



**CENTER FOR NATION RECONSTRUCTION AND
CAPACITY DEVELOPMENT**
United States Military Academy
West Point, New York 10996

May 2012

Environmental Benefit Unit Development

Prepared By

Kenneth McDonald, Michael Bang, Brad Buss, Caitlin McArdle, and
Jay Vonlehman
Department of Systems Engineering
United States Military Academy

Prepared For

USACE New York District
26 Federal Plaza
New York, NY 10278



DISTRIBUTION STATEMENT A: Approved for public release;
distribution is unlimited.

**CNRCD Report
2012-2**

The views and opinions expressed or implied in this publication are solely those of the authors and should not be construed as policy or carrying the official sanction of the United States Army, the Department of Defense, United States Military Academy, or other agencies or departments of the US government.

About Us

The Superintendent of the United States Military Academy (USMA) at West Point officially approved the creation of the Center for Nation Reconstruction and Capacity Development (C/NRCD) on 18 November 2010. Leadership from West Point and the Army realized that the US Army, as an agent of the nation, would continue to grapple with the burden of building partner capacity and nation reconstruction for the foreseeable future. The Department of Defense (DoD), mainly in support of the civilian agencies charged with leading these complex endeavors, will play a vital role in nation reconstruction and capacity development in both pre and post conflict environments. West Point affords the C/NRCD an interdisciplinary and systems perspective making it uniquely postured to develop training, education, and research to support this mission.

The mission of the C/NRCD is to take an interdisciplinary and systems approach in facilitating and focusing research, professional practice, training, and information dissemination in the planning, execution, and assessment of efforts to construct infrastructure, networks, policies, and competencies in support of building partner capacity for communities and nations situated primarily but not solely in developing countries. The C/NRCD will have a strong focus on professional practice in support of developing current and future Army leaders through its creation of cultural immersion and research opportunities for both cadets and faculty.

The research program within the C/NRCD directly addresses specific USMA needs:

- Research enriches cadet education, reinforcing the West Point Leader Development Systems through meaningful high impact practices. Cadets learn best when they are challenged and when they are interested. The introduction of current issues facing the military into their curriculum achieves both.
- Research enhances professional development opportunities for our faculty. It is important to develop and grow as a professional officer in each assignment along with our permanent faculty.
- Research maintains strong ties between the USMA and Army/DoD agencies. The USMA is a tremendous source of highly qualified analysts for the Army and DoD.
- Research provides for the integration of new technologies. As the pace of technological advances increases, the Academy's education program must not only keep pace but must also lead to ensure our graduates and junior officers are prepared for their continued service to the Army.
- Research enhances the capabilities of the Army and DoD. The client-based component of the C/NRCD research program focuses on challenging problems that these client organizations are struggling to solve with their own resources. In some cases, USMA personnel have key skills and talent that enable solutions to these problems.

For more information please contact:



Center for Nation Reconstruction and Capacity Development
Attn: Dr. John Farr, Director
Department of Systems Engineering
Mahan Hall, Bldg. 752
West Point, NY 10996
John.Farr@usma.edu
845-938-5206

This Page Intentionally Left Blank

Abstract

The United States Army Corps of Engineers conducts and manages dredging operations throughout the nation to keep the nation's rivers and ports open to commercial traffic. Historically USACE evaluates projects using a cost benefit analysis to determine which projects are more economical. With the creation of an Environmental Benefit Unit (EBU), emphasis on environmental consideration is considered simultaneously along with the financial aspect. The environmental benefits of using dredged material in a project such as restoring wetlands are quantified in order to provide the decision maker with pertinent information aside from economical data.

The purpose of this report is to assign a quantifiable number for the environmental benefits of utilizing the dredged material. Our focus area occurs after the dredging operation has occurred and the dredged material is being held for either a beneficial use or waiting to be discarded. Due to differences in geography resulting in different project opportunities it will be necessary for each District in USACE to have their own EBU scale. For this project Long Island, NY will be the focus area and the model created can be altered and used by every District.

