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Final report

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Abstract: The Environmental Enhancements and Navigation Infrastructure (EENI) study investigated the opportunities and challenges associated with increasing the environmental benefits of navigation infrastructure (e.g., jetties, locks, channels, and anchorages). This study sought to (1) identify existing and potential navigation project features 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. The study employed initial interviews, briefings, teleconferences, presentations, and the implementation of an internet-based survey and webinars to obtain the desired information. The concept of EENI was relatively new to most participants, but was viewed by 95% of the respondents as an activity for which there is considerable opportunity. Respondents provided several examples of projects designed to increase environmental benefits and they also provided numerous new ideas for possible enhancements. These ideas spanned a wide range of navigation infrastructure.

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Contents

Figures and Tables

Figures

Tables

Preface

This study, Environmental Enhancements and Navigation Infrastructure (EENI), was developed to investigate opportunities and challenges associated with increasing the environmental benefits of navigation infrastructure. Publication of this report was sponsored by the Dredging Operations and Environmental Research Program, Dr. Todd S. Bridges, Program Manager.

This report was prepared by personnel from the U.S. Army Engineer Research and Development Center (ERDC), Environmental Laboratory (EL), Vicksburg, MS. The findings and recommendations presented in this report are based upon research conducted at ERDC. The research team consisted of Dr. Thomas Fredette, Environmental Engineering Branch, EL; and Dr. Sandra Brasfield, Dr. Burton Suedel, Dr. Christy Foran, Cynthia Banks, and James Lindsay, Environmental Risk Assessment Branch, EL. The authors wish to thank Nicole Manasco, Lyle Maciejewski, William Hubbard, Catherine Rogers, Valerie Cappola, Joseph (Jay) MacKay, Gary Kamei, David Bowman, Cory Koger, and Pam Horner for serving as beta testers for the survey and providing valuable commentary. We also thank Nina R. Sinatra and Polina Bakhteiarov for valuable research on the EcoShape project and Upper Mississippi River Restoration Environmental Management Program.

This report was written under the direct supervision of Dr. Richard E. Price, Chief, Environmental Processes and Engineering Division; Deborah Felt and Andy Martin, Chiefs, Environmental Engineering Branch, EL, and Warren Lorentz, Chief, Environmental Risk Assessment Branch, EL; and Dr. Beth Fleming, Director, EL.

At the time this report was written, COL Gary E. Johnston was Commander and Deputy Director of ERDC; at the time of publication, COL Keven J. Wilson was Commander and Deputy Director of ERDC. Dr. Jeffery P. Holland was Director of ERDC.

Executive Summary

This study, Environmental Enhancements and Navigation Infrastructure (EENI), was developed to investigate opportunities and challenges associated with increasing the environmental attributes of navigation infrastructure such as jetties, locks, channels, and anchorages. The effort attempted to specifically *exclude* projects that involved the beneficial use of dredged sediments in order to explore ideas revolving around other aspects of the navigation arena. Beneficial use of dredged material has received considerable attention over the past few decades, whereas there has been little focus on the environmental benefits that might be possible with navigation infrastructure itself.

This investigation was conducted as a strategic initiative of the Dredging Operations and Environmental Research (DOER) Program. The genesis of the project was in a position paper prepared by The World Association for Waterborne Transport Infrastructure titled "Working with Nature" (PIANC 2008). The Working with Nature initiative "sets out to identify ways of achieving project objectives by working with natural processes to deliver environmental protection, restoration or enhancement outcomes" (PIANC 2008). Working with Nature provided the philosophical concept and the EENI project sought to determine where and how that broad approach might actually be applied in practice. The present study sought to (1) identify existing and potential navigation project features 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 navigation infrastructure projects.

The study involved a number of steps to collect information that began with some initial interviews, briefings, teleconferences, and presentations followed by the implementation of an internet-based survey and internet-based webinars. Additional follow-up via e-mail and telephone was

completed. Key individuals who participated in the webinars and surveys or received the emails were targeted for follow-up. The internet-based survey was the main data collection tool, consisting of 53 questions that addressed various aspects of the study.

The EENI study collected information and personal experience in response to questions such as the following:

- What activities is USACE currently engaged in to add environmental enhancements to navigation infrastructure?
- Are there any innovative, yet untried approaches to add environmental enhancements to our navigation infrastructure?
- What are potential impediments to achieving increased environmental enhancements?
- Are there concepts that need further research?

These and other questions were posed in the context of new projects or maintenance of existing infrastructure.

Meaningfully complete survey responses were provided by 41 individuals from four federal agencies. The majority of responses (80%) were from U.S. Army Corps of Engineers (USACE) employees, representing 19 USACE District offices. The survey respondents represented considerable career experience with 56% having more than 15 years of experience and 43% having over 20 years experience. Respondents also included a good cross section of the communities of practice (e.g., Operations, Planning, Engineering, and Project Management) and technical disciplines (e.g., engineers, ecologists, biologists, environmental engineers).

The concept of EENI was relatively new to most individuals, but was viewed by 95% of the respondents as a focus area for which there is considerable opportunity. Respondents provided several examples of environmental enhancement efforts that have been implemented or considered. They also provided numerous new ideas for possible enhancements. These ideas spanned a wide range of navigation infrastructure, including river training structures, locks and dams, channels, and jetties/breakwaters. For example, notched chevrons provide low flow pools and small down-river islands and light-transmitting dock materials increased intertidal plant growth and habitat. The concept has been frequently and successfully employed, particularly on the inland river systems under the Upper Mississippi River

Restoration Environmental Management Program (UMRR-EMP) (http://www.mvr.usace.army.mil/EMP/default.htm).

At the outset of the survey, it was recognized that there may be a number of impediments to the implementation of EENI. Consequently, twelve survey questions addressed this issue and prompted respondents for their views and ideas. Cost sharing was viewed by 72% of respondents as a potentially high or a very high impediment to implementation of EENI. Institutional resistance and future maintenance of infrastructure were viewed as potentially important impediments, but of a lower magnitude than cost sharing, with about 50% of the respondents ranking these as very high or high.

Survey participants indentified the documentation of existing successful case studies and the implementation and study of environmentally beneficial pilot projects as two research areas requiring more attention. There was a dearth of specific research ideas beyond those suggestions; that may be partially due to the fact that the concept was relatively new to most individuals.

The overall concept of EENI appeared to be well-received by those taking the survey. There were concerns that EENI has the potential to complicate future maintenance of navigation infrastructure projects, but there was also strong support for exploring ideas. Accordingly, there was strong advocacy for early and open communication with stakeholders and the development of documents, such as Memorandums of Understanding (MOUs), that would clarify that benefits may be punctuated by maintenance impacts. In general, it was believed that approaching the maintenance of existing projects or the building of new projects with these steps incorporated into the project process would result in both better projects and stronger project support.

Specific recommendations from this study are as follows:

- **Promote the EENI concept.** The concept of looking for ways to add environmental enhancements to navigation infrastructure was novel 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 adopted more quickly if there are documented projects that demonstrate success and benefits. Efforts to identify and document case studies that will advance the concept are recommended.
- **Conduct pilot projects.** Pilot studies are excellent opportunities for conducting field-scale proof-of-concept projects. The development and refinement of innovations can be advanced relatively quickly through pilot projects. Any opportunity 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 for which EENI projects could be implemented. This could be accomplished through regional dredging teams or other means.
- **Research new ideas.** Numerous new ideas for environmental enhancements were mentioned. These ideas could be implemented in association with navigation infrastructure, and this list should be used as a resource to develop future research efforts.
- **Develop EENI goals.** The USACE, or perhaps the National Dredging Team (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 be an on-going challenge for the implementation of EENI. However, developing a special authority and appropriation for EENI activities may mitigate any potential difficulties associated with cost sharing. Promoting corporate donations and utilizing non-profit funding avenues such as the Coastal America Foundation (http://www.coastalamericafoundation.org/) to support EENI may also be effective.
- **Maximize use of coordination mechanisms.** EENI projects will require coordination among multiple stakeholders. Maximizing the use of available coordination mechanisms such as the regional dredging teams (RDTs), Regional Ocean Councils, or other such forums is a priority.
- **Develop interagency agreements.** The success of EENI faces numerous impediments, but interagency agreements that specify long-term interagency policy towards environmental enhancement projects have great potential to decrease resistance to project implementation and future misunderstandings. These interagency agreements could be

done on a project-specific or a regional basis, but the development of such a policy at the national level, such as through the NDT, would be extremely valuable for advancing the concept.

1 Introduction

This study, Environmental Enhancements and Navigation Infrastructure (EENI), was developed to investigate the opportunities and challenges associated with increasing the environmental attributes of navigation infrastructure such as jetties, locks, channels, and anchorages. This investigation was conducted as a strategic initiative of the Dredging Operations and Environmental Research (DOER) Program. The genesis of the project was in a position paper prepared by The World Association for Waterborne Transport Infrastructure titled "Working with Nature" (PIANC 2008). The premise of Working with Nature was to "identify ways of achieving the project objectives by working with natural processes to deliver environmental protection, restoration or enhancement outcomes" (PIANC 2008). Working with Nature provided the philosophical concept and the EENI project sought to investigate where and how that broad approach might actually be applied in practice, specifically in the context of navigation infrastructure. The present study sought to: (1) identify existing and potential navigation project features 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 & Goals of the Project

Navigation infrastructure projects all involve the human management of certain aspects of the natural environment. Some examples of these aspects are 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 opportunities for environmental enhancements to be incorporated into the design of these projects. When identified early, these potential features are more easily incorporated into the planning process. While it is U.S. Army Corps of Engineers (USACE) policy (USACE, 2002, 2010a, ASA-CW and USACE 2010, USACE 2004) to incorporate

environmental design features into USACE projects, realities associated with funding policies must also be factored into decisions.

The concept that navigation infrastructure can serve as valuable habitat is not new. Almost 30 years ago, it was recognized that rubble mound breakwaters provide reef-like or rocky shore habitat for a variety of invertebrates, fish, and birds (Knott, Dolah, and Calder 1984, Van Dolah, Knott, and Calder 1984, Van Dolah et al. 1984, Manny et al. 1985). 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.

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 advance planning the opportunities for adding environmental attributes could have been 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, consultation among planners, engineers, designers, and ecologists may be able to identify project design features that can be incorporated with little to no cost increase that will better provide environmental services. Other design features may also serve the needs of other interested entities that are willing to share the added costs. The involvement of ecosystem service-focused entities (e.g., the Fish and Wildlife Service (FWS), the National Oceanic and Atmospheric Administration (NOAA)-Fisheries, The Nature Conservancy, and others) can create 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.

The EENI study collected information and personal experience from participants who answered questions such as the following: What activities are persons from USACE and other agencies engaged in to add environmental enhancements to navigation infrastructure? Are there any innovative, yet untried approaches that would add environmental enhancements

to our navigation infrastructure? What are potential impediments to achieving increased environmental enhancements? Are there concepts that need further research? These and other questions were posed in the context of new projects or maintenance of existing infrastructure.

Project Approach

The study was conducted using communication and data collection techniques that have become enabled by the proliferation of internet-based tools including email, webinars, and an on-line survey.

Initial Outreach

The project approach and survey was formulated after initial one-on-one interviews with environmental planners and navigation project managers to gauge initial reactions and explore ideas for the study. These were followed by a briefing to the USACE Environmental 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) (http://water.epa.gov/type/oceb/oceandumping/dregedmaterial/index.cfm).

e-mail Announcement

An e-mail list 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 e-mail describing the project with an invitation to participate in the webinar and survey was sent to this distribution list and also to the NDT distribution list. The e-mail included a request to further distribute the e-mail to staff or colleagues who might have an interest in providing perspectives on the project and its aims.

Webinars

An internet-based webinar was presented on two separate occasions on the 17th and 25th of June, 2010. The webinar provided an electronic slide presentation of the project concept, approach, information needs, and a request for individuals to participate in the survey and communicate the information about the project to colleagues and staff (Appendix A). The webinar participants were asked to provide their initial perspectives and

ideas for discussion. In addition, an initial project summary webinar was held on 6 October 2010 to brief interested participants on the initial findings of the survey and to seek further input.

The introductory webinars were attended by over 60 individuals from federal and state agencies, regional dredging teams, and other interested entities. The 6 October webinar had over 20 interested participants in attendance.

Survey

A commercial, internet-based software tool (SurveyMonkey™ www.surveymonkey.com) was used to implement a survey on attitudes, ideas, concerns, existing projects, unsuccessful projects, relevant laws and regulations, case studies, and participant demographics (Appendix B). Initial survey design included consideration of overall survey objectives, question structure, and overall survey structure (Andrews et al. 2003, Creative Research Systems 2010, Dillman et al. 1999, Halteman 2007a, 2007b, Shannon et al. 2002), with particular emphasis on internet-based surveys. Survey questions were drafted and influence diagrams were developed to identify the relationships between the questions, to identify gaps in the survey, and to evaluate how the data to be collected would be analyzed (Figure 1 and Figure 2). Survey questions were further refined following this influence diagram analysis.

Once the draft survey questions were loaded into the internet-based tool, they were reviewed by the project team members in mock runs to test the survey features and the clarity of the questions. The survey was further revised -- including the order of the questions -- and then provided to several USACE personnel with knowledge of navigation infrastructure to conduct a beta test. These employees had been previously introduced to the EENI project through one of the outreach methods presented earlier. They were asked to evaluate the questions in light of the project's goals and assess both the survey's ease of use and its completeness. Further survey refinements were made based on comments from the beta testers and the final survey was produced.

The survey had a total of 53 questions grouped into seven topical sections (Table 1). Depending on how much information a respondent might be able to provide, it was estimated that the survey would take a minimum of twenty minutes and a maximum of two hours to complete. The survey

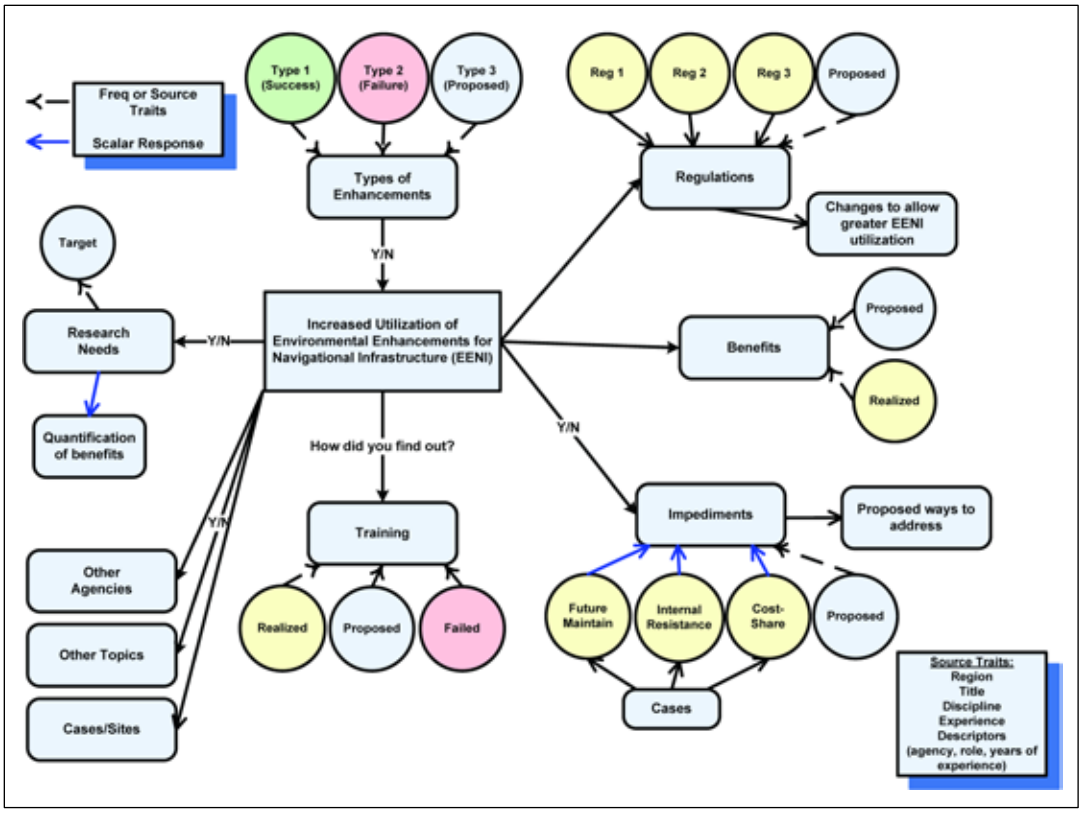

Figure 1. EENI Survey question influence diagram.

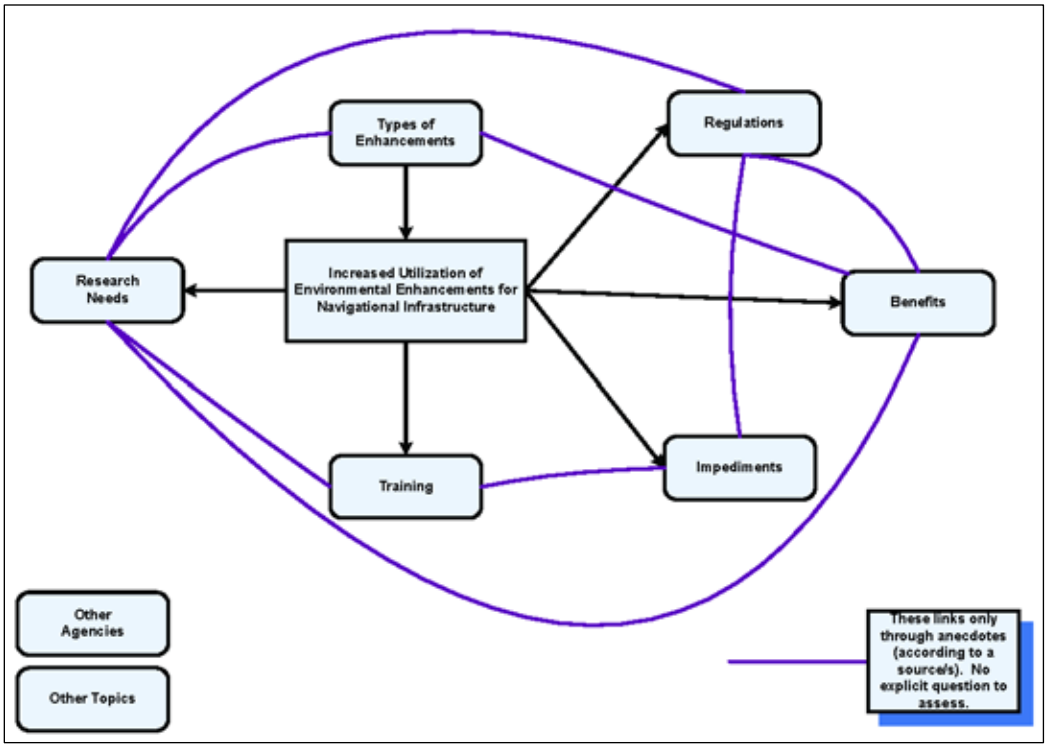

Figure 2. EENI major survey component influence diagram.

Table 1. EENI Survey sections and corresponding number of questions.

