea can produce an immediate change in how a planner or manager might look at an upcoming project. Absent the EENI concept, the planner or manager’s focus is on the primary project purpose, but EENI introduces the perspective of “could we be creative and do more for ecosystem services in addition to serving the primary purpose?” Other education, training, and technical transfer-related needs identified were the documentation of case studies, development of webinars or a workshop, and the coordination of site visits. It was also suggested that USACE develop annual or long-term goals for implementation of EENI projects, or create incentives for such projects. For example, the Leadership in Energy and Environmental Design (LEED) green building program has been instrumental in accelerating implementation of environmentally sustainable practices (US Green Building Council 2006).

Training/Education. A need to take advantage of opportunities to coordinate with stakeholders and investigate EENI opportunities was mentioned by many of the survey respondents. Using the Regional Dredging Teams (RDTs) (see: <http://water.epa.gov/type/oceb/-oceandumping/dredgedmaterial/index.cfm>) could be one mechanism by which these discussions could be fostered. Additionally, any other interagency or stakeholder coordination meetings could be used to discuss such ideas.

Research. Suggestions for research were largely focused on developing better and more widely distributed documentation of existing projects and conducting pilot studies. However, there were a number of innovative suggestions provided by respondents for which research on feasibility and success would be valuable. These suggestions include: adding reef modules to breakwaters, creating upland sand habitat on the protected sides of jetties or breakwaters, creating shelves in channel side slopes at the optimum depth for seagrasses, or seeding infrequently dredged anchorages with shellfish.

RECOMMENDATIONS:

Based on the results of the survey, other communications that the study generated, and further development of a number of the suggestions to advance the concept of EENI and further the USACE environmental sustainability goals, USACE (2002) should consider and use the recommendations that follow.

- **Promote the EENI concept.** The concept of looking for ways to add environmental enhancements to navigation infrastructure was new for many planners, engineers, biologists, project managers, and other individuals. The simple act of looking at a project from an EENI perspective has the potential to spark innovation and synergy. Therefore, continued promotion of the EENI approach through workshops, webinars, the internet, and conferences should be pursued.
- **Document existing projects.** The EENI concept will be more quickly adopted if there are documented projects that demonstrate success and benefits. This study recommends that efforts be undertaken to identify and document good case studies that will advance the concept.
- **Conduct pilot projects.** Pilot studies are excellent opportunities to conduct field-scale proof-of-concept projects. Development and refinement of innovations can be advanced relatively quickly through pilot projects. Opportunities to develop a range of pilot projects, in coordination with construction or maintenance of navigation infrastructure within USACE Districts, should be taken.
- **Prioritize project sites.** Regions should consider developing a priority list of projects in which various EENI plans could be implemented. This could be accomplished through regional dredging teams or other means.
- **Research new ideas.** Numerous ideas for environmental enhancements that could be completed in association with navigation infrastructure were proposed; this list should be used as a resource to develop future research efforts.
- **Develop EENI goals.** The USACE, or perhaps the NDT in coordination with USACE, should develop short- and long-term goals for achieving implementation of EENI.

- **Seek new funding mechanisms for EENI.** Cost sharing will represent a continuing challenge for the implementation of EENI. Solutions may include the development of a special authority and appropriation for such activities; the promotion of corporate donations; and the utilization of non-profit funding avenues such as the Coastal America Foundation (<http://www.coastalamericafoundation.org/>) to support EENI.
- **Maximize use of coordination mechanisms.** EENI projects will require coordination among multiple stakeholders. Maximizing the use of available coordination mechanisms such as the RDTs or other such forums is a priority.
- **Develop interagency agreements.** The success of EENI depends on the resolution of numerous impediments. Interagency agreements that describe long-term interagency policy towards such impediments have great potential to decrease resistance to project implementation and future misunderstandings. Such interagency agreements could be done on a project-specific or regional basis, but development of such a policy at the national level, such as through the NDT, would be extremely valuable for advancing the concept.

POINTS OF CONTACT: for additional information, contact Dr. Tom Fredette (978-318-8291, Thomas.j.fredette@usace.army.mil). This technical note should be cited as follows:

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