The purpose of an EBU is to supplement the decision maker with the benefits of using the material for a constructive project by analyzing the four accounts of the Principles and Standards. The four accounts are National Economic Development (NED), Regional Economic Development (RED), Environmental Quality (EQ), and Social Well-Being (SWB). The NED and RED are accounted for in a basic cost benefit analysis USACE conducts prior to beginning a project. The EBU will account for the environmental quality and social well-being aspects, which are not quantified during the cost/benefit analysis.

Chapter 1

Introduction

1.1 Introduction

Dredging is an excavation activity conducted partly underwater in order to collect sediments and move them to a different location. Dredging is primarily done in order to create navigable space for shipment of goods and trade, but it also serves to create underwater foundations, facilitate the emplacement of pipelines and tunnels, construct flood control structures, and create storage capacity in water supply reservoirs (Cohen, 2). However, the benefits of dredged material are overshadowed by problems with water quality, interference with marine-life habitats, public disturbance and changes to natural topography (Cohen, 6).

Because dredging operations are necessary in order to spur economic and environmental growth within the United States, public support and funding are critical to maintain their usage. A difficult issue to overcome is how to measure the effectiveness of dredging before operations begin to take place. Many factors affect its cost-benefit ratio such as the amount of dredged material produced, transportation of dredged material to a treatment facility, public response and economic benefit. In order to better assess dredging projects across the country, it is necessary to quantify an EBU that weighs all these factors based on their values so that dredging companies and organizations like the United States Corps of Engineers (USACE) can make efficient decisions about whether to go forth or prevent operations from occurring without dealing with potential side-effects and consequences. While dredging is necessary to keep waterways and ports open, there is a lot of debate about the harmful effects of dredging and dredged material placement; therefore, it is the goal of our project group to mitigate these effects by creating a value that will show the most beneficial use of dredged material for each community.

1.2 Original Problem Statement

The idea of an environmental benefit unit can be approached in a variety of techniques. The systems department at West Point teaches a technique known as the systems decision process (SDP). In order to begin analyzing any problem it is essential to create a definition for the problem at hand. This problem statement is revised throughout the problem definition stage of the SDP as the project scope begins to narrow down. The problem statement is what guides the initial research and stakeholder analysis and will lead to the creation of a qualitative value model. The original problem definition was to create a quantifiable EBU for dredged material placement in order to account for the environmental benefit of using dredged material for a project. This will provide the decision maker with additional information when selecting a placement site for dredged material.

Chapter 2

Literature Review

2.1 Introduction

The purpose of this literature review is to address the various works written on the EBU. Compiling and analyzing the works of multiple perspectives on the creation and sustainment of an EBU allows us to grasp the social and technical requirements of reproducing a model that can assess and prioritize environmental projects. This literature review is divided into categories related to dredging, such as surveying and sampling, techniques, issues, benefits, laws, key stakeholders, and its level of utility in the future.

2.2 Surveying and Sampling

The first two steps of the dredging process are surveying and sampling of the dredged material. These steps are sometimes conducted unilaterally depending on the operation. These steps are the most important stages of the process and allow the dredging operation to proceed intelligently. Surveying is generally conducted utilizing satellite technology because this is an extremely accurate method of photographing the bottom of the waterways. The surveying and sampling aspects of site preparation allows the operation to use the best dredging technique possible by understanding the ground layout and the sediment type. There are several different sampling devices dredging operations use depending on dredge depth. Sampling equipment can cover small samples by using the Peterson Grab device that gathers a sample of 1'x1'x1' (Gregory, 739). If the dredging operation requires a deeper sampling to occur then a piston corer is a better choice as it can obtain samples up to eighty feet in depth (Gregory, 739).

2.3 Dredging Techniques

Dredging techniques have adapted tremendously to the constant changes and growth that the world experiences on a day-to-day basis. With larger ships being created the strain to develop more efficient dredging technologies is increasing. On the Mississippi River one dredging technique involves a 45 foot dustpan hydraulic dredge (Krenkel, 118). According to USACE dredging can be divided into two main subtopics, which are mechanical and hydraulic dredging. Both techniques have their advantages and disadvantages and the two techniques may often work in conjunction with each other.