Survey Section	Number of Questions
1. Environmental enhancements: present and potential	13
2. Laws, policies, and regulations	6
3. Impediments to use	12
4. Research needs	8
5. Anything we missed?	3
6. Invite others to participate	2
7. Information about you	9
Total	53

consisted of different question types: Yes/No, Value Ranges, Demographic Check Boxes, and Open-Ended Text Responses (Table 2 and Appendix B). Most questions were optional, although those questions that requested a "Yes/No/No Opinion" answer or a determination of value (e.g., importance of a factor) were required. Respondents were provided an opportunity to enter relevant references, internet links, views, and reactions. They also were provided multiple opportunities to identify important topics that the survey might have missed. To encourage further participation, respondents were asked to provide contact information for colleagues or to forward the survey link, was according to their preference. Queries for demographic information allowed respondents to remain anonymous or not, but did require responses that were relative to the USACE district(s) with which they interacted the most. and also required their generic employment background (e.g., planner, project manager; engineer, biologist). A full copy of the survey is provided in Appendix B.

Following the webinars, the number of survey responses was tallied and follow-up emails were sent requesting completion of the survey (Figure 3). Phone calls and individual emails were particularly effective at increasing survey response. Potential respondents were offered an opportunity to take the survey via telephone interview; they were also encouraged to set up a specific appointment time on their calendars so that a specific time would be dedicated to the effort. Additional emails and phone calls were made to survey respondents who did not mind being contacted (as indicated by their responses to a specific survey question) to collect additional information on case studies or reports.

Table 2. 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?

Question #	Survey Questions by Section
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?
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?

Question #	Survey Questions by Section
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)

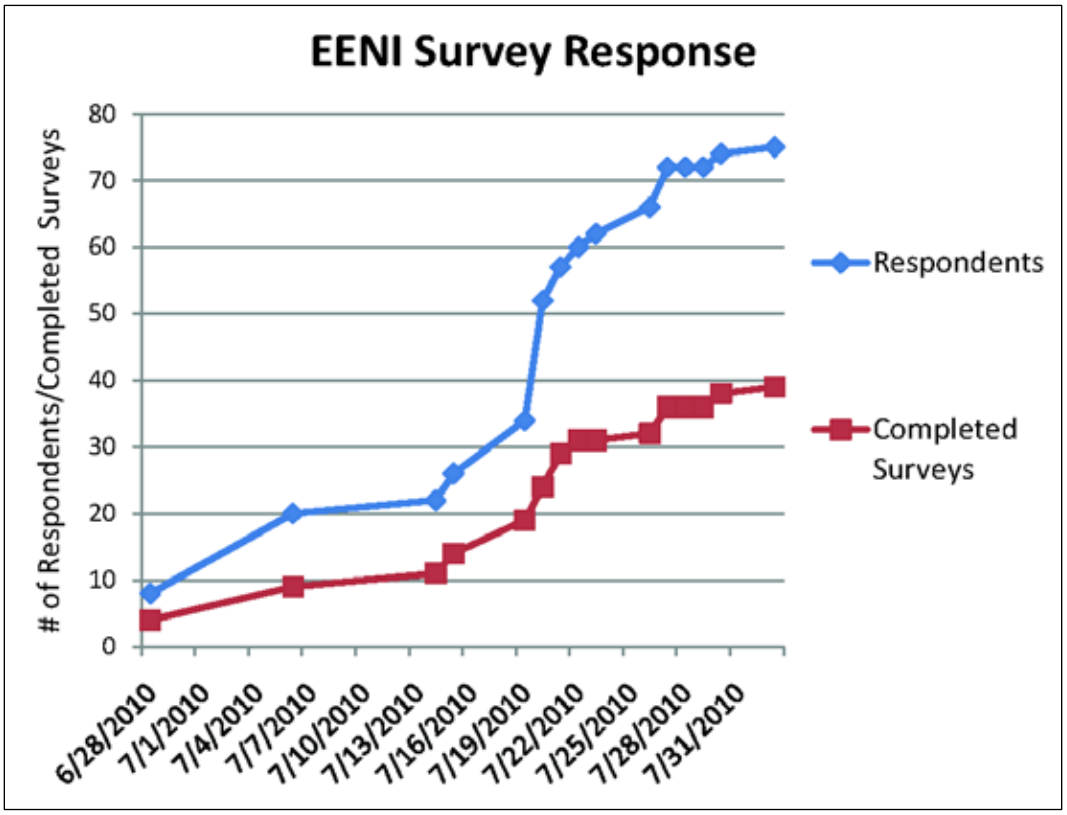

Figure 3. Timeline of survey participation showing number of respondents and completed surveys.

2 Survey Findings

This section provides a graphical and narrative summary of the survey responses. First, a summary of response numbers and respondent demographics from survey section 7 is provided. Next follows a summary of the questions in survey sections 1-4 (Table 1), which collected information and views on the use of EENI. Survey sections 5 and 6 are addressed, as appropriate, in the discussion section. The longest two sections of the survey, "Environmental enhancements: Present and potential" and "Impediments to use," are summarized on a question-by-question basis, whereas the shorter survey sections, "Laws, policies, and regulations" and "Research needs," have the responses summarized as a synthesis of the section.

Respondents

A total of 75 people began the survey and completed the first question (a required answer to continue) (Figure 3). 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 of those respondents answered question 2; therefore, there must have been a certain curiosity/interest factor if 26 individuals decided not to complete the survey after taking an initial view. Of the 49 that did answer question 1, the attrition rate through Section 6 — the final survey question before the demographics questions — was only eight individuals. The minimum time for any respondent to complete all sections of the survey was four minutes. Respondents who completed the survey in only a few minutes usually did not answer any of the narrative questions; thus, their views are captured only by the Yes/No and scaled-value questions. Most surveys (63%, 31 of 49) were completed in less than one hour and the modal time was between 15 and 20 minutes. Some survey respondents appeared to keep their internet browser survey windows open for hours to days and answered questions at a leisurely pace. The following figures and text provide a brief, quantitative summary of the respondent population who provided information about themselves, their employer, and other job-related information requested in section 7 of the survey.

Respondents worked for several federal agencies, including the U.S. Environmental Protection Agency (USEPA), NOAA, and the USACE (Figure 4). A preponderance of the respondents supplying this information worked for the USACE, as 31 of 39 (80%) worked for this organization. The one person selecting the "Other" category worked for the Natural Resource Conservation Service (NRCS).

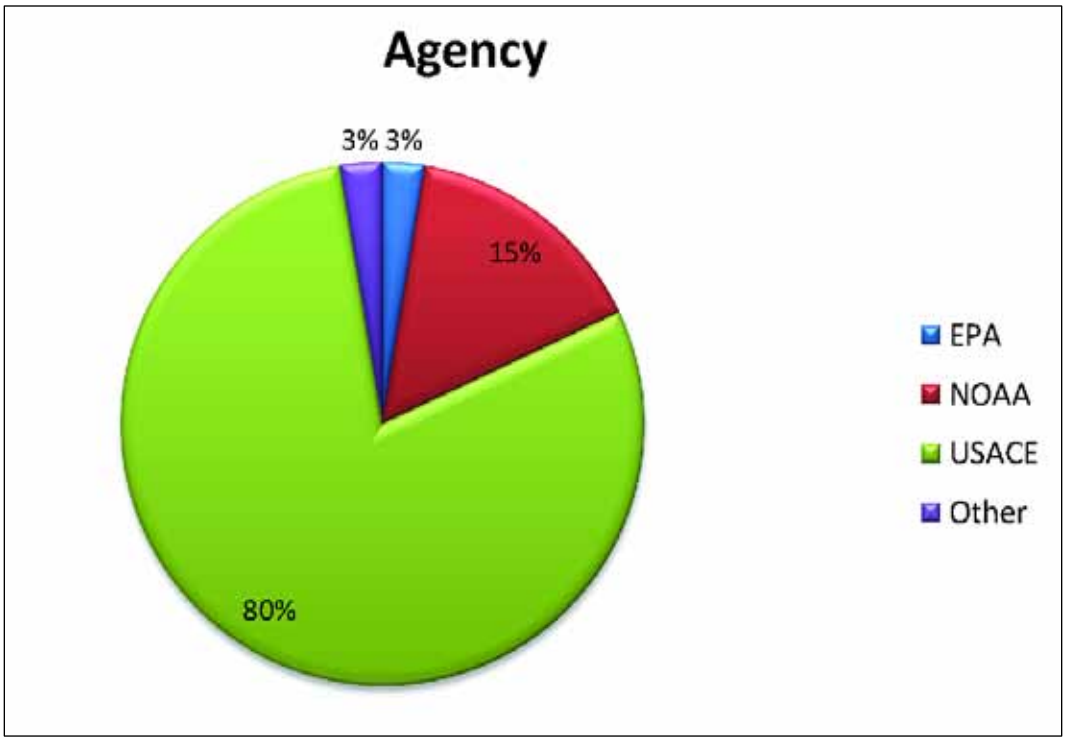

Figure 4. Respondent agency/organization represented.

Respondents indicated they worked with a variety of USACE District offices across the United States (Figure 5). A total of 19 USACE Districts were represented in the survey, providing a cross-section of this organization. Of the 37 respondents who answered the question, nine respondents worked with the New England District office, the most represented in the survey. Districts with three respondents each were Buffalo, Chicago, and Memphis. Respondents (4) in the "Other" category represented USACE laboratory and USACE Division offices.

Survey respondents held multiple office positions within the USACE (Figure 6). Most of the 39 respondents served in planning (39%), operations (33%), and engineering (26%) capacities. Also represented were regulatory, construction, and project management offices, providing a broad cross-section of office affiliations.

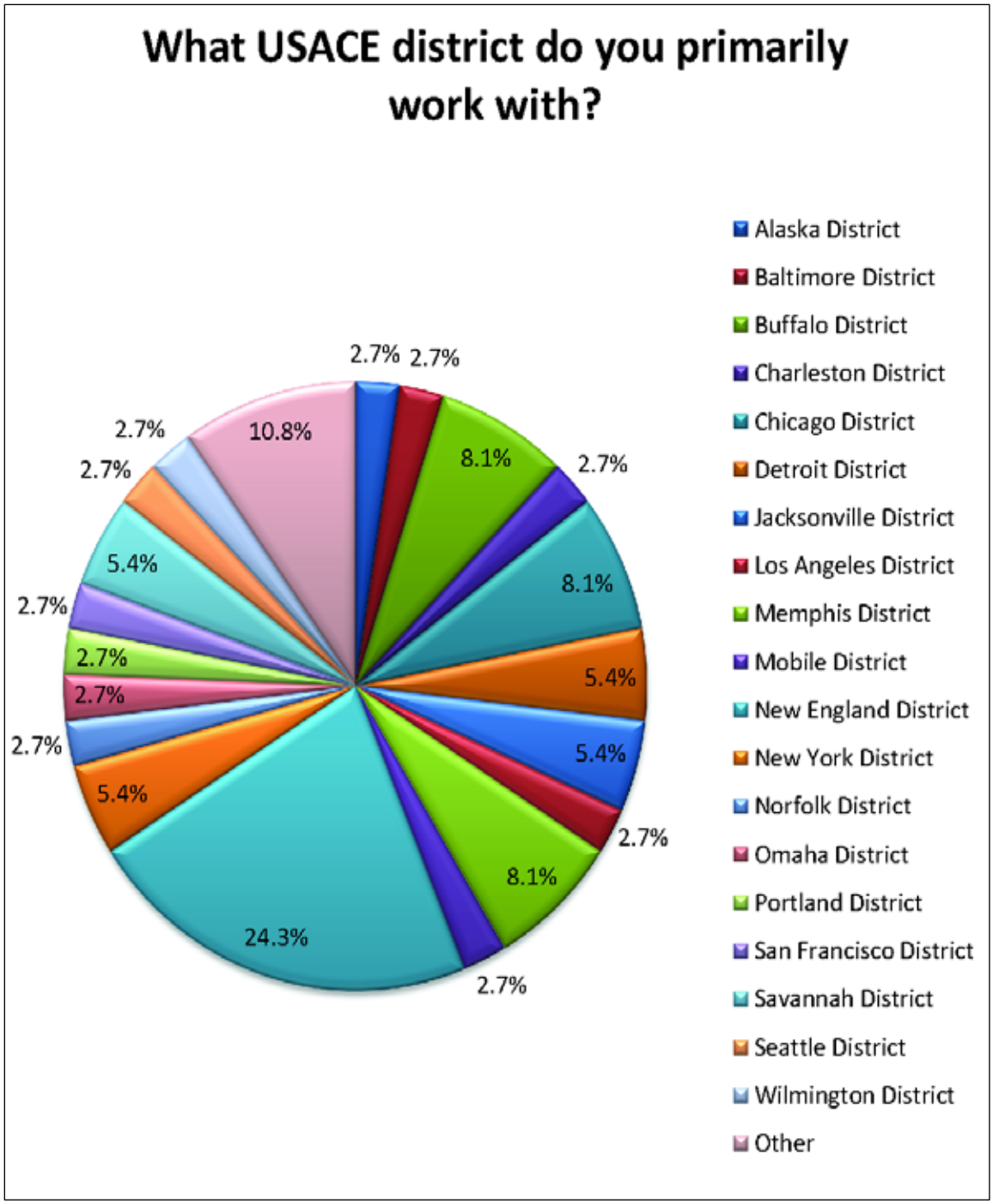

Figure 5. USACE District offices represented in the survey.

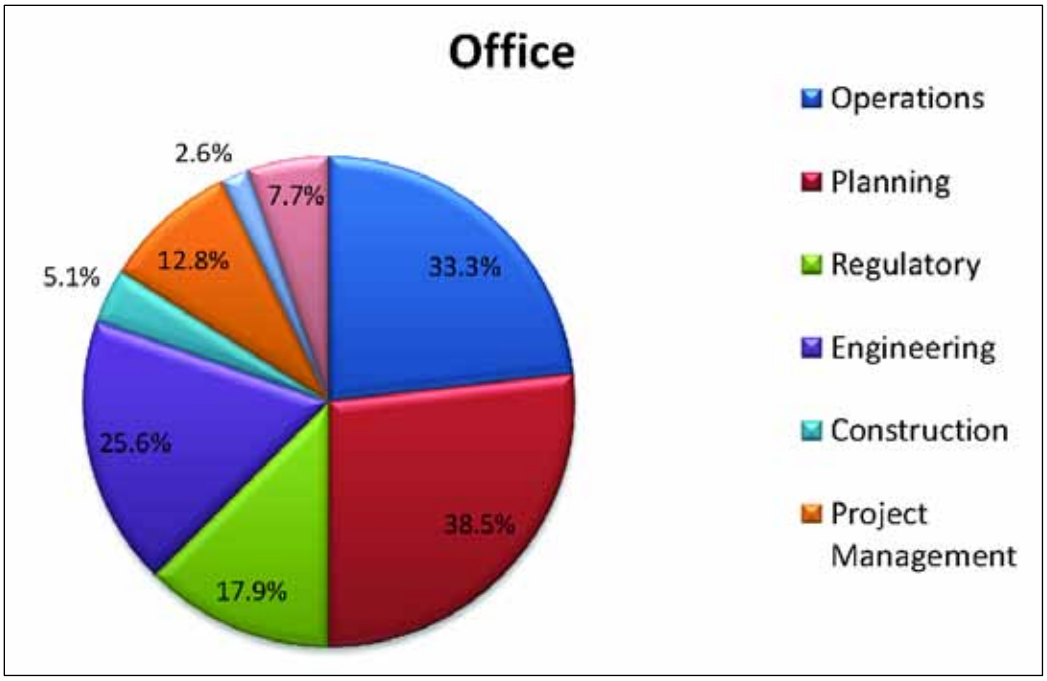

Figure 6. Respondent USACE office affiliations.

The most represented job titles were project manager (21%), planner (18%), researcher (18%) and supervisor (18%) (Figure 7). Regulators (5%) also were represented. Other respondents listed their job titles as biologist, ecologist and manager (other than project manager).

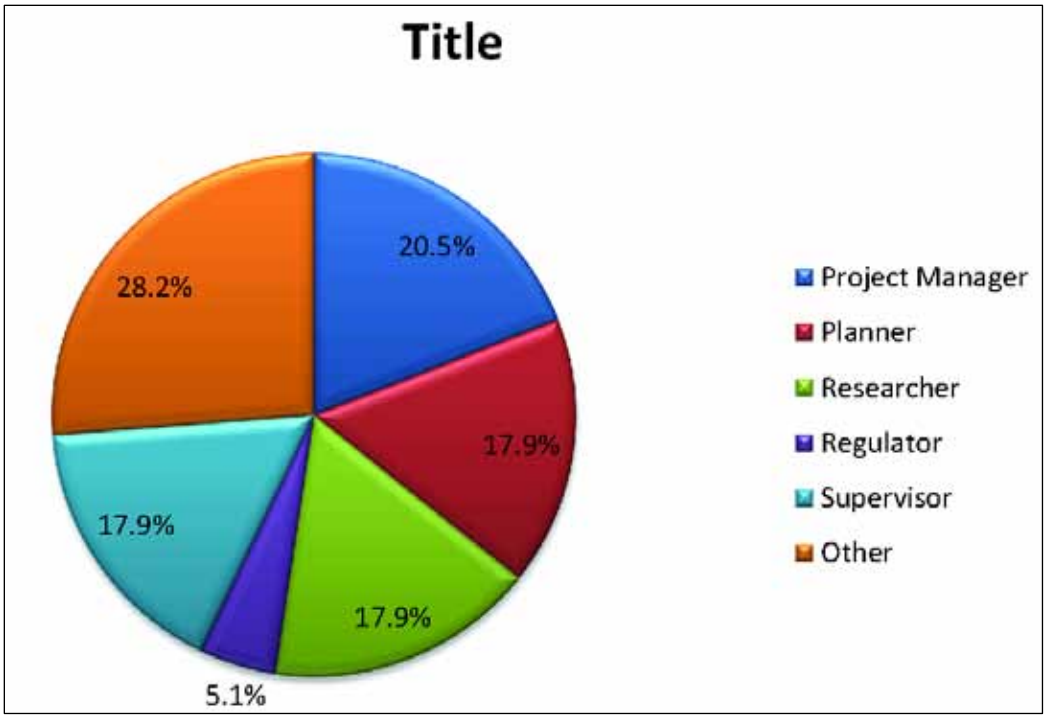

Figure 7. Respondent job title represented in the survey.

Of the 39 respondents providing such information, 13 were engineers (33%), the largest discipline represented (Figure 8). Also represented were ecologists (26%), biologists (26%), fishery biologists (13%), and environmental engineers (3%). In the "Other" category (10%), disciplines represented were two geologists, one environmental scientist and one plant materials specialist.