Mechanical dredging, according to the USACE, works great in tight confines and for hard packed water bottoms. The mechanical dredging technique is not good for high trafficked area though, because it is generally not self propelled but rather hauled to the dredged site. Once at the dredge site the ship will dredge an area in nearby proximity to the floating barge which the mechanical dredge is located on. Once it has dredged an area, it has to be physically moved by another ship.

Hydraulic dredging covers most of the mechanical dredging disadvantages. Hydraulic dredging can take place without disrupting the flow of traffic and can pump the material away or put it in an on board storage area (USACE5). The hydraulic dredges require certain conditions such as softer bottom conditions and must have the right water to sediment ratio in order to function properly.

Mechanical dredging involves physically picking debris and sediment off the bottom of the water floor. According to Tsinker there are several types including backhoe, bucket, ladder, clamshell, dragline, dipper, and bucket ladder. It is hard to establish one type of dredging as better than the alternative because it depends on the problem definition and any external factors. Re-suspended particles and residuals left over from post dredging surfaces pose an environmental concern and in most cases is a large factor in choosing what type of dredging to use (USACE4, 53).

Hydraulic dredging uses water pressure to practically suck the material off the bottom of the waterways. Tsinker describes several types of boats such as hopper, sidecasting, pipeline, agitation-plain suction, cutterhead, bucket wheel, and the dustpan method. The hydraulic method intakes about 20 percent material and 80 percent water (Gregory, 737). Because of the large amount of water it intakes this method is usually not the best option if the dredging operation is attempting to remove contaminants from the water.

2.3 Environmental and Economic Issues Caused By Dredging

Managing dredged material requires extensive research into uses or disposals while maintaining a healthy environment. “Every year, 200 to 300 million cubic yards of material are dredged from U.S. ports, harbors, and waterways” (USACE4, 53). Unfortunately, most of this material is used ineffectively; 20 percent of dredged material is disposed of into ocean waters, 80 percent through other means in estuarine, fresh waters, upland or other areas, and of the material placed, only 30 percent is used for beneficial purposes (USACE4, 86).

Ivan Sheall reports that USACE spends upwards of \$400 million every year dredging waterways to keep them open for commercial traffic and an additional \$200 million for improvements in research and development for new dredging operations (Sheall, 537). In 2010, USACE spent \$1.5 million on maintenance, new work, and emergency dredging for federal and non-federal purposes (USACE3, 3). More than 25,000 miles of navigable rivers and channels are used to transport commercial products within the U.S. and to other countries, which affects about 20 percent of the job industry in the United States. According to USACE, between 500,000 to 5,000,000 cubic yards of dredged material has to be transported upwards of 250 miles for placement in proper treatment facilities (USACE2, 37). It is clear that although the United States is significantly dependent on dredging operations to maintain a major portion of its economy, it has to deal with major financial constraints that negatively impact the gains.

Dredging operations have also shown signs of hurting social health in target regions. In 2011, Magnus Sparrevik conducted a study to assess the effects of polychlorinated dibenzo-*p*-dioxins and –furans (PCDD/Fs) in the Grenland fjord in Norway on human health, ecosystems, and

resources, using the Life Cycle Assessment (LCA) method. Findings showed that human toxicity significantly outweighed the impacts of marine and sediment ecotoxicity while local toxicity impacts were higher than regional impacts (Sparrevik, D). The importance of this study was to prove that if contamination of land due to any construction operations was to occur, the chronic effect on humans was even more revealing than the effect on the land or resources. Another grave concern is the release of semivolatile compounds, such as polychlorinated biphenyls (PCBs), into the atmosphere from dredging operations that target large isolated or buried contaminant repositories (Chiarenzelli, 47). This shows the extensive reach that the effects of dredging operations have because they target not only bodies of land and water, but the atmosphere as well, which can be aggregated as everything the earth is made of. This also highlights the urgency of finding quick, effective solutions to the problems associated with dredging operations.

Although the Clean Water Act (CWA) regulates dredged material, it does not provide any guidance for protection and preservation of human health and the environment after dredged material is placed in an upland environment. According to Childs, “protection of human health and the environment in an upland environment requires evaluation of groundwater; surface water; ingestion, inhalation and dermal contact for humans; and ingestion and absorption in terrestrial wildlife and vegetation.” He concluded that the coordination of several regulatory programs was necessary in order to beneficially use dredged material in an upland environment while most effectively protecting human and environmental health (Childs).

Currently, dredging poses many threats to the environmental and economic welfare of the US. These issues are key factors in creating EBUs to measure the effectiveness of dredging operations. Environmental factors are particularly important because the EBU must account for many impacts that dredging has on the ecosystem, such as habitats for many animal species, unprecedented changes to the state of nature’s equilibrium and human health. Public response is a driving force in creating EBUs because ultimately, humans decide whether they will support the excavation of sediments in their respective regions. Advocate groups of environmental protection will naturally fight against any human activity interfering with the environment, even with factual evidence of dredging benefits. Unfortunately, people tend to seek visual and immediate results of beneficial uses of dredged material and refuse to compromise when too much time and resources are taken up. It is important for the project group to create clear and factual EBUs that determine the validity of dredging operations so that public response can be altered and USACE can garner support from the general population to continue its excavation activities.

2.4 Environmental and Economic Benefits of Dredging

USACE lists seven categories for beneficial uses of dredging: 1) habitat restoration and development; 2) beach nourishment; 3) parks and recreation; 4) agriculture, forestry, horticulture, and aquaculture; 5) strip-mine reclamation and solid waste management; 6) construction/industrial development; 7) multiple-purpose activities (USACE4, 9).

The Engineer Research and Development Center (ERDC), in which dredging is a major operation monitored, involves national and international organizations, such as the London Convention, PIANC, and AAPA, which provide policies, committees, and projects to address environmental, societal, and economic issues concerned with dredging.

The Dredging Research Program (DRP), initiated by USACE, was created to find more effective management and technical methods of dredging without risking the health of the environment or spending too much. It was divided into five focus areas: Analysis of Dredged material Placed in Open Water; Material Properties Related to Navigation and Dredging; Dredge Plant Equipment and System Processes; Vessel Positioning, Surveying Controls and Dredge Monitoring Systems; and Management of Dredging Operations (Sheall, 536).

These beneficial use projects have become extremely important in the management of dredged material because of the scarcity of land today. Severe environmental constraints have increased the values placed on coastal and riparian wetlands and aquatic areas and have made the idea of beneficial use of dredged material an acceptable and attractive solution.

A real-world example of a beneficial use found in dredging is the construction of low berms along the Gulf Intracoastal Waterway (GIWW) between the Galveston Causeway and Bastrop Bayou, Texas by the U.S. Army Engineer District of Galveston, Texas. Dredged materials would then be used to preserve and enhance marsh habitats by preventing salt-water from entering fresh marshes. Dredged material could provide erosion protection and raise elevations in drowned marsh of other low areas, thus sustaining about 250 acres of wetlands (USACE1, 2). Wetlands provide homes to hundreds of species of marine-life, act as natural barriers against floods, replenish groundwater, stabilize shorelines, provide storm protection, and maintain water purification (Delaware Estuary).

Small steps have been attempted to quantitatively and qualitatively measure the beneficial impact of dredged material, similar to the project team's EBU, because many organizations have dedicated their research efforts to justify the need for dredging operations. For instance, ERDC's dredged material management has been broken down into predicting the fate of dredged material using simple algorithms and 2D models, re-suspension of dredged material, and beneficial uses (Clausner, 18). These algorithms and models can be used as stepping stones to creating more efficient measurement values for dredging operations. When creating EBUs, it is critical to incorporate these beneficial uses, as well as the time horizon (EPA). The questions project managers will have to ask themselves will be: how long will the benefits last? How often will maintenance be mandated? What are the fiscal costs associated with the effects of dredging over a long period of time? EBUs will have to weigh the difference between the benefits and costs and accurately assess the validity of projects. The most effective EBUs will not guarantee project success for every proposal, but guide the project team in making the smartest decisions. A significant key to enhancing decision making will be to step up monitoring activities at dredging and disposal sites in order to determine whether cleanups are working and to build knowledge of what cleanup techniques are effective under various conditions and time horizons (National Research Council)