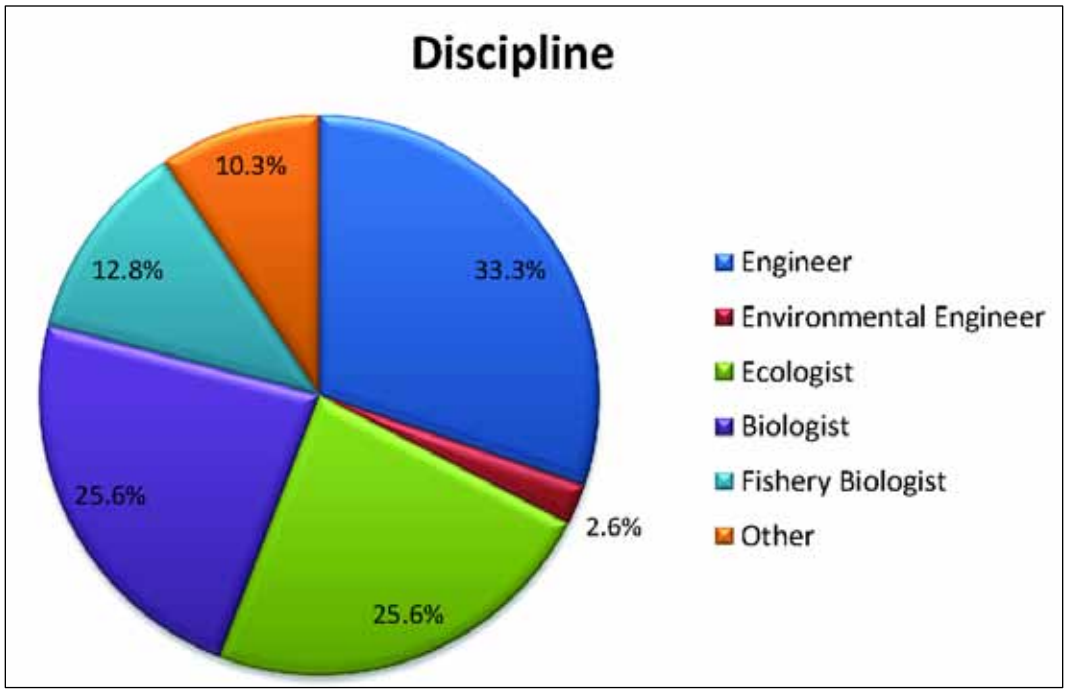

Figure 8. Respondent discipline represented in the survey.

Respondents were asked about their years of experience working with navigation infrastructure projects. There was a bimodal response to this question, with 11 respondents (28%) indicating they had 1-5 years of experience and another 11 respondents indicating they had more than 25 years of experience (Figure 9). Of the 39 respondents answering this question, 22 (56%) had more than 15 years of experience working in the navigation infrastructure field.

Figure 10 shows the contribution of years of experience in the navigation infrastructure field to discipline. Respondents with more than 25 years experience were included in four of six major disciplines represented in the survey (including "Other"), indicating a strong cross-section of participants with a wealth of relevant experience.

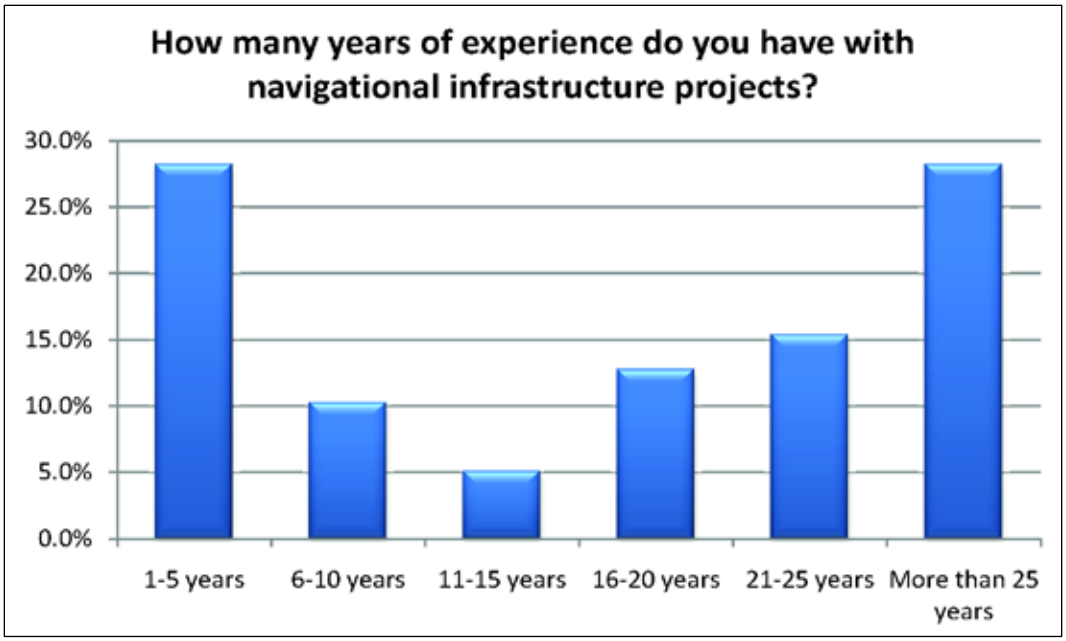

Figure 9. Respondent years of experience involving navigation infrastructure projects.

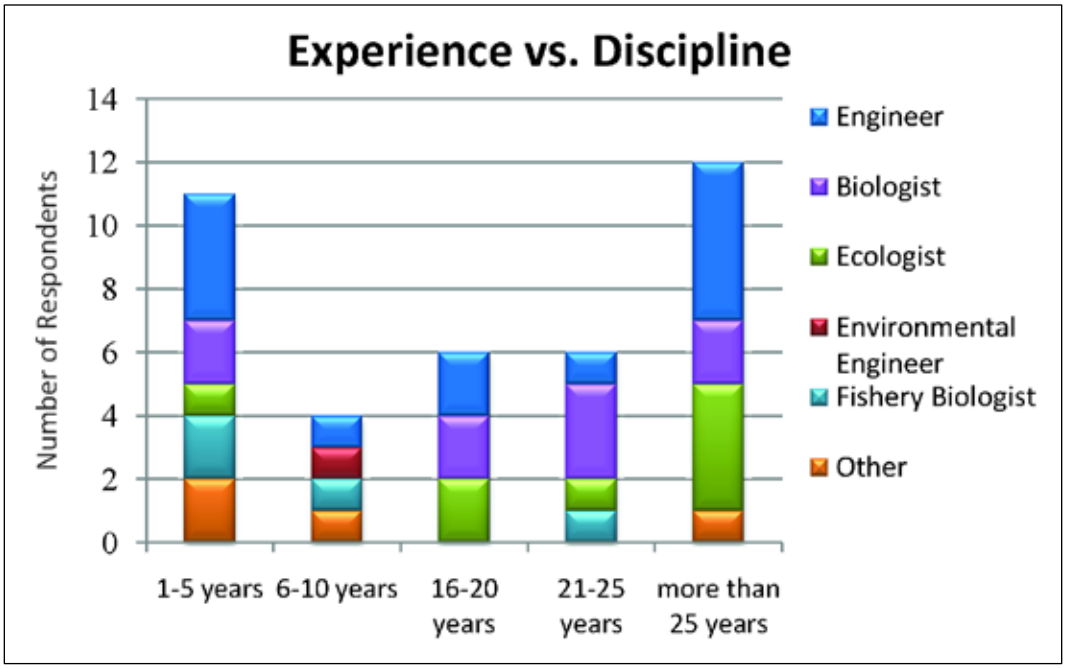

Figure 10. Contribution of years of experience to respondent discipline.

Likewise, Figure 11 shows the years of experience in the navigation infrastructure field according to respondents' profession. Respondents with more than 25 years of experience were included in five of the eight categories represented in the survey, again indicating a strong cross-section of participants with a wealth of relevant navigation infrastructure experience and varied perspectives on the issues.

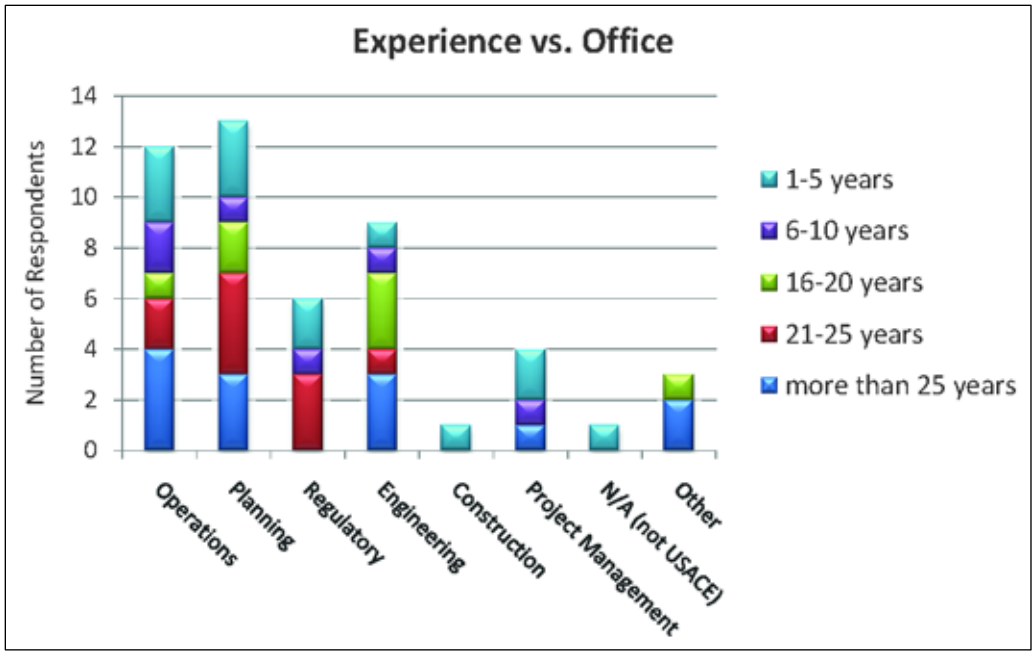

Figure 11. Contribution of years of experience to respondent office affiliation.

Environmental enhancements: Present and potential

Section 1 of the survey consisted of thirteen questions, the greatest number of questions in any of the sections. Questions in this section prompted participants to identify existing EENI projects and innovative ideas for infrastructure enhancements; there were also questions on training or about additional information needs. This section presents each of those thirteen questions followed by a summary of the responses:

1. Do you believe there are opportunities to improve the environmental attributes of existing or future navigation infrastructure projects?

This first question provided entry into the survey and was specifically designed to be simple to answer. Survey design theory and practice (Dillman et al. 1999) indicates that survey initiation and completion is very dependent on the first question. Successful surveys quickly get respondents into the topic. This question was answered by 75 respondents with a large majority (95%) believing that there is opportunity to improve environmental attributes of navigation infrastructure (Figure 12). The other four respondents replied “Not Sure” and no respondent believed there are no such opportunities.

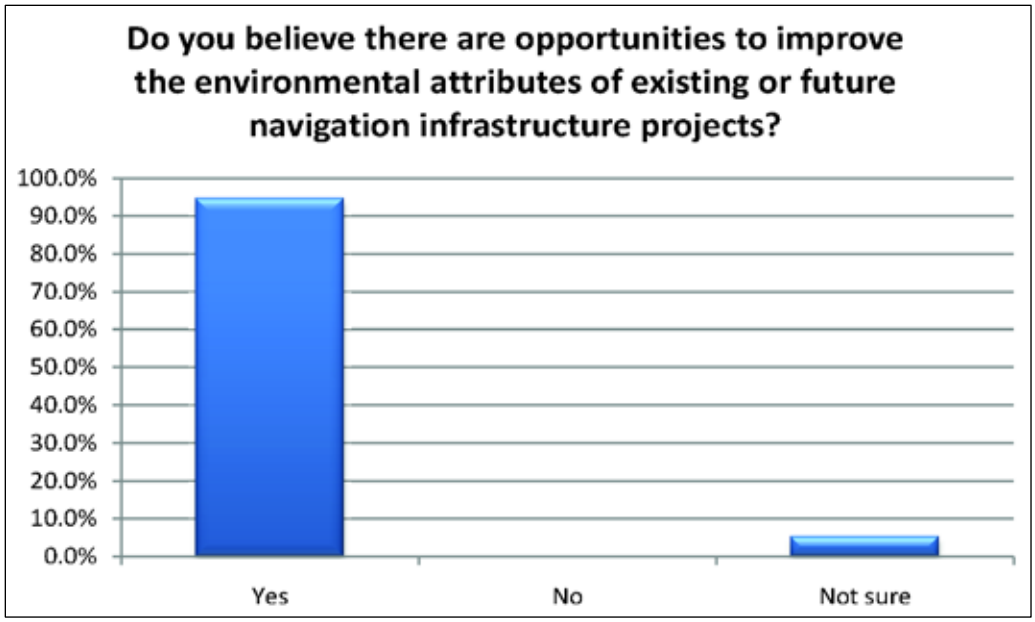

Figure 12. Respondent views on opportunities for EENI on navigation infrastructure.

2. Are you familiar with any projects in which environmental enhancements have been considered or incorporated?

Only slightly more than half (53%) of the 49 respondents to this question stated that they were familiar with projects in which environmental enhancements had been incorporated (Figure 13). A few (4%) were unsure and 43% were unfamiliar with any such projects.

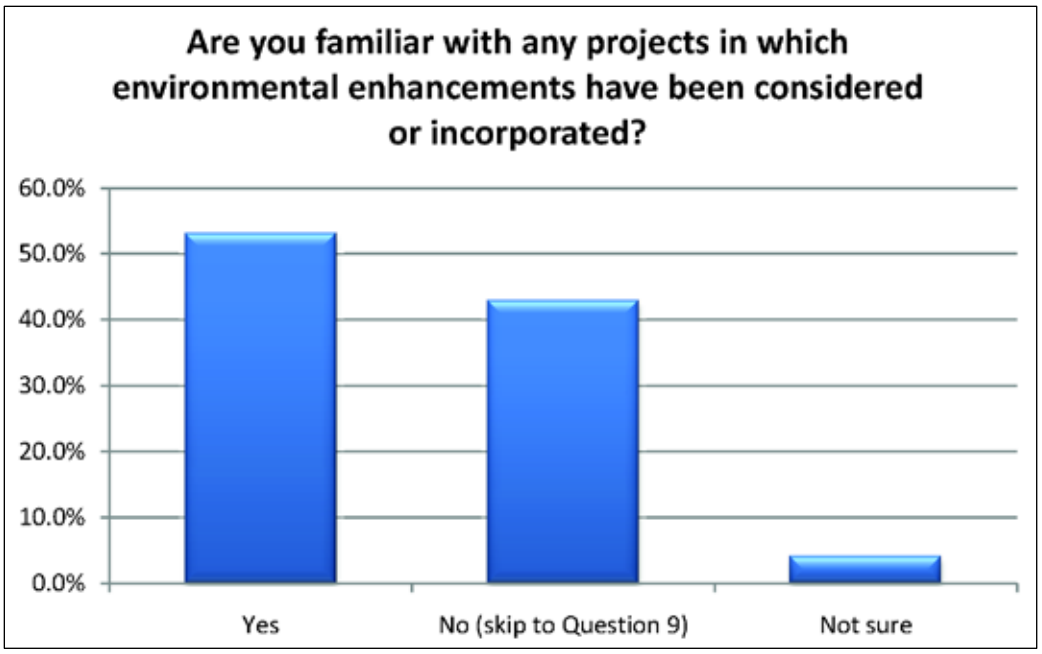

Figure 13. Respondent familiarity with existing EENI projects.

3. Please identify any relevant project(s), the environmental enhancement(s) and provide links to references as appropriate.

When asked to identify projects that respondents were familiar with, 27 individuals provided narrative responses. A number of these responses were related to beneficial use of dredged material the authors of this study and the survey considered this outside the realm of EENI. Other non-EENI projects mentioned included environmental restoration or mitigation projects. However, because information on these types of projects might be useful for others, the information from respondents is summarized at the end of this section.

Respondents provided several examples of environmental enhancements that are currently in place, others that are suggested or part of the planning process, as well as modifications of existing navigation structures that can offer some environmental benefit (Table 3). Some of the responses provided only a general description of the project or concept, but others provided project names or internet links to resources. Using the responses provided, the internet links, and after making follow-up contacts with respondents, we have summarized information on the various projects below.

River Training Structures and Channel Enhancements

Nature-inspired fish ladders such as rock arch rapids (Figure 14) aid in upstream fish migration. These are created by placing large rocks on the surface of the rapids in vanes so that they slow the water velocity and provide “flow shadows” which allow the fish to rest. This fish passage method has been used on over 30 lock and dams in the upper Midwest, Red River of the North in North Dakota and was developed by Luther Aadland of the Minnesota Department of Natural Resources.

Dikes are long, linear berms of large rock constructed perpendicularly from the riverbank towards the main channel of the river. They are used to deflect or direct water flows toward the navigation channel of the river at medium to low river stages. Often dikes are constructed in a series, known as a dike field. Dikes increase current velocity in the navigation channel, thereby increasing transport of sediments and maintaining open and safe navigation. A notch is a trapezoidal opening in a dike that can be large or small, depending on the specific channel conditions. Notches are made either by removing rock during maintenance work on an existing dike or by leaving an open, low section when a new dike is built; this low section

permits lower river stages to pass through. Notches reduce sedimentation in old chute channels and behind sandbars and maintain flowing water conditions at low stages in secondary channels. Additionally, low water stages flowing through a notch result in a diversity of current velocities at the notch that increase substrate diversity (both in composition and topography/bathymetry), thereby increasing aquatic habitat and aquatic species diversity downstream of the notch. These methods have been employed in various reaches of the Mississippi River in efforts to maintain habitat for larval and juvenile fish, while also enjoying successes in protecting least tern nesting colonies (Boysen et al, 2010). Chevron dikes, as the name implies, are v-shaped rock structures placed facing down-stream and staggered to provide an effect similar to a solid linear dike

Table 3. Categories and descriptions of existing navigation infrastructure environmental enhancements provided by survey respondents.

Environmental Category	Description
Breakwaters, Jetties, Groins	Placed pea gravel on stone toe for fish spawning habitat. Rochester Harbor, NY Wave Surge Reduction Project
	Notched some of the continuous breakwater protecting a shoreline to pump behind, create a wetland, and provide tidal flushing
Locks & Dams	Hard structures are “scratched” to enhance the settlement of aquatic insects
	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.
River 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.
	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
Islands	Oyster shell added to the surface of a dredged material island to promote nesting of least terns at Barren Island
	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
Channels & Anchorages	Eelgrass planting in anchorages
Piers & Wharves	Marina in Canada incorporated vegetation and shaped breakwaters to accommodate habitat
	Coral enhancement projects for a new wharf on Guam
	The inclusion of light-transmitting materials used for docks and stationary structures as a modification, allowing vegetative colonization of areas beneath the structures

Figure 14. Rock arch rapids used to replace a low head dam (Photo courtesy of Minnesota Department of Natural Resources).

structure discussed above. They can be designed to allow the river to sculpt the riverbed (and dredged material deposited there) into a more diverse physical environment. Similar to the modifications to linear dikes, chevron dikes can also be notched to develop more diverse habitat types (Figure 15).

Figure 15. Aerial views of chevrons used in river engineering. (Photos courtesy of USACE Rock Island District)

Anchorages, Wharves, and Docks

The inclusion of light transmitting materials used for docks and stationary structures is a modification which allows vegetative colonization of areas beneath the structures. The integration of light-transmitting materials (LTM) (Figure 16) may include various materials shaped in the form of grids, grates, lattices, etc., to allow the passage of light through the open spaces. In Florida, LTM used in construction for minor piling-supported structures is required to have a minimum of 43% open space, based on construction guidelines for minor piling-supported structures constructed in or over submerged aquatic vegetation, marsh, or mangrove habitat (USACE/NMFS 2008).