2.5 Laws Governing Dredging

USACE is the nation's largest dredger and is responsible for issuing permits for dredged material disposal, after review or concurrence by the Environmental Protection Agency (EPA). "Other federal, state, and local agency reviews are required based on the location and jurisdictions in which the dredging operations occur (USACE4, 6).

The five major federal statutes that affect dredged material disposal are the Marine Protection, Research, and Sanctuaries Act of 1972 (MPRSA), the Clean Water Act (CWA), the Rivers and Harbors Act of 1899 (RHA), the National Environmental Policy Act (NEPA), and the Coastal Zone Management Act (CZMA). The MPRSA regulates the transportation of dredged material to be dumped in ocean waters. The RHA requires a permit from USACE for work that affects navigable waters in the United States. The CWA covers the dredged material that is discharged into U.S. waters. NEPA ensures that environmental impacts and public input are considered in any federal actions by requiring an environmental assessment or an environmental impact statement (USACE4, 7).

Furthermore, the CWA, CERCLA (Comprehensive Environmental Response, Compensation, and Liability Act), SARA (Superfund Amendments and Reauthorization Act), and the Water Resources Development Act of 1990 all serve as authorities for contaminated sediment cleanup. There are many more environmental laws and regulations through executive orders that are applicable to dredging and dredged material disposal activities listed by USACE, all of which address some specific aspect of dredging operations (Wilson, 13).

When EBUs are created, the myriad of laws that govern dredging must be taken into consideration. Some obstacles that must be addressed are that although the primary impact and concern of legislation is related to the disposal operation, most laws do not differentiate between dredging and disposal. There is also a lack of consistency with federal dredging laws because the Federal Government leaves land control up to state and local governments (USACE2, 1). When developing EBUs, federal and state government control must be remediated so that proper approval of dredging operations can occur. Possible conflicts could arise because there are so many different organizations that are impacted from a single dredge project. For example, a project must adhere to federal and state laws, then reach negotiation between contractors and dredging companies, acquire the necessary funding, and ensure the local population is at least somewhat supportive before a single grain of sediment can be excavated. These considerations all serve as variables that affect the production of EBUs alongside environmental and economic factors.

2.6 Engineering Research and Development Center

The USACE Engineering Research and Development Center (ERDC) is a group in charge of doing the cost benefit analysis for dredging projects and conducting flood analysis and river research. They are the primary stakeholder and decision maker for this project, therefore making it very important to understand their position within USACE. ERDC was created in October 1999

in order to consolidate research facilities and make them more efficient. They conduct research and development for four major areas including Military Engineering, Geospatial Development, Environmental Quality, and Civil works. They have five technical areas including Warrior Support, Environment, Information technology, water resources, and installations on which they focus. Their environmental technical area is the reason ERDC created the capstone for beneficial use of dredged material. ERDC has 2,500 employees and a one billion dollar budget. They have a highly professional staff to research and create solutions in some of the best facilities in the world. Their lab hosts one of six of the Department of Defense High Performance Computing Centers. Some of their laboratories include a 1,800 foot pier, water way and coastal models and simulations, blast effect facilities, and hazard waste research facilities (US Army Research and Development Center).

2.7 The United States Corps of Engineers

The United States Corps of Engineers is there to provide vital public engineering services in peace and war to strengthen the Nation's security, energize the economy, and reduce risks from disasters (United States Army Corps of Engineers HQ). USACE is responsible for many different types of engineering in both the civilian sector and the military. USACE is one of the most important branches not only to the military, but to the civilian world as well. USACE is divided up into districts across the United States based on water sheds. It is important to know the background and responsibilities of USACE because they are a primary stakeholder and are the main consumer of the overall product. In 1824 the Supreme Court ruled that interstate commerce, including river navigation, was a federal responsibility (USACE4, 7). After that several other laws were passed that gave USACE complete responsibility for navigation and flood control due to the cost and cooperation required between states (Yoe, 31). For example, the New York district of USACE is currently working on a project to deepen 35 miles the waterways to 50 feet within the port to accommodate larger container ships (Baron). In order to start this dredging project, USACE had to get a permit from the local government in New York and create a contract to decide how much each party would pay, and then finally put out a bid for the contract (Baron). Information on how these projects are started and planned out are extremely important to our project group because in order to come up with a beneficial use for dredged material, the decision making on where the dredged material is going to be placed has to be started in the planning process. An important process to understand is the relationship between USACE and the local government working together to create solutions because each has their own values that needs to be accounted for in an EBU.

2.8 The Port Authority of New York and New Jersey

The third largest port in North America is the Port Authority of New York and New Jersey. It is an example of one of the ports that is a stakeholder because they will be the consumer of the final product so it is important to know the background and statistics on this particular port. By 1850, the Port of New York was more active than Boston, Baltimore, and New Orleans combined and by 1970 was the largest container port in the world (Rodrigue). Currently the New

York port has a hinterland of 20 million people in the metropolitan area and an additional 80 million that can be reached in less than 24 hours, making it one of the busiest ports in the world (Rodrigue). The port of New York handles 11 percent of all ocean borne general cargo imported into the United States and 25 percent of all containers handled on the Eastern seaboard (Rodrigue). In 2001 it handled more than 5,000 cargo ships and contributes \$14.6 billion dollars to the regional economy (Rodrigue). The New York Port is controlled by the Port Authority of New York and New Jersey, and is one of the most unique government agencies in the United States because it expands over two states that must work together to make decisions and find solutions. The PANYNJ has the authority to undertake any project concerning transport mode that promotes commerce, trade, and the public good (Rodrigue). The PANYNJ was originally created because of the disputes between the two states concerning use of the Hudson River; because of these disputes it was ruled that whole region was a single harbor and should be governed as such which lead to the creation of PANYNJ in 1921 (Rodrigue). The PANYNJ is responsible for many well known projects that were created to link the two states and make commerce easier, one example being the George Washington Bridge (Rodrigue). The PANYNJ is just one example of how important the use of ports and waterways are to the United States.

2.9 Improvements for Future Projects and Public Relations

There are many beneficial uses of dredged materials but the problem of expensive cleaning and transportation of the material, along with the public's negative perception of dredged material, makes it very difficult to use it as efficiently as possible. There are several ways we can overcome these difficulties and drastically increase the use of dredged materials for beneficial projects and select the most beneficial projects possible. In order to achieve this, more techniques need to be developed and improved to clean the material more efficiently and less costly. More types of projects need to be developed and more objective ways to measure or grade the products needs to be developed. By developing an EBU we will be able to score different projects and prioritize them by level of positive impact they will have on the environment. Along with these developments, it is essential that the public is educated on dredged materials so that they will accept the projects that USACE decides to carry out. As long as the public is against the use of dredged materials in their local areas, it does not matter how good of a system to determine good projects USACE can develop, because it will be too difficult to complete them. It is essential that we have develop good projects to beneficially use the dredged materials, and for the public to understand them.

2.10 Uses of Dredged materials

When waterways were first dredged all of the dredged materials were simply disposed of as waste; dumped somewhere to be forgotten about. But as dredging operations became more frequent it became clear that something needed to be done with all of the materials. Many alternative uses of dredged materials have been developed and as a consequence, dredged material is looked upon first as a potential resource rather than a waste (Murray, 644). Non-

wildlife uses of dredged materials are classified in six categories: industrial/commercial, recreation, agricultural, material transfer, waterway-related, and multiple purposes (Patin).