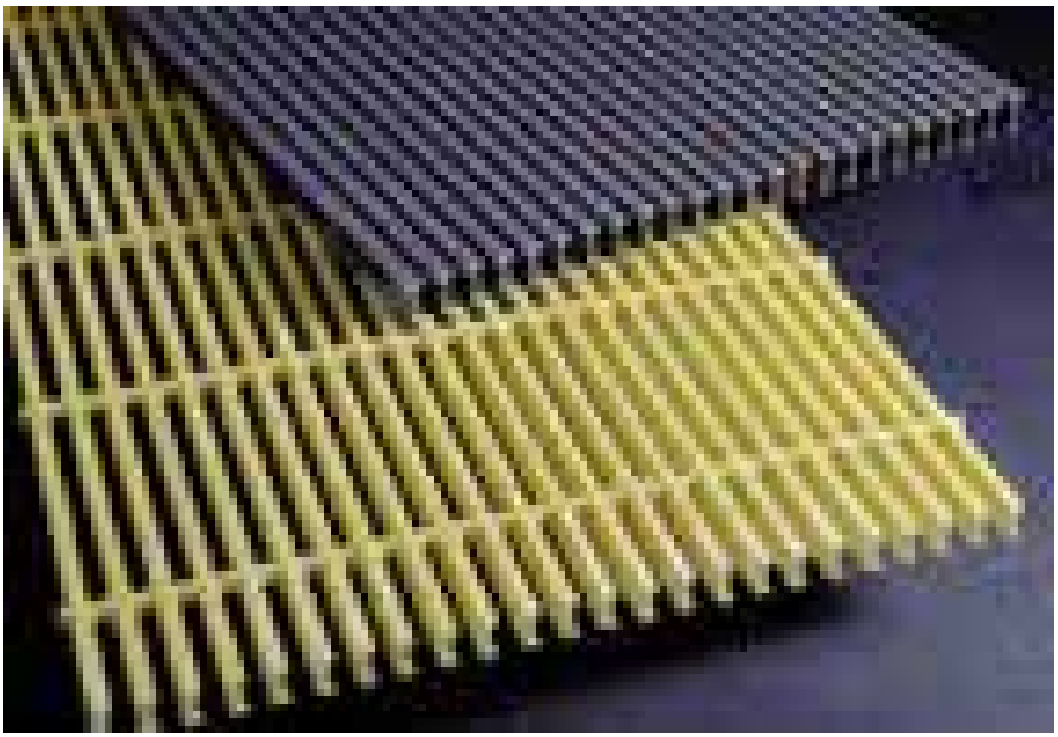

Figure 16. Example of light-transmitting material used for docks near submerged aquatic vegetation. (Photo courtesy of www.seasafe.com)

Eelgrass planting in anchorages has been considered in several cases, and – according to one report — implemented in a maintenance dredging project in Little Harbor, New Hampshire. There is a significant amount of literature that can be used as a resource to increase the success of eelgrass planting efforts (Paling et al. 2001, Orth et al. 2006). However, the establishment of beds of eelgrass can complicate maintenance dredging operations; an agreement must be reached about the periodic removal of these beds.

Jetties and Breakwaters

These hard structures are likely to provide habitat diversity even in the absence of improvements. Significant fish and lobster populations have been observed around stone breakwaters in southern Florida. However, as reported earlier, adding pea gravel around a breakwater toe has been done in the Great Lakes to enhance the available fish spawning substrate. Breakwaters for shoreline protection have been designed with notches to increase tidal washing of wetlands.[1] In freshwater systems, hard structures are "scratched" to enhance the settlement of aquatic insects (Way et al. 1995). Similar modifications may be possible to encourage settlement of bivalves in marine systems. Active inclusion of oyster or mussel shells to these structures was suggested as a means to enhance biological filtration and improve water quality.

EENI Ideas for Created Islands and Dikes

Substrate control and management is underway in several areas of the nation to promote shorebird nesting sites and success. These projects result in the creation and management of near shore nesting sites, monitoring of nesting populations, and controlling predators. One such example is Craney Island, a confined disposal facility (CDF), which is managed as a wildlife habitat (Figure 17). Similar to the Craney Island example, other dredged material disposal areas have been capped with oyster shells to promote and establish least tern nesting sites. The addition of culverts in constructed wetland areas to allow fish passage was an important part of Chesapeake Bay program to restore wetlands and habitats on the Poplar Island CDF (NMFS, 1997).

4. How did you find out about designing and implementing these features? What process(es) enabled their consideration?

When asked the origin of EENI ideas that have been (or were being) considered, survey respondents provided a variety of answers. Of 23 written responses, six indicated that the enhancement under consideration was an original or shared idea. Interagency coordination was cited as a source of ideas by several (5) people, especially in cases of beneficial use of dredged material. At least three respondents indicated the idea came from an analysis or document prepared for the project (specifically Biological Opinion, mitigation requirements, or NEPA documentation).

[1] Brasfield, S. M. 2010. Personal communication with Robert Blama. August 3. Electronic mail.

Figure 17. Aerial view of Craney Island confined disposal facility, an area that when capped was planted and managed for wildlife habitat (Photo Courtesy of the U.S. Army).

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)

One important piece of information is determining at what phase these enhancements may have been considered. Respondents (23 total) primarily reported that EENI (or similar initiatives such as beneficial use of sediment) were considered in the comparison of alternative plans (5). Also mentioned were several instances of consideration of the incorporation of enhancements during the feasibility study (3), the planning phase (3), or the O&M (3) phase.

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.

Twenty-two respondents commented on the benefits resulting from enhancements that have been incorporated into existing projects. Of these

respondents, seven indicated that they were unsure of the ultimate benefit of the project. Three of these stated that there was no post-construction monitoring. Six responses indicated that monitoring to determine the benefits was under way. Comments in three cases indicated the benefit of the incorporated enhancement was to recruit the support of other stakeholders that ultimately allowed the project to proceed. Other enhancements resulted in acres of bird nesting habitat (3) or increased plant community diversity (1). Responses also indicated that projects had enabled greater compliance with state coastal zone plans, better relations with state and federal resource agencies, cost savings on transport of sediments, greater habitat connectivity for fishery species, and good publicity.

7. In cases where these features were not incorporated, what was the reason?

Thirteen (13) respondents addressed the question of why enhancements that may have been considered were not ultimately incorporated. Two answers indicated that it was too early in the project to determine if the EENI would be incorporated. Four indicated that additional funds for enhancements were not available. Other reasons included were engineering concerns (e.g., structural stability) (2), safety, and increased maintenance needs or future restrictions on maintenance (2). Another respondent indicated that incorporation was not possible because the short dredging window was insufficient for the construction needs of the enhancement project.

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?

The survey included a question about the agencies and stakeholder groups that were involved in the investigation and evaluation of EENI features. Nearly all of the 22 responses mentioned local or (interested communities, Regional Water Quality Control Boards, port authorities, baykeepers, Lower Mississippi River Conservation Committee) state organizations, (Departments of Environmental Protection or Conservation, Departments of Natural Resources, Coastal Commissions, state universities) federal agencies (USEPA, NOAA, NMFS, USFWS, National Park Service), and non-profit groups (beach alliances, American Littoral Society). Three responses specifically mentioned working directly with stakeholder groups

or interested individuals. One responder stated that stakeholders were responsible for acquiring the state and federal funding necessary to initiate the project.

9. Are there (other) environmental enhancements that you believe might be possible to incorporate into existing or future navigation infrastructure projects?

Over 60% of the respondents believed that there are other possible environmental enhancements that can be incorporated into navigation infrastructure (Figure 18). Whereas only 2% believed there were no other possibilities and 37% were unsure.

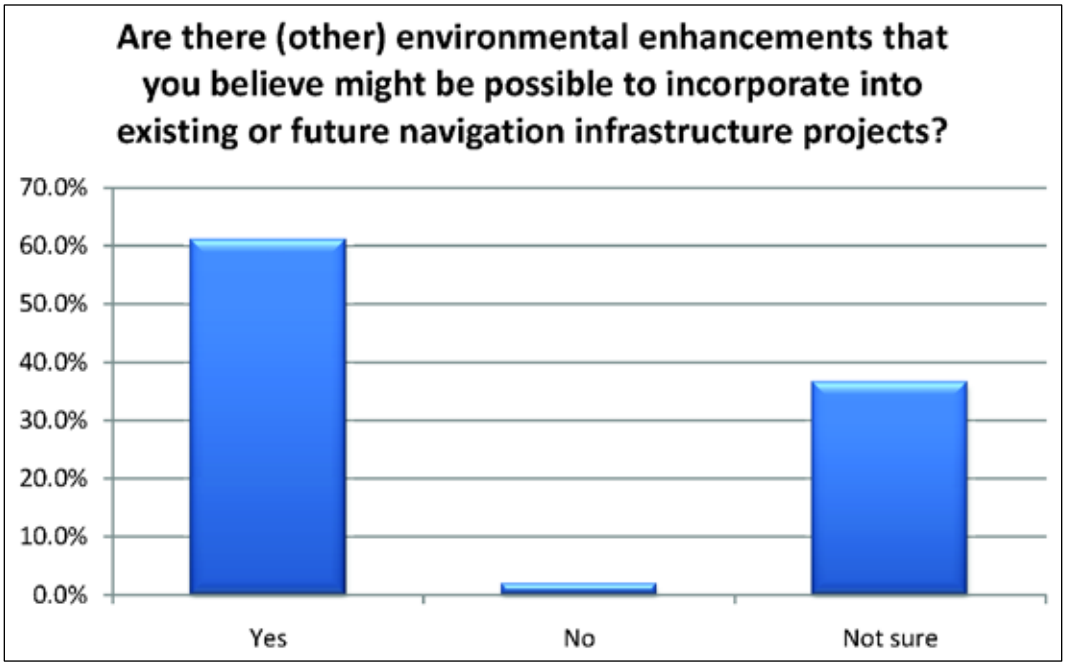

Figure 18. Respondent views on potential for other environmental enhancements.

10. If Yes, please describe any environmental enhancements that you envision and on what type of project. Be creative.

When asked to describe any environmental enhancements that they could envision and to list the type of projects for which the enhancements could be implemented, 33 respondents replied with narrative responses. A synopsis of the responses received is provided in Table 4.

11. What information/training would facilitate incorporating these or other environmental enhancements?

Table 4. Categories and descriptions of innovative navigation infrastructure environmental enhancements provided by survey respondents.

Environmental Category	Description
Breakwaters, Jetties, Groins	Use different sizes of stone (i.e., to increase surface complexity) or place cross-sectional modifications around other coastal structures like groins and revetments to enhance habitat
	Place or anchor other materials at the toe either inside or outside the protected area, to create areas attractive to fish
	Partially or completely convert older breakwaters into rubble mound structures, using the original structure as the core
	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
	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
	Use boxes to enhance fish spawning and habitat for structures such as breakwaters
	Create living reefs, shorelines (see, for example, http://ccrm.vims.edu/livingshorelines/index.html)
	Glue live oysters or mussels to rock jetties and breakwaters to encourage larval settlement and reef creation
	Encourage shellfish reefs to create self-sustaining biological filters
	Provide terrestrial habitat for birds on offshore breakwaters
Locks & Dams	(No specific suggestions for this category)
River Structures	(No specific suggestions for this category)
Islands	Plant and/or seed shellfish and native species
	Design island creation to incorporate features that promote native vegetation and wildlife productivity
Channels & Anchorages	Create shallow terraces or steps outside the channel footprint to enhance shallow water habitat (photic zone) for submerged aquatic vegetation, macroalgae, and oysters
	Add structural modifications such as large woody debris and additional rock to provide habitat depth/velocity/substrate
	Excavate back channels in river systems
Piers & Wharves	Design hard structures to facilitate better seaweed recruitment
	Provide aquatic habitat features on the sides of piers, jetties, and breakwaters
	Place spurs on jetties
	Create lay down/haul-out areas for marine mammals such as seals at jetties that could be incorporated onto existing structures
	Construct nesting platforms for ospreys and other shore birds
Water Quality	Implement projects to increase water quality or increase circulation to improve habitat as opposed to habitat creation

Participants were asked what information/training would facilitate incorporating environmental enhancements into infrastructure projects. A total of 32 respondents provided narrative responses, which echoed several major themes. These themes are identified and discussed below.

- **Coordination with stakeholders/agencies:** Coordination with resource agencies early in the project should be strengthened, as discussions at the start of a project might promote slight design changes that can enhance the environment. Stakeholders and agencies need to be aware of potential impacts that maintenance activities may have on enhancements. State regulators should be educated to improve receptiveness to the potential wildlife benefits derived from USACE actions, and to more easily facilitate the permitting process in cases where the USACE has expanded the footprint of a project.
- **Consultation with biologists/ecologists in design:** Engineering and operations staff need to coordinate with fishery biologists to determine the specifications related to toe stone sizes, cross-sections, placement methods, etc. that would create conditions to attract fish and their prey. Other sources of fisheries information could originate from NOAA and university researchers regarding the design of enhancement opportunities. Pertinent research data should be included in early conversations so data can be shared and incorporated during engineering design.
- **Training:** Training planners to perform environmental enhancement studies could improve EENI implementation success. Environmental design training also may be useful. For example, see web link by the Center for Coastal Resources Management (CCRM) at http://ccrm.vims.edu/.
- **Tradeoffs and benefits:** Sharing information on the tradeoffs and benefits of environmental enhancements with resource agencies may help sway those who are typically opposed to including enhancements in navigation projects. It would also be necessary to identify state and federal regulations that could potentially serve as roadblocks.
- **Pilot projects:** Success stories and problem issues related to enhancement techniques in pilot and demonstration projects should be documented. Assurances should be made that future maintenance of the environmentally enhanced project will not be impacted or become more difficult to permit.
- **Enhanced communication:** Information sessions, workshops, conference calls, site visits, among other methods should be used to enhance communication. There is also a need for better communication

and dissemination of EENI materials to employees via the appropriate courses and communities of practice within the USACE. Better communication is needed about USACE concerns regarding implementation and management of EENI projects. On the local scale, many enhancement alternatives are not widely known by regulatory agencies, resulting in a lack of communication to project proponents about design modifications. Better communication among regulatory agencies is therefore needed to facilitate wider implementation.

- **Establish trust:** There is a need to establish trust that USACE is seeking to cooperatively work with state and federal resource agencies to identify and implement EENI projects.
- **Information on existing structures:** Information on existing structures that are currently being used as habitat should be more effectively shared, along with the characteristics that have made them successful. Information should also be shared in order to avoid situations where structure function or maintenance requirements would be substantially altered.
- **Field trips to projects:** More field trips with various agency representatives from the USFWS, NOAA/NMFS, states and others to successful Corps projects are needed to observe success stories and to brainstorm potential ideas. It is important to get the right people together to make progress on EENI projects.

12. What training/information or programs have we tried that didn't work? Why do you think it didn't work?

Respondents were asked what training/information or programs have been tried that didn't work, and if they did not work, respondents were asked the potential reasons why. Sixteen narrative responses were received, although information directly answering the question was generally lacking. What follows summarizes the responses received from participants indicating which factors they believe need to be changed.

- **Instilling environmental enhancement values:** There needs to be a philosophical change for the mission so that the point of view shifts from just getting the project done to making sure that projects are designed to enhance the environment within existing environmental laws. The challenge lies in part in trying to instill environmental values in organizations.

- **Lack of post-project monitoring:** Most USACE projects attempting to restore SAV by transplanting existing beds and have not succeeded. There are likely multiple reasons behind this lack of success, including inadequate site selection criteria. But because post-project monitoring is limited or lacking, few data exist to understand why SAV transplants have not succeeded.
- **Training in small quantities:** Training/information that takes too long to read and comprehend, as is often the case, is usually ignored due to time constraints; thus, it does not receive the full attention it deserves.
- **Concern with the usefulness of ERDC technical notes:** Concerns were expressed by one respondent that ERDC technical notes (TN) could be more helpful to USACE districts. The information in the TNs could be more useful and the authors could do a better job of presenting the material in a way that is more easily understood and meets the needs of the districts. Authors and editors should redouble efforts to ensure that technical notes are written with the district audience in mind.

Beneficial Use of Dredged Material, Environmental Restoration, and Mitigation-Related Responses

As discussed earlier, respondents to the survey provided reference to a number of dredged material beneficial use projects or other projects not directly related to EENI. These responses are summarized in Table 5 in the event the information might be useful to those interested in these projects. The table presents the level of detail provided by each respondent and further project information was not sought by the EENI study; however, it may be possible for others to use this basic information to get greater details, as needed.

Laws, policies, and regulations

At the beginning of this six-question section (Table 2), respondents were provided with a list of regulations believed to be important when considering environmental enhancements for building or maintaining navigational infrastructure (Table 6). The list contained several sections of the Water Resources Development Act, the Rivers and Harbors Act, the Coastal Wetlands Planning, Protection and Restoration Act as well as the National Environmental Policy Act and the Clean Water Act (Appendix B). The responses to the six questions are addressed in a single narrative below.

Table 5. Beneficial use and other projects mentioned by respondents while identifying environmental enhancements.

Environmental Category	Project Description and Location
Beneficial Use	Nearshore Berm Design, Placement, and Monitoring Project; Beaufort Inlet, NC
	Sand dredged from Cape Cod Canal Federal Navigation Project used to cap Boston Harbor Federal Navigation Project
	Sand from Point Judith Pond Federal Navigation Project used to nourish nearby beach
	Sand by City of Saco, ME pier used to nourish Ferry Beach
	Sand from Clinton Harbor Federal Navigation Project and Patchogue River Federal Navigation Project used to nourish Hammonasset Beach, CT
	Dredged sediment approved for ocean disposal used to cap the Historic Area Remediation Site (HARS); see http://www.nan.usace.army.mil/business/prjlinks/dmmp/benefic/hars.htm
	Excavated rock placed at state-managed and NOAA-approved offshore artificial reef sites used to enhance fisheries habitat in NY and NJ Harbor deepening project
	Dredged sand used to restore eroded marsh islands in Jamaica Bay, NY Federal Navigation Project and NY & NJ Harbor Deepening project
	Mudflat created at Jonesport, ME
	Beach nourished under the 204 Program at Newburyport, MA
Habitat Restoration	Beach reconstructed in Grays Harbor, WA and Half Moon Bay, WA projects
	Sweetgrass plantings used to benefit wildlife habitat and renourish beaches on Hoover Dike, FL
	Dredged material from Snohomish River, WA used to cap creosote contaminated sediments at the Pacific Sound Resources and Wyckoff/Eagle Harbor East Operable Units
Mitigation	Bird and salt marsh habitat created as part of mitigation requirements for the Savannah Harbor Long Term Management Strategy and Brunswick Harbor Deepening projects

Table 6. Initial list of EENI-related national laws and regulations provided in the survey*.

LAW	SECTION	PROVISION	EFFECT	LINK/ SOURCE
Water Resources Development Act of 1986	Section 1135	"Authorizes the Secretary of the Army to modify the structures and operations of water resources projects constructed by the Corps to improve the quality of the environment consistent with authorized purposes"	Allows for inclusion of enhancements in development or maintenance of structures related to water resources. A non-federal cost share of 25 percent for incremental costs is required for project implementation, and the non-federal sponsor must operate, maintain, repair, rehabilitate, and replace the completed project. If the estimated federal cost of such a modification exceeds $5 million, specific congressional authorization is required	http://www.tpub.com/content/USACEengineeringpamplets2/EP-1165-2-1/EP-1165-2-10230.htm
Rivers and Harbors Act and Flood Control Act of 1970	Section 216	"This provision authorizes review of the operation of completed projects in two situations: (1) when significantly changed physical or economic conditions make a review of such projects advisable, and (2) for improving the environmental benefits that such projects provide to society."	Provides a mechanism for improvement of downstream conditions, either in terms of fish populations or habitats. This study authority can be used to seek specific congressional authorization of a navigation project modification	http://www.nao.usace.army.mil/projects/civil%20works%20projects/GATHRIGHT%20DAM-LAKE%20MOOMAW/homepage.asp
River and Harbor Act of 1968	Section 111	"Provides authority for the Corps of Engineers to develop and construct small projects for the purpose of mitigation of shoreline erosion or accretion problems directly influenced by the construction of a federal navigation project. The amount of mitigation is limited…"	"Feasibility (study phase) and Design and Implementation Phase (detailed project design and construction). The first $100,000 of Feasibility Phase costs are financed at 100% federal costs. All Feasibility phase costs above $100,000 are cost-shared 50% federal and 50% non-federal in accordance with a Feasibility Cost-Sharing Agreement (FCSA) prepared for the study."	http://www.lrb.usace.army.mil/missions/SECTION%20111%20FLYER%20Letter.doc

LAW	SECTION	PROVISION	EFFECT	LINK/ SOURCE
Water Resources Development Act of 1996	Section 206	Authorizes the Corps to plan, design and build projects to restore aquatic ecosystems for fish and wildlife	The Corps of Engineers provides the first $100,000 of study costs. A non-federal sponsor must contribute 50 percent of the cost of the feasibility study after the first $100,000 of expenditures, 35 percent of the cost of design and construction, and 100 percent of the cost of operation and maintenance.	http://www.nae.usace.army.mil/pservices/206.htm
Water Resources Development Act of 1990	Section 306	"The Secretary shall include environmental protection as one of the primary missions of the Corps of Engineers in planning, designing, constructing, operating, and maintaining water resources projects."	Allows for environmental protection without requiring budgetary or procedural constraints to planning maintenance or construction	http://www.nab.usace.army.mil/whatwedo/civwks/wrda90.pdf
Water Resources Development Act of 1992	Section 204	This provision authorizes projects for the protection, restoration, and creation of aquatic and ecologically related habitats, including wetlands, in connection with dredging in new project construction and maintenance of existing federal navigation projects, including harbors and inland waterways. The Section 204 cost is the increment above the cost for the base plan for dredged material disposal.	Non-federal sponsors are responsible for 25 percent of the project cost and 100 percent of the cost of Operation and Maintenance, Repair, Replacement and Rehabilitation (OMRR&R). There is an annual appropriations limit of $15 million.	http://www.tpub.com/content/USACEngineeringpamplets2/EP-1165-2-502/EP-1165-2-5020011.htm

LAW	SECTION	PROVISION	EFFECT	LINK/ SOURCE
Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA or "Breaux- Johnson Act"; [PL 101-646])	Section 307(a)	The Secretary is authorized to carry out projects for the protection, restoration, or enhancement of aquatic and associated ecosystems, including projects for the protection, restoration, or creation of wetlands and coastal ecosystems. In carrying out such projects, the Secretary shall give such projects equal consideration with projects relating to irrigation, navigation, or flood control.	Equal consideration of environmental and navigational benefits projects. This act establishes a matching grant program for coastal wetlands-conservation projects by coastal states.	http://www.mvn.usace.army.mil/pd/CWWPRA%20Desk%20Reference%20Digital%20Binder_with%20PPL17%20maps.pdf
National Environmental Policy Act (NEPA)		The National Environmental Policy Act (NEPA) requires federal agencies to integrate environmental values into their decision-making processes by considering the environmental impacts of their proposed actions and reasonable alternatives to those actions.		http://www.epa.gov/compliance/nepa/
Clean Water Act (CWA)		The objective of the Federal Water Pollution Control Act, commonly referred to as the Clean Water Act (CWA), is to restore and maintain the chemical, physical, and biological integrity of the nation's waters..."		http://www.epa.gov/agriculture/lcwa.html
*Some of this information was compiled from Chapter 5 of the Beneficial Use Planning Manual, "Funding Beneficial Use Projects."				

The response to the question asking if the provided list was correct and complete (Figure 19) was informative. The majority of respondents (59% of 46 responses) were unsure if the mentioned policies were the only ones that might impact the development of EENI. A 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. A list of the regulations believed to be relevant by respondents is included below (Table 7).

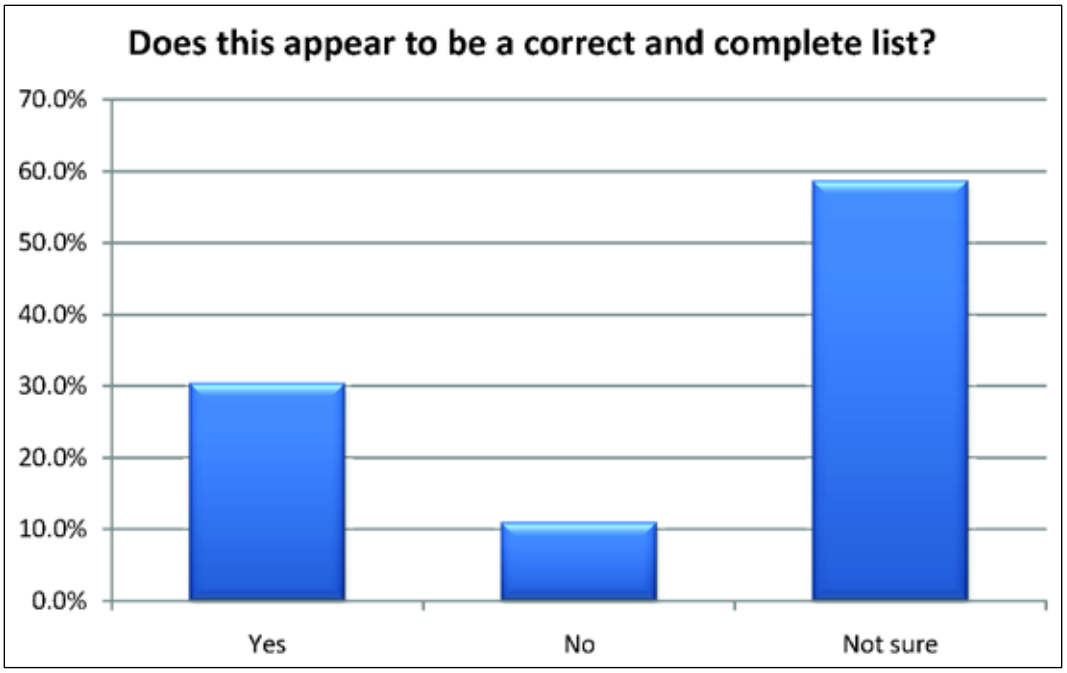

Figure 19. Responses of survey participants to a question concerning the laws, policies and regulations that might govern consideration of EENI.

Many of the relevant laws, policies and regulations presented to survey takers are described in Chapter 5 (Funding Beneficial Use Projects) of the Beneficial Use Planning Manual (USEPA and USACE 2007) and summarized below in Table 6. Specifically mentioned were Section 1135, Water Resources Development Act (WRDA) of 1986 (as amended by Section 202 of WRDA 1992 and Section 204 of WRDA 1996), Section 216 of the Rivers and Harbors Act and Flood Control Act of 1970, Section 111 of the 1968 River and Harbor Act, Section 206, Aquatic Ecosystem Restoration, Section 306 of the Water Resources Development Act (WRDA) of 1990, Section 204 of WRDA 1992 (as amended by Section 207 of WRDA 1996 and Section 209 of WRDA 1999), Section 307(a) of Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA or "Breaux-Johnson Act;" (PL101-646).

Table 7. EENI-related national laws and regulations submitted by survey respondents.

Law	Section	Provision	Effect	Source/link
Migratory Bird Treaty Act	US FWS	Must be permitted for take of migratory birds or any part, nest, or egg of any such bird		http://www.fws.gov/laws/lawsdigest/migtrea.html
Marshland Protections Act	State of GA		Erecting structures, dredging, or filling marsh areas requires a Marshlands Protection Committee Permit.	http://crd.dnr.state.ga.us/content/displaycontent.asp?txtDocument=85
Endangered Species Act	Section 7 Interagency Cooperation	To protect and recover imperiled species and the ecosystems upon which they depend	Federal agencies to use their legal authorities to promote the conservation purposes of the ESA and to consult with the FWS and NMFS, as appropriate, to ensure that effects of actions they authorize, fund, or carry out will not jeopardize the continued existence of listed species. During consultation the "action" agency receives a "biological opinion" or concurrence letter addressing the proposed action.	http://www.fws.gov/endangered/laws-policies/esa.html
WRDA 1990	Sec 312	Environmental Dredging of Contaminated Sediments		
Magnuson-Stevens Act 16 U.S.C. 1801 et seq. as reauthorized by the Sustainable Fisheries Act of 1996.		Mandated identification of essential fish habitat for managed species	The Magnuson-Stevens Act requires cooperation among NOAA Fisheries Service, fishery management councils, fishing participants, federal and state agencies, and others in achieving EFH protection, conservation and enhancement.	

Several of these laws require non-federal cost sharing. Sections 1135 and 204 of the WRDA of 1986 and 1992, respectively, require a 25% non-federal cost share toward the costs of improvement, protection or restoration of habitats. Section 206 of the WRDA of 1996 allows the USACE to provide the first $100,000 of a study of aquatic ecosystem restoration; the provision specifies 50% non-federal contributions above $100,000 for a feasibility study and 35% contributions for design and construction. Section 111 of the River and Harbor Act of 1968 requires a 50% contribution towards costs greater than $100,000 for a feasibility study for measures to mitigate shoreline accretion and erosion related to federal navigational projects. Furthermore, nearly all of the laws require 100% non-federal funding of maintenance of those enhancements.

Transfer of authority for completed navigational infrastructure to state and local entities may complicate maintenance needs for any incorporated improvements. The River and Harbor Act and Flood Control Act of 1970 allow review of completed projects in an effort to seek congressional authorization of improvements or modifications. Section 204 of the WRDA of 1992 allows for consideration of environmental protection in the design, construction and maintenance of specific projects. The CWPPRA allows for equal consideration of enhancements and navigational benefits, and establishes a matching grant program for eligible projects.

The survey also mentions the National Environmental Policy Act (NEPA) and the Clean Water Act (CWA). NEPA was enacted in 1970 to ensure environmental protections and established the Executive Branch's Council on Environmental Quality. Although NEPA has been extended and modified over the years, the intent remains to establish some balance between conservation, restoration, and protection of natural resources and other public interests such as growth and development. NEPA requires evaluations of the effects of federal and federally-approved projects on environmental quality. The CWA, as originally passed by Congress in 1972, was designed to control chemical pollution entrance into waters of the United States. Since its passage, the CWA has been modified and expanded to protect and restore watersheds and to promote development in ways that result in minimal impact to water resources. Discharge of dredged or fill materials is governed by the CWA under many conditions.

Respondents suggested a number of laws and regulations that were relevant to inclusion of EENI. Table 7 details the national regulations that were

submitted. Many responses concerned Coastal Zone Management programs or other state policies that impacted consideration of improvements.

Coastal Zone Management

Of 17 written responses, many (10) respondents stated the need to work with the Coastal Zone Management (CZM) programs in their states. The 34 federally-approved state programs were created under the Coastal Zone Management Act of 1972 (Public Law 92-583, 86 Stat. 1280, enacted October 27, 1972, 16 U.S.C. § 1451–1464, Chapter 33). Generally, the CZM programs are partnerships between various state, local and federal agencies. They are designed to tackle new and emerging issues and inform policy and management addressing those issues; they are also coordinated through NOAA's Office of Ocean and Coastal Resource Management (OCRM). NOAA is developing a set of performance metrics for CZM which they expect to implement throughout these state programs. Those metrics include measures related to the state objective of improvement of "the capacity of state and local governments to make decisions that balance coastal growth and development with protection of ecosystems and quality of life" (NOAA, FY 2007 CZM Strategic Plan).

Other Policies, Attitudes and Approvals to be Reconciled

Overwhelmingly, the respondents agree there is a need to get state and local authorities involved early in the process to provide the support for permitting and execution. The issue of creating habitat or other attractants for species raises the concern that sensitive ecological receptors will begin to use these enhancements, potentially resulting in increased restriction for operations and maintenance. In recent examples, protected species have inhabited confined disposal facilities (CDFs), resulting in limits of the use of the facilities in order to protect the species. Some infrastructure projects now have wildlife exclusion plans, which are specifically developed to repel and discourage animal interest in the infrastructure project (USACE 2010b). The State of NJ has come out against reestablishment of oysters in NY-NJ Harbor for fear of creating an attractive nuisance (harvesting in uncertified waters) that could impact the shellfishery in other parts of the state. In order to build a stronger case for inclusion of environmental enhancements, there is a need to be able to quantify improvements, possibly as with habitat evaluation procedure (HEP), and predict monitoring or maintenance costs and requirements. Considerations of allowable funding for incorporating these enhancements should perhaps be broadened to

include the O&M navigation program. Concern was expressed by one respondent that the exclusion of recreational harbors from funding consideration excludes a majority of the existing opportunities to provide environmental enhancements to existing coastal projects.

Impediments to use

This section of the survey consisted of 12 questions seeking to identify views on factors that might hinder — or be impediments — to the implementation of EENI and to seek ideas on solutions to such impediments. A total of 43 respondents completed the survey through this section. Each of the twelve section questions are presented below followed by a summary of the responses

1. How high of an impediment do you believe cost sharing is to EENI?

Almost three-quarters of the respondents (72%) felt that cost sharing is a high or very high impediment to EENI (Figure 20). The mode of the responses (49%) ranked this belief as high and 23% ranked it as very high.

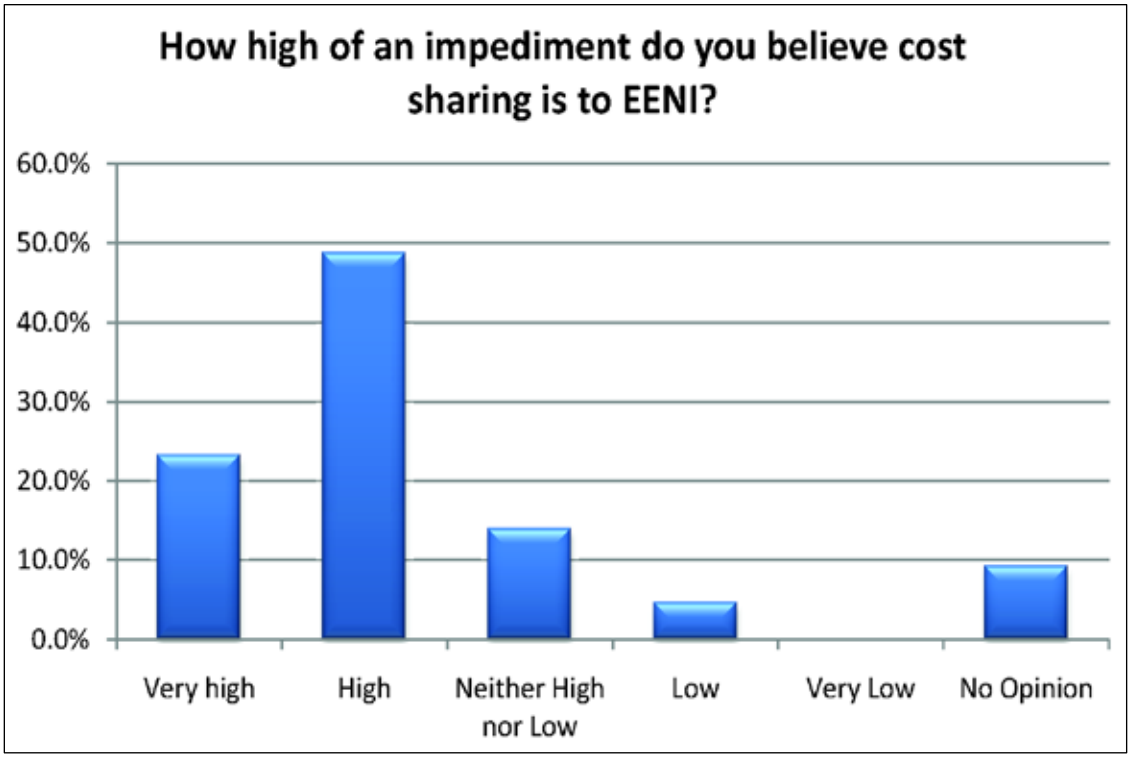

Figure 20. Respondent views on cost sharing as an impediment to EENI.

2. Can you describe an experience in which cost sharing was the reason an enhancement was not considered?

Twenty (20) individuals provided narrative or responses of "No" to the second question of this section. Most of the responses were not specific to EENI projects; rather, they described analogous cost-shared projects such as beneficial use or habitat restoration. Fourteen (14) of the respondents cited projects where cost sharing was an impediment to successful implementation. Several of these respondents made the point that EENI projects would face similar hurdles.

3. If you believe cost sharing is an impediment, please describe any potential solutions that you can think of to reduce the impediment.

This question generated 17 narrative responses. Many of the responses identified overall budget increases and modification to cost-sharing requirements as one potential solution. The concept of allowing greater "in-kind" contributions to the sponsor cost share was also suggested. Two respondents recommended setting up a special program and funding to support such work, similar to that done in Section 227 for innovative technologies or material used in designing erosion control projects. Other respondents suggested better advance planning with sponsors and stake-holders to include better education on goals, options, and constraints. One of those respondents indicated that if the concepts can be included early in the planning process it may be possible to include them at little to no additional cost. Concerns were also expressed about how USACE prioritizes projects for funding and that smaller harbors where EENI opportunities may be greater often go unfunded.

4. How high of an impediment do you believe institutional resistance is to EENI?

About two-thirds of the respondents (63%) did not view institutional resistance as a major impediment, rating it as low, neutral, or generating no opinion (Figure 21). Only 9% of the respondents viewed this as a very high factor.

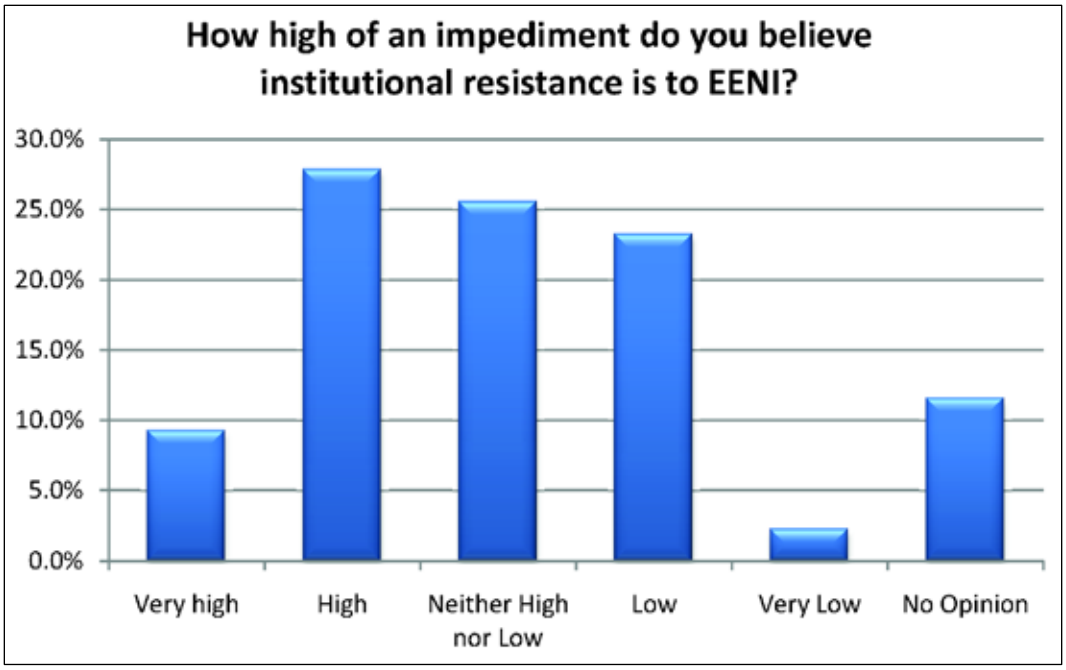

Figure 21. Respondent views on institutional resistance as an impediment to EENI.