The most popular beneficial use of dredged materials is in land reclamation. Dredged sand, clay, and rock from riverbeds or the seabed is used to create new land where water has washed it away. This can be very useful for filling in swamplands that were once dry land, to make them useful for agriculture or other purposes (Weinstein). This is sometimes done by the government through USACE or private companies for commercial purposes. Land reclamation is especially good because it has two benefits, economic and environmental. By reclaiming lost land, coasts can be much more protected from water erosion, floods, and storms, while economically productive activities can be done on this land.

The sand obtained from dredging is often used for beach replenishment. The sand which is lost through long shore drift causes beaches to erode away. As the ocean waves and currents continuously pound the beach, the sand washes down the coast. Because most commonly visited beaches have building developments built next to the beach, when the sand erodes and the water comes closer the beach basically starts to vanish, as it cannot be pushed beyond the man-made developments. In order to battle this erosion, sand from dredging can be placed all along the beach to replace the sand that was washed away (Greene).

Commercial users have developed tiles, glass, cement blocks, bricks, and potting soils from dredged material (Krause 8). A simple and easy use of dredged material is in the construction of dikes to prevent flooding. This has been done with great success in several states (Weishar). It is of course more expensive to cleanse the material and prepare it to be made into materials ready for construction, but the value of the material increases greatly when this can be done successfully. By making the material into construction materials we will also save the time and resources devoted to the development of these materials from other sources.

Artificial rock reefs are built with the harder dredged materials like rocks, coarse sand, and glacial till. These reefs can increase the number of species, number of individuals, and average length of fish both at the reef and in adjacent waters (Yozzo). Artificial rock reefs have been made in New York City to serve as a habitat for oysters.



Table 3. Summary of Innovative Technologies for the Beneficial Reuse of Contaminated Dredge Material

Technology ID	Feature	Pros	Cons	Costs
Contaminant Separation				
Thermal Desorption/ Cement-Lock	Heat (up to 1400° C) to remove contaminants from the sediment matrix, then added to cement mix. The process takes place in a rotary kiln.	Beneficial uses include construction fill and habitat restoration. Existing cement plants may be able to be used to handle large volumes of dredged material. Process can remove all organic compounds and much of the metals.	A side product formed from some of these types of processes is a waste stream of hazardous material that requires disposal at a hazardous waste treatment facility.	Processing cost of \$50 per cubic yard Value of construction-grade product \$50-\$70 per cubic yard Disposal costs of waste stream will depend on the level of contamination
Fluidized Bed Treatment	High temperature heating unit (not an incineration or oxidation process) that converts all organic materials to carbon monoxide, hydrogen, and methane.	99.9% free of organic material and, depending on the metal content, can be disposed of without restriction. It can operate with a continuous feed of material and can use the material without dewatering.	Extremely energy intensive and costly. Process has only been demonstrated in a small pilot scale project	Pilot and full-scale production costs are estimated at between \$40 and \$120 per cubic yard
Plasma Vitrification	Plasma torch (~5000°C) melts sediment using fluxes to produce a glass product.	Glass product can be resold to recover some of the costs associated with the process.	Does produce a small waste stream of oversized debris and CaSO ₄ which can be readily landfilled.	Processing cost of \$90-120 per cubic yard (depending upon the cost of electricity).
Contaminant Destruction				
Base Catalyzed Decomposition	2-stage process which primarily removes halogenated compounds	99.8% free of chlorinated compounds. Also removes volatile and semi-volatile compounds. Remaining metals are not leachable.	PAHs are not removed.	Production costs are approximately \$108 per cubic yard



Table 3. (Cont.) Summary of Innovative Technologies for the Beneficial Reuse of Contaminated Dredge Material