5. Can you describe an experience in which resistance within the USACE was the reason an enhancement was not considered?

Narrative responses were provided by 22 individuals on this question. One response identified bank protection work in Savannah Harbor as a project that fit this question. Another respondent observed that his/her experience involved designers who did not seek to be innovative with such projects. Four respondents discussed and foreshadowed later survey questions on hindrances to future maintenance of the navigation feature as an issue. Concerns about overall budget availability and authority continued to be echoed in the responses by many of those surveyed.

6. If you believe institutional resistance is an impediment, please describe any potential solutions that you can think of to reduce the impediment.

The themes that were raised in response to earlier questions; greater education and earlier outreach with stakeholders, greater budgets, and changing how USACE prioritizes projects, were also contained within the 17 narrative responses provided on this question. Relative to the education element, it was pointed out that internally to the Corps continuing to do the same maintenance approach may simply be a lack of knowledge of EENI concepts. Building trust between federal agencies was another need related to conducting earlier project outreach.

A recommendation to develop written assurances among agencies may be one means of decreasing institutional resistance. Written assurances among agencies may ensure that the incorporation of enhancements would still allow the navigation feature to be maintained and utilized. Another concept was to provide metrics within the Corps' programs to provide incentives for incorporating EENI into dredging projects. One respondent commented, "The administrative burdens must be eased on projects that may result in environmental enhancements, so people will be more likely to try to get them through the review process."

7. 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?

The response to this question, from those who expressed an opinion, was almost evenly split between those who felt that this factor was of high or very high importance (44%) and those who felt it was neutral, low, or very low (46%) (Figure 22).

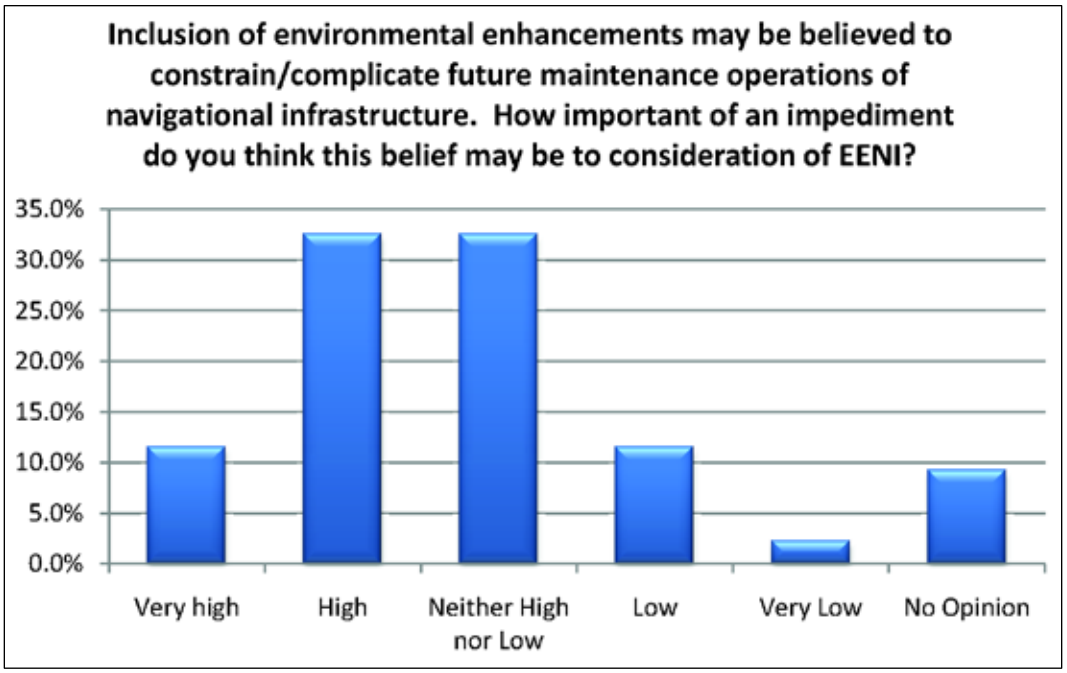

Figure 22. Respondent views on future maintenance concerns as an impediment to EENI.

8. Can you describe an experience in which these future maintenance concerns were the reason an enhancement was not considered?

Eighteen (18) respondents provided narrative responses to this question. Of those, eight simply responded in the negative and were unfamiliar with any specific examples. A few other responses provided reinforcement to the views expressed earlier that, overall, future maintenance concerns are a high or very high impediment to potential EENI proposals. Two respondents indicated that this concern extends to the idea that future maintenance could be saddled with providing mitigation for disturbing the environmental enhancement. Another concern expressed was that some activities have the potential to threaten the structural integrity of the structure, leading to increased maintenance costs.

Three specific activities or projects were cited where the issues of future costs for the maintenance project resulted in lack of implementation of EENI. This included reintroduction of eel grass into federal channels or anchorages, other proposed work in the Piscataqua River, ME/NH, and river training structure chute work conducted on the Missouri River Bank Stabilization and Navigation project.

9. If you believe future maintenance concerns are an impediment, please describe any potential solutions that you can think of to reduce the impediment.

Suggestions provided by the 11 respondents repeated solutions suggested earlier on similar questions and these included (1) improved education; (2) promotion of success stories; (3) inclusion of resource agency and Operations and Maintenance staff early in the planning process; (4) increased budget funding; (5) innovative funding solutions and (6) implementation of agreements that will impact the enhancement in the future and it is an accepted impact that will not force mitigation or expensive avoidance measures. One commenter pointed out a common sense notion that on frequently maintained projects, EENI should generally not be considered.

10. Do you believe there are other impediments that we have not considered?

While few respondents (12%) felt that there were impediments that the survey had not considered, the large majority of people (65%) were uncertain (Figure 23). About one-quarter of the respondents (23%) believed that the survey had identified all of the impediments.

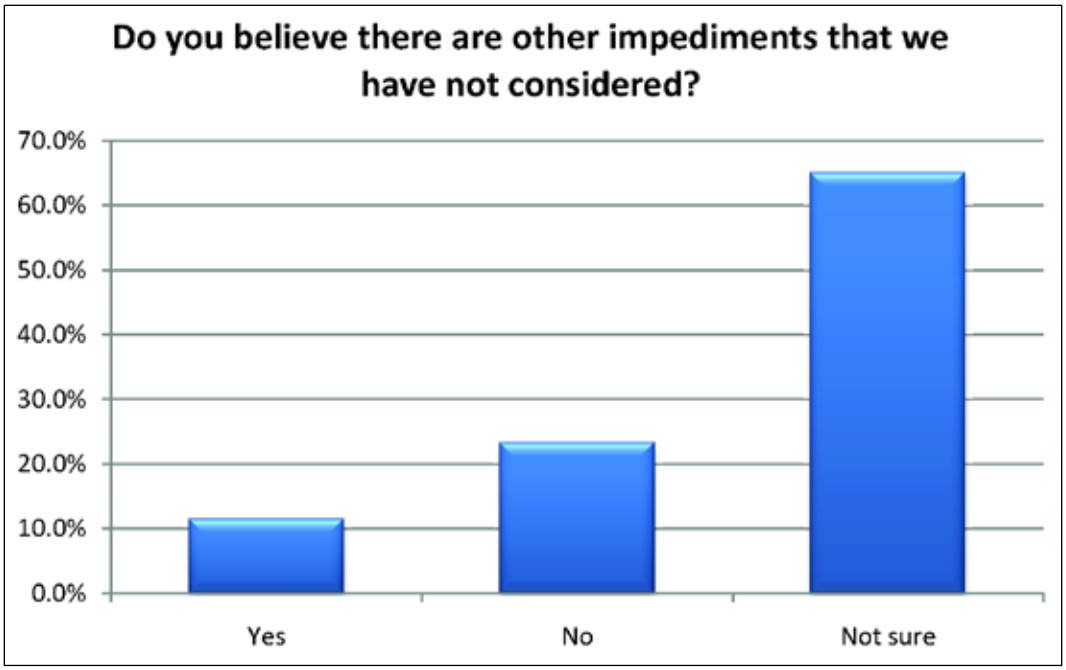

Figure 23. Respondent views towards the possibility of other impediments to EENI.

11. If Yes, please describe those impediments.

All five of the respondents who believed there were impediments that the survey had not touched upon provided narrative descriptions to explain their views. One respondent felt that sometimes the lack of science was not the issue; rather, it was the inability of project managers to "work across different levels" (presumably of the organization or coordination community). The theme of overall budget inadequacy was also raised again as a potential impediment, but with the further perspective that construction cost increases outpace budget increases and results in net budget decrease and, as a consequence, environmental enhancement projects "take a back seat." Lack of funding for low commercial-use harbors was also viewed as an impediment the survey had not acknowledged.

Two other comments focused on the increased complexity of such projects or the potential of the added features to degrade project function or reliability. In the first instance, concern was expressed that, particularly when the project manager was unconvinced of the value of the project, the added complexity would become a large disincentive.

12. Can you describe potential ways to minimize these other impediments?

All five respondents to the previous question also responded to this question, although one of those respondents indicated they did not have any suggestions for ways to minimize the impediments they identified. The other four respondents suggested using "incremental development of proposals backed by literature review and synthesis studies," revisiting "the policy on not funding maintenance of low commercial use projects," having the Corps "further reinforce the importance of natural resources," and "providing careful design and better guidance/methodology."

The concept of sustainability of navigation features and environmental services seems to have become ingrained within parts of the river system districts. There has been sharing of ideas, pilot projects, and full-scale projects. They are far ahead of other segments of the Corps in this area.

Research Needs

The section of the survey dedicated to the identification of "research needs," yielded a variety of responses concerning activities that could best promote the consideration and incorporation of environmental enhancements into navigational infrastructure. The section consisted of eight questions; five involved narrative responses (Table 2). The responses to the questions asked in this survey section are addressed in a single narrative below.

The overwhelming majority of survey respondents (73%) indicated that additional information would be useful for the consideration and implementation of enhancements (Figure 24). This can be contrasted with a later question about the need for research. Most participants (61%) were unsure about the usefulness of further research (Figure 25). A comparison of the two results reflects the respondents' prioritization of sharing ideas regarding types of improvements, costs and benefits of implementation, potential funding mechanisms, and the most effective means of collaboration.

When asked what kind of information would be most useful for promoting EENI, respondents overwhelmingly asked for case studies or written "success stories" about the implementation of environmental enhancements. Seventeen (17) written answers mentioned the value of archiving this type of information. Several of these (4) stated the value of a full synthesis of information relating to a specific type of enhancement, including discussion of the relevant literature, estimation of cost of implementation, and

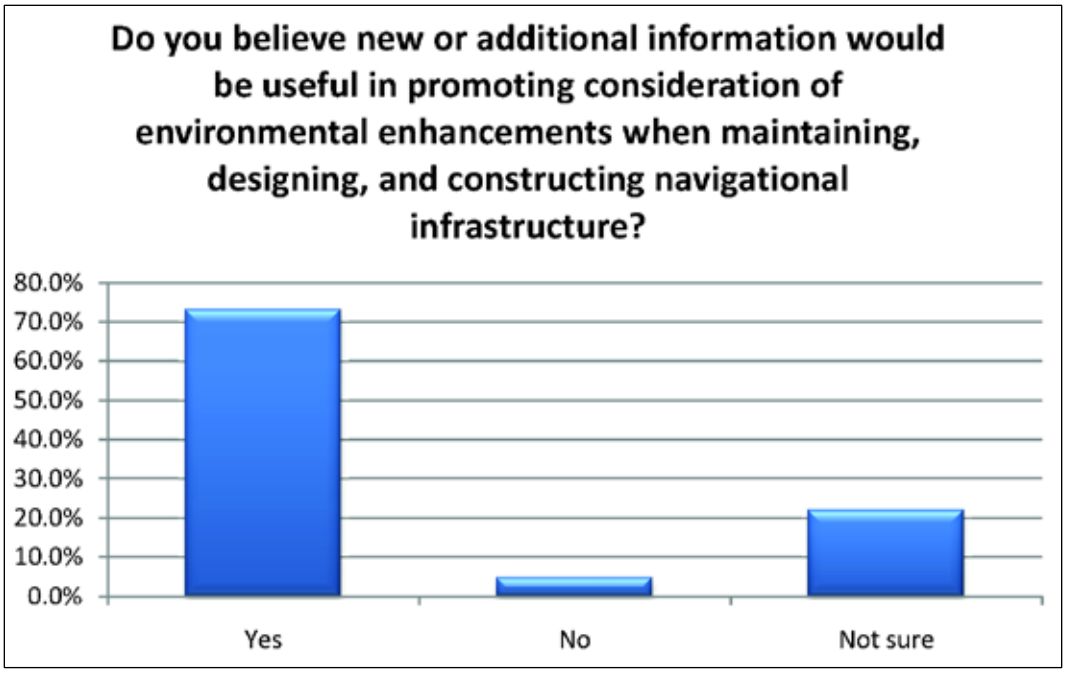

Figure 24. Respondent views on the usefulness of more EENI information.

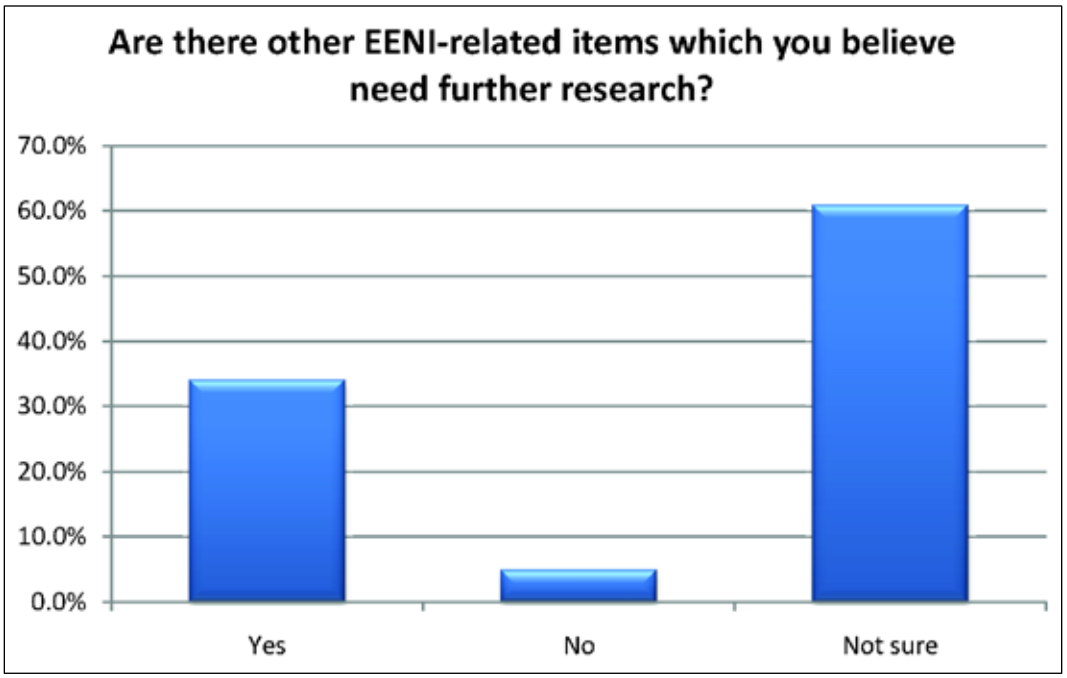

Figure 25. Respondent views on usefulness of more EENI research.

projection of the environmental benefits. Three respondents suggested that researching the best way(s) to develop collaborations between project managers, states, local entities and other stakeholders would be productive. Other comments (2) indicated that research was needed to determine the impact(s) of modifications to "authorities, laws and regulations."

Survey respondents felt that case studies, "success stories," pilot projects, and synthesis of enhancement options should be targeted. Several respondents (5) mentioned that environmental benefits arguments might be targeted at state and local authorities who would be responsible for advocating additional funds or efforts to incorporate these enhancements.

Concerning the several comments made about the importance of quantification of environmental benefits from enhancements. Before enhancements can be quantified, it was purported by several that baseline information on function would be needed, leading to the ability to quantify increases in benefits, such as a 30% increase in the population compared to a control area. Quantitative metrics were among the most commonly described, ranging from habitat suitability indices to species richness and abundance, as this would provide a mathematical basis for demonstrating progress or even success. Others suggested avoiding the species metrics, which would help avoid intensive monitoring efforts, and focusing more on a qualitative approach, such as video or photographs of organisms utilizing an area that has been enhanced. This could also result in improved public relations and education. The valuation of ecological resources (e.g., salt marsh, oyster reef, upland and bottomland forests) can be a difficult and controversial task, and economists have often been criticized for trying to put a price tag on nature. One respondent commented that the overall attitude may be permissive as long as costs are not excessive, but since there are no allowances for incorporating environmental enhancements in our projects, ultimately the only benefits that count are the navigational benefits.

When asked specifically about research needs related to EENI, some were of the opinion that lack of research in this area isn't the problem. These respondents suggested that policy changes and improvements at the federal, state and local levels would be the most effective use of resources. Others thought knowledge management and a more effective way to track projects and success stories would be most beneficial. Identified research needs included evaluating the effectiveness of various types of enhancements. Since environmental enhancement is an emerging area for navigation projects, little or no precedent exists and a lack of documentation or awareness may limit implementation, therefore performance monitoring of pilot projects would be a logical starting point for research. Other unknowns include the amount of structures/projects needing maintenance, number of proposed new projects and number of each category of projects such as

jetties, channels, etc to determine where each type of enhancement opportunities exist. Further, prioritization of sites to determine which sites would most benefit from environmental enhancements was identified as a need. As mentioned in a previous section, methods to quantify ecological benefits would be helpful in the justification of added cost of constructing a specific enhancement feature. Research is needed in alternative methods for the restoration of targeted species, such as oysters or submerged aquatic vegetation (i.e., surfgrass), one restoration method will not be effective and multiple methods need to be developed. Respondents were asked to prioritize research needs related to EENI. The quantification of benefits, and sharing experiences, were mentioned most frequently as being a top priority. The other priorities that were described included partnering and collaboration, ways to avoid maintenance conflicts on enhanced structures, and prioritization of habitats most influenced by navigational infrastructure.

3 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 communications we identified a considerable number of ideas and projects in which EENI has been implemented or may be possible for infrastructure such as breakwaters, river training structures, locks and dams, channels, and anchorages (Table 8). 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 further consulted by planners and environmental engineers working in any ecosystem for ideas and guidance.

Respondents. Due to the breadth of the survey group, we were able to capture a wide range of perspectives on the EENI concept including ideas, concerns, research needs, and relevant laws and policies. Participants in the survey came from multiple federal agencies, with the greatest representation coming from the main target group, the U.S. Army Corps of Engineers. 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 (Figure 9). Respondents represented all of the principle Corps office elements, Operations (33%), Planning (39%), Regulatory (18%), Engineering (26%), Construction (5%), and Project Management (13%) (Figure 6).

Laws, policies, regulations. There are clearly numerous laws and regulations, both federal and state-specific, that 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. Certainly this lack of clarity about the policies that may impact the implementation of EENI has the potential to be a significant obstacle to inclusion of these enhancements in projects. Early consultation by project managers with individuals possessing expertise in environmental

Table 8. List of Existing and Innovative EENI Projects Identified through the Survey, Webinars, and Personal Communications with Survey Participants.

Environmental Category	Description	Reported Project (P) or Innovative 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
	Place or anchor other materials 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 encourage larval settlement and reef creation to	I
	Encourage shellfish reefs to create self-sustaining biological filters	I
	Adding salt marsh or eel grass habitat behind a spur jetty	I
	Provide 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
	Add energy generating features to structures (wind turbines, wave turbines) - indirect environmental benefit (less fossil fuel use)	I
Locks & Dams	"Scratched" hard structures 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 Structures	Added 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
	Notched river dikes, hardpoint, and constructed chevrons in addition to grooving the surface of Articulated Concrete Revetment. Recent projects are Island 63 back channel, Kangaroo Point, and Below Ludlow dikes.	P

Environmental Category	Description	Reported Project (P) or Innovative Idea (I)
	Created of islands that maintain flow in the main channel, create habitat diversity on the non-channel side, and that are CDFs	P
	Change 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	Eel grass planted in anchorages	P
	Excavated 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
	Seed 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
	Enhanced coral for a new wharf on Guam	P
	Included light transmitting materials 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
Water Quality	Complete projects to increase water quality or increase circulation to improve habitat as opposed to habitat creation	I

law and policy is a paramount step towards achieving success. The NEPA process and compliance activities employed in the planning process should alleviate any compliance concerns.

Impediments. As with any project, there are always challenges or impediments that will need to be addressed, and respondents provided a number of insights relative to potential EENI projects. Cost sharing was viewed as a strong impediment to the implementation of EENI (Figure 20), as it is for beneficial use of dredged sediments or habitat restoration, but respondents also recommended 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 National Dredging Team, 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 of establishing sustainability goals that could be emulated is the USACE Strategic Sustainability Performance Plan (ASA-CW and USACE 2010).

While there were fairly strong concerns about EENI hampering future maintenance of infrastructure projects (Figure 22), particularly as expressed by respondents in a number of the narrative responses, there also appeared to be an openness to the concept, as institutional resistance was not viewed as a very high or high impediment by most (63%) of those surveyed (Figure 21). The main concern with future maintenance revolves around potential environmental restrictions that may result from the enhancement. Survey respondents identified a number of projects where 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 any future ability to properly and efficiently maintain the project. To address this potential problem, one key suggestion was to develop interagency agreements, such as Memorandums of Understanding (MOUs). MOUs would acknowledge and accept that the enhancement will be disturbed by maintenance and would also recognize that barring that willingness to accept the periodic disturbance, the enhancement would not exist at all.

One important potential impediment to implementing EENI that the survey did not directly address and that was mentioned in narrative comments was the concern of compromising the structural integrity or primary navigation

function of the infrastructure. This certainly is a key aspect that would need to be featured in any proposal to conduct environmental enhancements and requires careful consideration as part of the overall project review and planning.

Recommendations for reducing impediments were strongly focused on increased coordination and education activities. A primary education recommendation was that the EENI concept be strongly promoted, because it is a relatively new concept for many individuals. It was believed that the simple act of 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. Greater use of opportunities to coordinate with stakeholders and investigate EENI opportunities was voiced by many of the survey respondents. Using mechanisms such as the Regional Dredging Teams (see: http://water.epa.gov/type/oceb/oceandumping/dregedmaterial/index.cfm) could be one mechanism to foster these discussions. 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 (Table 8). These include suggestions such as 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.

EcoShape - A Related Initiative

As part of the EENI investigation, we also learned about an initiative in Europe called EcoShape (http://www.ecoshape.nl/ecoshape-english/home), that has goals similar to our work. The EcoShape "Building with Nature" project is an integrated, decision-oriented effort that focuses on the challenge of creating an environmentally-conscious approach to hydraulic engineering. The organization, based in the Netherlands, aims to maximize the potential and efficiency of a given infrastructure system while reducing any harmful effects upon the regional environment. Additional objectives of Building with Nature (BwN) include: the expansion and application of ecological knowledge to engineering, the further integration of BwN principles into society and construction, and the development of relevant design principles. BwN represents a primary example of an important and applicable program that is grounded in both the public and private sector; this partnership allows the organization to ascertain new challenges and objectives in hydraulic engineering, and to effect change in national policy.

EcoShape is grounded in the concept of collaboration and partnership between various systems of government, ecology, and engineering. The BwN program presents five specific research themes that reflect the organization's multidisciplinary approach to engineering and policy. These five topics are defined as: the interactions between abiotic and biotic systems; scale interactions in space and time; uncertainties and risks and how to manage them; aspects of design, engineering, and execution; and innovations in governance. These subject areas guide an integrated assessment of and approach to hydraulic engineering projects within the Dutch infrastructure.

The base of EcoShape's experience rests upon four main cases, located in the Netherlands and Singapore. The decision of the organization to undertake these projects was determined by the relevance of each challenge to BwN, the characteristics of the ecosystems involved, and the potential opportunity to craft a novel administrative and scientific approach. These case studies represent an integral piece of the EcoShape portfolio, allowing ecologists, engineers, and policy-makers to develop knowledge in practice and to apply this methodology to future endeavors. In addition to examining selected cases, BwN also supports generic scientific research related to the mission of the organization. This research examines the dynamics of marine and coastal ecology, the role of ecosystem engineers in such regions, and the development of models that can be reliably applied to

hydraulic and ecological projects. BwN sponsors a variety of research projects (some of which are accomplished in an academic setting by PhD candidates) relating to each of these themes and topics.

Affiliates of EcoShape working on these and other projects strive to contribute their research to a growing knowledge resource within the organization. Over time, BwN aims to accrue a firm foundation of working knowledge that can be readily applied to any new project that the organization accepts. This basis will enrich EcoShape's practical experience and quality of work, as well as allowing the organization to serve as a resource for other engineers, stakeholders, and ecologists for work in their respective fields.

A final theme in the BwN projects is the approach to and understanding of the uncertainty surrounding ecodynamic development and design. EcoShape's integrated perspective allows professionals of different disciplines to bring light to the interaction between the uncertainties in each area of a case, and to better understand how to cope with it. In order to present an innovative, effective, and environmentally-conscious strategy in hydraulic engineering, engineers, ecologists, and policy-makers must gain a deeper understanding of how to approach and overcome inherent uncertainties. This holistic approach to reducing uncertainty fits effectively into EcoShape's mission to provide novel, eco-friendly, and efficient solutions to challenges in infrastructure and hydraulic engineering.

4 Recommendations

Based on the results of the survey, other communications that the study generated, and further development of a number of the suggestions efforts 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 novel for many planners, engineers, biologists, project managers, and other individuals. The simple act of looking at a project from a new EENI perspective has 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. Efforts to identify and document good case studies that will advance the concept are recommended.
- **Conduct pilot projects.** Pilot studies provide an excellent opportunity 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 undertaken.
- **Prioritize project sites.** Regions should consider developing a priority list of projects where various EENI projects could be implemented. This could be accomplished through regional dredging teams, Regional Ocean Councils conducting coastal and marine spatial planning, or other means.
- **Research new ideas.** Numerous new ideas were presented for environmental enhancements that could be done in association with navigation infrastructure and this list should be used as a resource to develop future research efforts.
- **Develop EENI goals.** The USACE, or perhaps the National Dredging Team (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 be an on-going challenge for implementation of EENI. Solutions may include the development of a special authority and an appropriation for such activities. Another possibility would be to promote corporate donations and utilize 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 regional dredging teams (RDTs) or other such forums is a priority.
- **Develop interagency agreements.** Success of EENI faces numerous impediments. Interagency agreements that describe long-term interagency policy towards such projects 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.

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Appendix A – June Webinar Slide Presentation

Webinar Agenda

- Introductions
  - EENI Team
  - Participants
- EENI Presentation
- Discussion
- Closing

2

EENI Project Concept (1)

Identify opportunities to increase environmental enhancements of navigation infrastructure projects

[Focus is on infrastructure (channels, anchorages, jetties, locks, etc.) and not beneficial use of sediment]

3

EENI Project Concept (2)

- Beneficial Use of Dredged Material is Reasonably Well-established
  - Beach Nourishment
  - Wetland Restoration
  - Land Reclamation
  - Construction Material
- *We Focus on Environmental Enhancements of Navigation Infrastructure (EENI)*

4

Possibilities for Jetties?

Enhance for shellfish?

Crabs?

Example to illustrate concept. Can we make changes in design to build a jetty in ways that will provide enhanced use by shellfish? Add oyster shell to encourage settlement? Create a sinuous toe to provide semi-protected areas? Add caverns? As we maintain these structures can we build in environmental features?

5

EENI Project Concept (3)

Initially based on PIANC* Paper

PIANC Position Paper

'Working with Nature'

October 2008

What do we mean by '**Working with Nature**'?

Maximising opportunities; reducing frustrations. **Working with Nature** is an integrated process which involves working to identify and exploit win-win solutions which respect nature and are acceptable to both project proponents and environmental stakeholders. It is an approach which needs to be applied early in a project[1] when flexibility is still possible. By adopting a determined and proactive approach from conception through to project completion, opportunities can be maximised and - importantly - frustrations, delays and associated extra costs can be reduced.

6

*The World Association for Waterborne Transport Infrastructure, formerly the Permanent International Association of Navigation Congresses

EENI Project Concept (4)

Builds on USACE Goals

US Army Corps of Engineers®

ENVIRONMENTAL OPERATING PRINCIPLES

One Corps Serving The Army and the Nation

Further information is available at: **http://www.usace.army.mil**

EOPs especially relevant to the concept

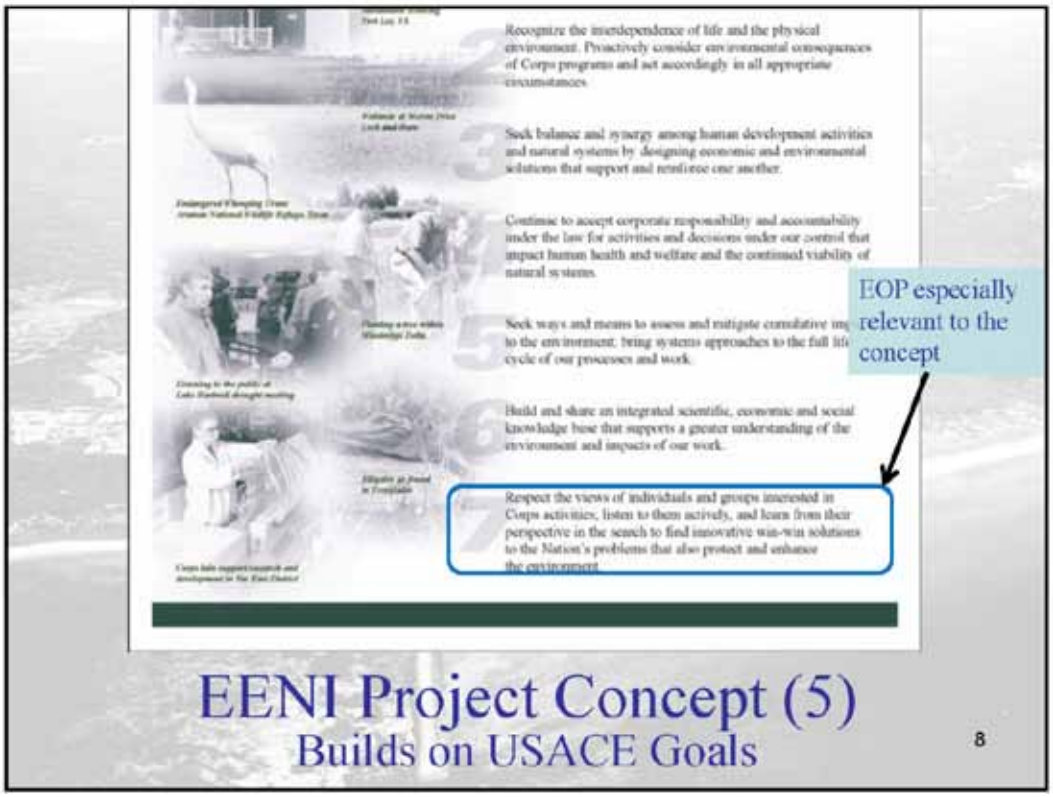
1. Strive to achieve Environmental Sustainability. An environment maintained in a healthy, diverse, and sustainable condition is necessary to support life.

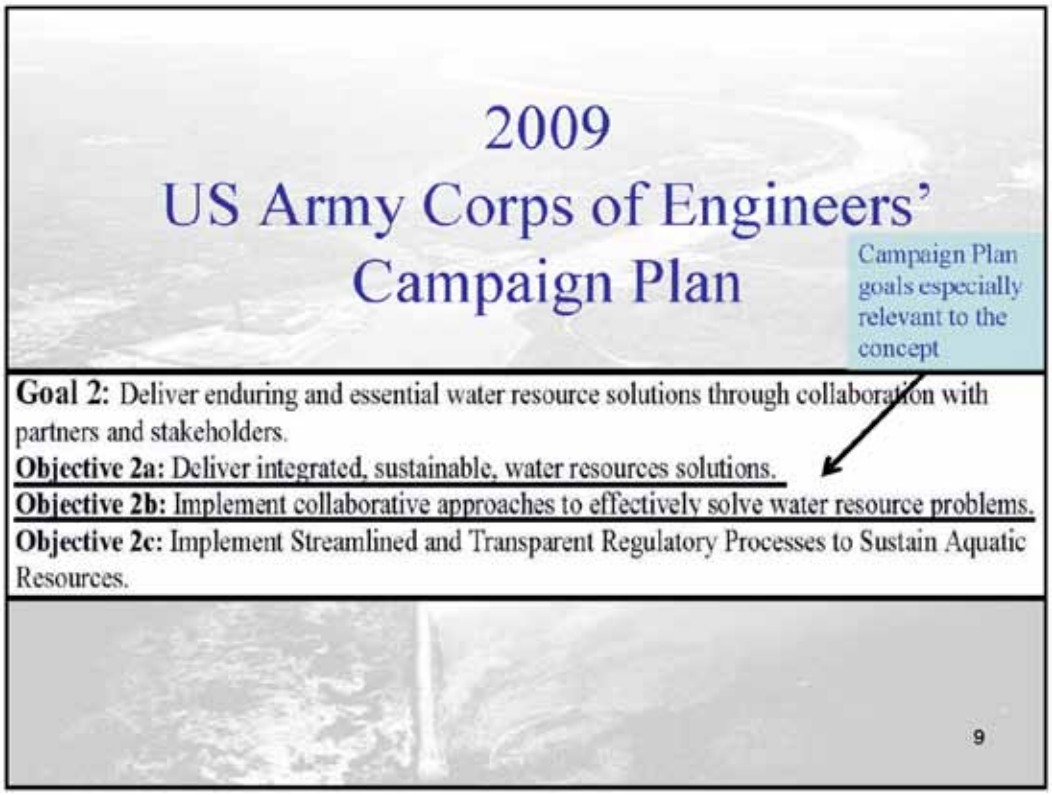
2. Recognize the interdependence of life and the physical environment. Proactively consider environmental consequences of Corps programs and act accordingly in all appropriate circumstances.

3. Seek balance and synergy among human development activities and natural systems by designing economic and environmental solutions that support and reinforce one another.

4. Continue to accept corporate responsibility and accountability under the law for activities and decisions under our control that

7


Recognize the interdependence of life and the physical environment. Proactively consider environmental consequences of Corps programs and act accordingly in all appropriate circumstances.
Seek balance and synergy among human development activities and natural systems by designing economic and environmental solutions that support and reinforce one another.
Continue to accept corporate responsibility and accountability under the law for activities and decisions under our control that impact human health and welfare and the continued viability of natural systems.
Seek ways and means to assess and mitigate cumulative im to the environment; bring systems approaches to the full life cycle of our processes and work.
Build and share an integrated scientific, economic and social knowledge base that supports a greater understanding of the environment and impacts of our work.
Respect the views of individuals and groups interested in Corps activities; listen to them actively, and learn from their perspective in the search to find innovative win-win solutions to the Nation's problems that also protect and enhance the environment.
EOP especially relevant to the concept
EENI Project Concept (5)
Builds on USACE Goals
8


2009
US Army Corps of Engineers'
Campaign Plan
Campaign Plan goals especially relevant to the concept
Goal 2: Deliver enduring and essential water resource solutions through collaboration with partners and stakeholders.
Objective 2a: Deliver integrated, sustainable, water resources solutions.
Objective 2b: Implement collaborative approaches to effectively solve water resource problems.
Objective 2c: Implement Streamlined and Transparent Regulatory Processes to Sustain Aquatic Resources.
9

DOER: EENI Benefits

- USACE projects with greater overall environmental benefit and broader stakeholder support
- Stakeholder support is critical for streamlining both public and internal
  - Review processes
  - Approval processes
- Such support can be critical in avoiding costly, last minute project delays

10

Information Needs

- Key policies, regulations, & laws
- Things we already do
- Ideas for new possibilities
- Things tried that haven't worked and why

- Impediments to improvement
- Potential solutions to impediments
- Items needing further *research* to support use
- Case studies and relevant reports

11

A Lock Undergoing Improvement

Where are there opportunities?

What have we tried?

What has/hasn't worked?

What needs research?

12

Bird Nesting Opportunities

Can "sunk costs" associated with maintenance be leveraged for environmental improvement?

Possible for Jetties?

Locks?

New England District:

41 miles of breakwaters/jetties

2006 acres of anchorages

473 miles of navigation channel

13

Former CDF

Breached, graded, planted with marsh and dune grasses, and oyster cultch placement

Near Moorehead City, North Carolina

14

Project Approach

- Development of Webinars
- Development of Survey*
- Telephone Follow-up
- Meeting/Conference Presentations
- Data Summary
- Report

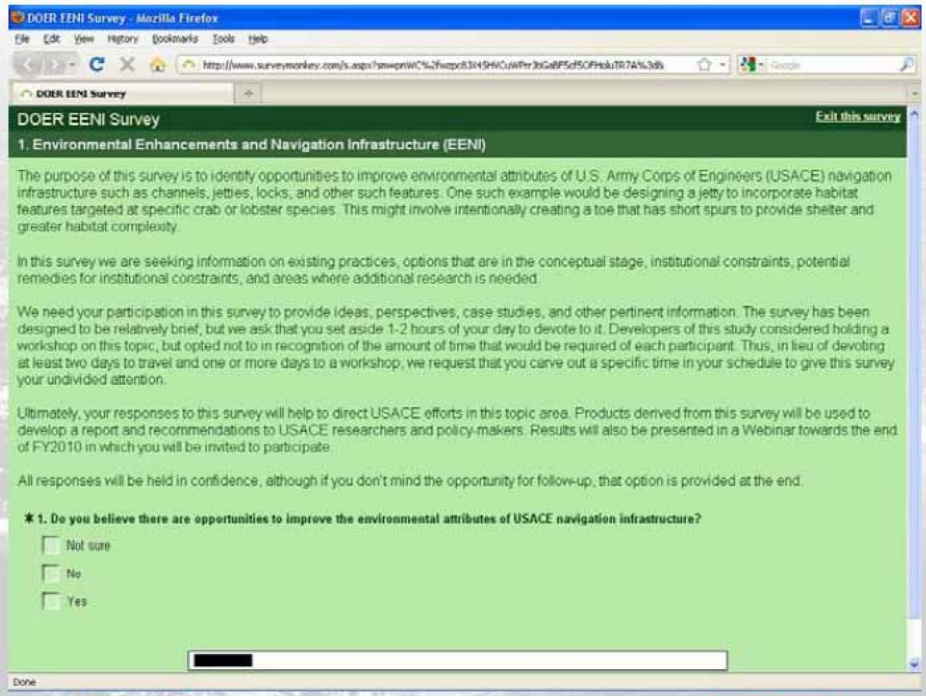
*Initial Target Group: US Federal Agencies (USACE, USEPA, etc.)

15

Your Help is Needed!

- Provide Ideas & Suggestions
- Provide Case Studies
- Provide References
- Provide Contacts (please e-mail interest!)
- Attend Webinar (6/17 or 6/24) & Complete Survey

16



http://www.surveymonkey.com/s/EENI

17

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18

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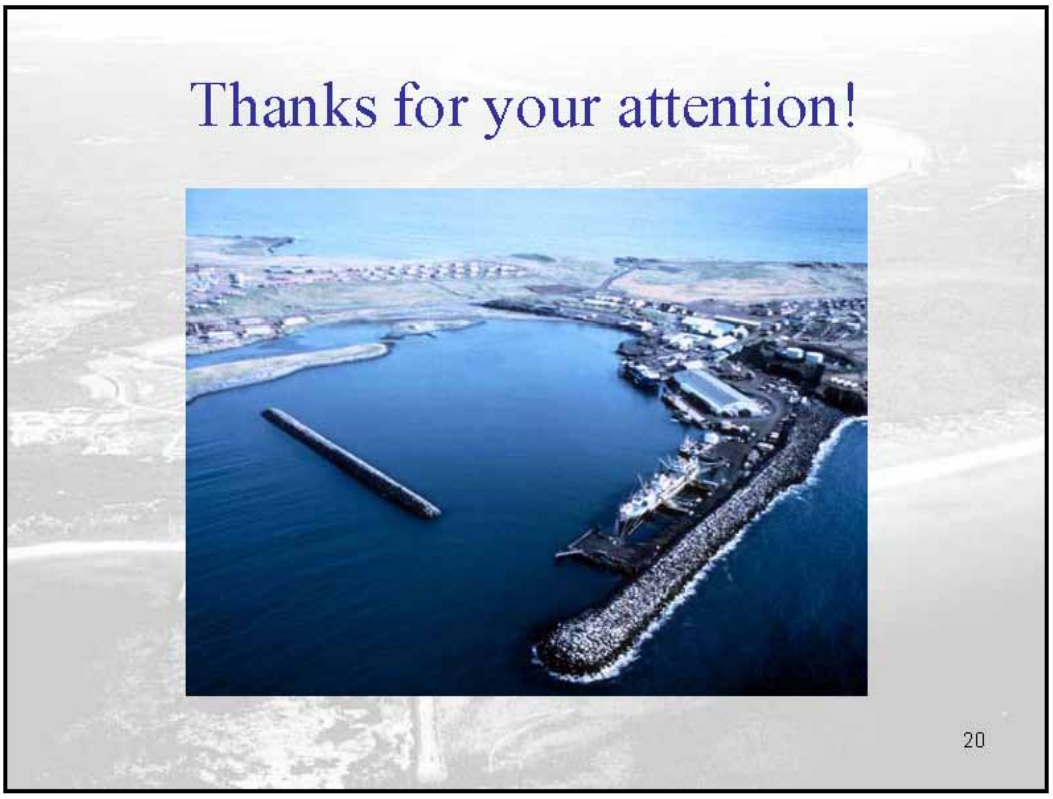

Thanks for your attention!
20

Appendix B – On-line Survey

DOER EENI Survey

1. Environmental Enhancements and Navigation Infrastructure (EENI)

The purpose of this survey is to identify opportunities to improve environmental attributes of new or existing U.S. Army Corps of Engineers (USACE) navigation infrastructure such as channels, jetties, locks, and other such features. One such example would be designing a jetty to incorporate habitat features targeted at specific crab or lobster species. This might involve intentionally creating a toe that has short spurs to provide shelter and greater habitat complexity.

In this survey we are seeking information on existing practices, options that are in the conceptual stage, institutional constraints, potential remedies for institutional constraints, and areas where additional research is needed. If you have reached this survey without having attended one of our webinars or seeing the slide presentation and would like more background on this work before completing the survey, please email a request to cynthia.j.banks@usace.army.mil.

We need your participation in this survey to provide ideas, perspectives, case studies, and other pertinent information. The survey has been designed to be relatively brief, but we ask that you set aside 1-2 hours of your day to devote to it. Developers of this study considered holding a workshop on this topic, but opted not to in recognition of the amount of time that would be required of each participant. Thus, in lieu of devoting at least two days to travel and one or more days to a workshop, we request that you carve out a specific time in your schedule to give this survey your undivided attention.

Ultimately, your responses to this survey will help to direct USACE efforts in this topic area. Products derived from this survey will be used to develop a report and recommendations to USACE researchers and policy-makers. Results will also be presented in a Webinar towards the end of FY2010 in which you will be invited to participate.

All responses will be held in confidence, although if you don't mind the opportunity for follow-up, that option is provided at the end.

*** 1. Do you believe there are opportunities to improve the environmental attributes of existing or future navigation infrastructure projects?**

- ☐ Not sure
- ☐ Yes
- ☐ No

DOER EENI Survey

2. Environmental Enhancements: Present and Potential

Thank you for your help with this research. Your experiences are critical to the success of the project. What follows is a series of questions organized by topic. In general, we are asking you to supply written responses to the questions. However, a few questions require either a Yes/No or a scaled response. Questions marked with an asterisk (*) require an answer. The topics and questions are organized as follows:

Environmental enhancements: present and potential (12 questions)
Laws, policies and regulations (6 questions)
Impediments to use (12 questions)
Research needs (8 questions)
Anything we missed? (3 questions)
Invite others to participate (2 questions)
Information about you (8 questions)

*** 1. Are you familiar with any projects in which environmental enhancements have been considered or incorporated?**

- ☐ Yes
- ☐ Not sure
- ☐ No (skip to Question 9)

2. Please identify any relevant project(s), the environmental enhancement(s) and provide links to references as appropriate.

3. How did you find out about designing and implementing these features? What process(es) enabled their consideration?

DOER EENI Survey

4. 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)

5. 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.

6. In cases where these features were not incorporated, what was the reason?

7. 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?

8. What other specific projects would be helpful to investigate for this survey?

DOER EENI Survey

* 9. Are there (other) environmental enhancements that you believe might be possible to incorporate into existing or future navigation infrastructure projects?

- [ ] No
- [ ] Not sure
- [ ] Yes

10. If Yes, please describe any environmental enhancements that you envision and on what type of project. Be creative.

11. What information/training would facilitate incorporating these or other environmental enhancements?

12. What training/information or programs have we tried that didn't work? Why do you think it didn't work?

Page 4

DOER EENI Survey

3. Laws, Policies, and Regulations

The principle Federal laws and regulations we have identified that enable or impact upon conducting environmental enhancement in association with navigation related infrastructure (beyond broader laws such as NEPA and the CWA) are:

a. Section 1135, WRDA 1986 (PL 99-662), as amended by Section 202 of WRDA 1992 and Section 204 of WRDA 1996: Project Modifications for Improvement of Environment
b. Section 216 of the Rivers and Harbors Act and Flood Control Act of 1970
c. Section 111 of the 1968 River and Harbor Act
d. Section 206, Aquatic Ecosystem Restoration
e. Section 306 of the Water Resources Development Act(WRDA) of 1990
f. Section 204 of WRDA 1992, as amended by Section 207 of WRDA 1996 and Section 209 of WRDA 1999
g. Section 307(a) of Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA or "Breaux-Johnson Act"; [PL 101-646]).

* **1. Does this appear to be a correct and complete list?**

- ☐ Not sure
- ☐ No
- ☐ Yes

2. If No, please provide additional citations for those you feel need to be added or identify any other problems with the list.

3. What state or local regulations/mandates affect the consideration or inclusion of EENI in your region?

4. If you added information above, why do you think it is important?

DOER EENI Survey

5. What other policies, attitudes or approvals (formal or informal) need to be reconciled in considering environmental enhancements?

6. What potential changes in laws or regulations would allow greater use of environmental enhancements?

DOER EENI Survey

4. Impediments to Use

A number of potential impediments to incorporating environmental enhancements into USACE navigation features have been identified. These include (1) non-federal cost sharing requirements, (2) institutional resistance within the USACE, and (3) concerns about future maintenance on "enhanced" infrastructure.

*** 1. How high of an impediment do you believe cost sharing is to EENI?**

- ☐ Very high
- ☐ High
- ☐ Neither High nor Low
- ☐ Low
- ☐ Very Low
- ☐ No Opinion

2. Can you describe an experience in which cost sharing was the reason an enhancement was not considered?

3. If you believe cost sharing is an impediment, please describe any potential solutions that you can think of to reduce the impediment.

*** 4. How high of an impediment do you believe institutional resistance is to EENI?**

- ☐ Very high
- ☐ High
- ☐ Neither High nor Low
- ☐ Low
- ☐ Very Low
- ☐ No Opinion

Page 7

DOER EENI Survey

5. Can you describe an experience in which resistance within the USACE was the reason an enhancement was not considered?

6. If you believe institutional resistance is an impediment, please describe any potential solutions that you can think of to reduce the impediment.

* 7. 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?

- [ ] Very high
- [ ] High
- [ ] Neither High nor Low
- [ ] Low
- [ ] Very Low
- [ ] No Opinion

8. Can you describe an experience in which these future maintenance concerns were the reason an enhancement was not considered?

9. If you believe future maintenance concerns are an impediment, please describe any potential solutions that you can think of to reduce the impediment.

Page 8

DOER EENI Survey

✱ 10. Do you believe there are other impediments that we have not considered?

- [ ] No
- [ ] Yes
- [ ] Not sure

11. If Yes, please describe those impediments.

12. Can you describe potential ways to minimize these other impediments?

Page 9

DOER EENI Survey

5. Research Needs

* 1. Do you believe new or additional information would be useful in promoting consideration of environmental enhancements when maintaining, designing, and constructing navigational infrastructure?

- ☐ No
- ☐ Yes
- ☐ Not sure

2. Please describe information that would be useful.

3. Who do you anticipate would use this information and how?

* 4. How valuable are measured or predicted benefits for considering the incorporation of an environmental enhancement in infrastructure design?

- ☐ Very valuable
- ☐ Valuable
- ☐ Uncertain
- ☐ Low Value
- ☐ Very Low Value
- ☐ No Opinion

5. If the benefits resulting from environmental enhancements were to be measured, what measurements do you feel would be most important?

Page 10

DOER EENI Survey

* 6. Are there other EENI-related items which you believe need further research?

- [ ] Not sure
- [ ] Yes
- [ ] No

7. What research is needed?

8. Of the research topics mentioned, what do you believe is the most important for promoting consideration of these enhancements?

Page 11

DOER EENI Survey

6. Is There Anything We Missed?

* 1. Do you think we have covered all of the major issues related to this topic?

- [ ] Not sure
- [ ] Yes
- [ ] No

2. If No, please describe additional issues we need to consider.

3. 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?

DOER EENI Survey

7. Invite Others

* 1. Is there anyone else you feel might be able to provide useful information for this survey?

- [ ] No
- [ ] Yes
- [ ] Not sure

2. Please either provide contact information, or if they are Federal employees provide them with a link to this survey. (Federal rules on surveys limit us from directly seeking input from non-Federal entities without OMB review and approval)

Page 13

DOER EENI Survey

8. Information About You

All answers will be kept in confidence; no identifying information will be associated with the answers you have provided. However, to maximize the impact of the information you have offered, we may need to contact you with follow-up questions related to your responses. Therefore, we are asking for your name, title, and some personal information. If you want to remain completely anonymous, feel free to omit your name and email address. If you do choose to do include your name, we appreciate the identification because it will allow for us to generate a more comprehensive analysis.

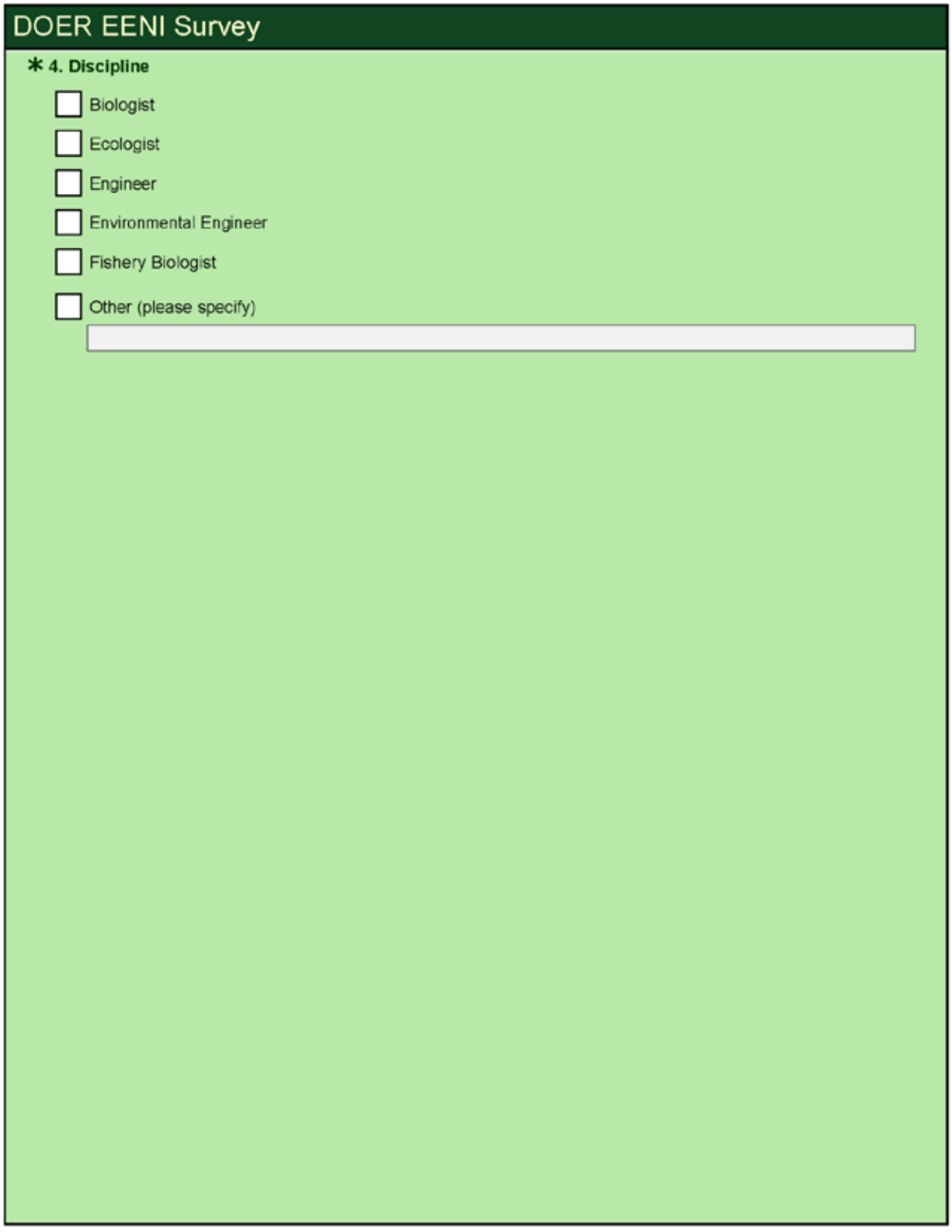
1. Name

*** 2. Agency.**

- [ ] EPA
- [ ] FWS
- [ ] NOAA
- [ ] USACE
- [ ] Other (please specify)

*** 3. Title**

- [ ] Planner
- [ ] Project Manager
- [ ] Regulator
- [ ] Researcher
- [ ] Supervisor
- [ ] Other (please specify)


DOER EENI Survey
* 4. Discipline
Biologist
Ecologist
Engineer
Environmental Engineer
Fishery Biologist
Other (please specify)
Page 15

DOER EENI Survey

5. What USACE district do you primarily work with?

- ☐ Afghanistan Engineer District - North
- ☐ Afghanistan Engineer District - South
- ☐ Alaska District
- ☐ Albuquerque District
- ☐ Baltimore District
- ☐ Buffalo District
- ☐ Charleston District
- ☐ Chicago District
- ☐ Detroit District
- ☐ Europe District
- ☐ Far East District
- ☐ Fort Worth District
- ☐ Galveston District
- ☐ Gulf Region District
- ☐ Honolulu District
- ☐ Huntington District
- ☐ Jacksonville District
- ☐ Japan Engineer District
- ☐ Kansas City District
- ☐ Little Rock District
- ☐ Los Angeles District
- ☐ Louisville District
- ☐ Memphis District
- ☐ Middle East District
- ☐ Mobile District
- ☐ Nashville District
- ☐ New England District
- ☐ New Orleans District
- ☐ New York District

DOER EENI Survey

- [ ] Norfolk District
- [ ] Omaha District
- [ ] Philadelphia District
- [ ] Pittsburgh District
- [ ] Portland District
- [ ] Rock Island District
- [ ] Sacramento District
- [ ] San Francisco District
- [ ] Savannah District
- [ ] Seattle District
- [ ] St. Louis District
- [ ] St. Paul District
- [ ] Tulsa District
- [ ] Vicksburg District
- [ ] Walla Walla District
- [ ] Wilmington District
- [ ] Other (please specify)

*** 6. Office**

- [ ] Construction
- [ ] Counsel
- [ ] Engineering
- [ ] N/A (not USACE)
- [ ] Operations
- [ ] Planning
- [ ] Project Management
- [ ] Regulatory
- [ ] Other (please specify)

Page 17

DOER EENI Survey

* 7. How many years of experience do you have with navigational infrastructure projects?

- [ ] 1-5 years
- [ ] 6-10 years
- [ ] 11-15 years
- [ ] 16-20 years
- [ ] 21-25 years
- [ ] more than 25 years

8. Briefly describe your personal experience.

9. Email optional: (only if you don't mind giving us the opportunity to follow-up with you, if needed)

Page 18

DOER EENI Survey

9. Thanks

Thank you for participating in this survey. We appreciate that you have taken time out of your busy schedule to answer our questions and assist in supporting our work and the Corps Environmental Operating Principles.

Please contact cynthia.j.banks@usace.army.mil if you have specific information that you would like to provide beyond that included in this survey or if you have any questions.

REPORT DOCUMENTATION PAGE

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14. ABSTRACT

The Environmental Enhancements and Navigation Infrastructure (EENI) study investigated opportunities and challenges associated with increasing the environmental benefits of navigation infrastructure such as jetties, locks, channels, and anchorages. This study sought to (1) identify existing and potential navigation project features 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. The study employed initial interviews, briefings, teleconferences, presentations, and the implementation of an internet-based survey and webinars to obtain the desired information. The concept of EENI was relatively new to most participants, but was viewed by 95% of the respondents as an activity for which there is considerable opportunity. Respondents provided several examples of projects designed to increase environmental benefits and they also provided numerous new ideas for possible enhancements. These ideas spanned a wide range of navigation infrastructure.

15. SUBJECT TERMS

Channel enhancements
EENI
Environmental enhancements
Navigation infrastructure
River training structures
"Working with Nature"

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