Technology ID	Feature	Pros	Cons	Costs
Contaminant Reduction				
Soil Washing	Process blends detergents, chelating and oxidizing agents, and high pressure water jets	90% organic compound reduction & 70% inorganic compound reduction. Process (after blending) yields a product suitable for manufactured topsoils.	Only useful for low to medium contamination levels.	Processing costs estimated at \$30-50 per cubic yard
Contaminant Stabilization				
Solidification/Stabilization	Addition of cement, fly ash, lime and/or chemicals to soil aggregates. Can be used in conjunction with other processes.	Bound aggregates can be used for some types of construction processes as well as landfill closure and Brownfield remediation projects. Both freshwater and marine sediments used.	Highly contaminated sediments may need to be pre-cleaned with another process prior to S/S to produce a beneficial end product. In some cases the S/S treatment may change the chemistry of the contaminants and render them more susceptible to leaching.	Production costs vary by sediment/soil type, raw materials costs, and the level and type of contamination. Costs of production were not inclusive of contamination removal which may be necessary prior S/S. Production costs estimated at \$30-60 cubic yard.
Manufactured Soils	Dredge material mixed with other proprietary materials to produce a topsoil.	Provides beneficial use for other waste products. Topsoil product can be sold to both municipalities and the public.	Process requires relatively small (<5000 cy) per batch	Production costs estimated at approximately \$20 per cubic yard, but does not include contamination reduction costs.
Construction Products	Used as a raw material for manufacturing construction products such as building blocks, tiles, and bricks.	Both freshwater and marine sediments can be used.	Full-scale production is not yet available.	Industry estimates at \$20-80 per cubic yard do not include contamination removal costs.

Screen clipping taken: 10/24/2011, 3:16 PM (Krause)

2.11 Restoration of Jamaica Bay

The main use of dredged materials in the New York City area is in helping the reconstruction of Jamaica Bay. Historically, most of the Jamaica Bay area consisted of large expanses of salt marshes and pine dominated forests. European settlement led to the development of the majority of the upland areas for residential, commercial, and industrial land uses. Degradation of the natural systems in the study area continued into the 20th Century. Large expanses of wetlands were lost as a result of the construction of large commercial, industrial, and military facilities such as John F. Kennedy International Airport and Floyd Bennett Field. The material used to fill the wetland areas was dredged from the shallow water areas of Jamaica Bay, such as Grassy Bay (Johnson).

This project is a great example of something that can be done that has significant environmental benefit. The marsh islands ecosystem within Jamaica Bay is a home for a variety of wildlife. Salt marshes provide valuable habitat for fish and shellfish, are an important food source for native and migratory birds, and also help improve water quality by removing nutrients such as nitrogen and phosphates (Elias). The project will beneficially utilize about 200,000 cubic yards

of clean sand from the ongoing New York-New Jersey Harbor 50 ft. deepening project to restore about 35 acres of low and high marsh habitat in Jamaica Bay (Elias). As all the dredged material used for this project is all material that was taken from the seabed of the harbor in order to enable larger ships carrying larger loads to move through and dock in the harbor. Therefore the benefits of this project are twice-fold, making it a model to other cities with similar problems.

2.12 Resistance to Dredged Materials Usage

Industrial companies have been dumping their waste products into waterways in America for decades. Although today there are many pollution regulations in place to protect the environment there is still a large buildup of waste, including hazardous waste, in riverbeds and along the coasts. This waste decomposes into the materials in the river bottom and causes much of the riverbed to be a mixture of natural and hazardous materials. The short-term impact of dredged material on water quality and aquatic organisms is related to the concentration of chemically mobile, readily available contaminants rather than the total concentration (Brannon). The toxicity of dredged materials has deterred it from being used because of this. There is a widespread misperception that dredged material is a waste instead of a resource (National Dredging Team). Many techniques are being developed to separate the actual hazardous components of the dredged materials from the rest which can be easily used for construction and other operations. Methods to test the toxicity of the materials are also being studied to improve safety and confidence in the material (Munns). One particular study found that nematodes, which are a type of roundworm, are found in dredged materials that are highly toxic. The study established that nematode communities can provide a sensitive indicator of change in response to dredged material disposal at a variety of locations and have introduced a new monitoring tool for a practice that has a wide significance around the U.K. coast (Boyd).

The toxicity level of dredged materials makes them much more difficult to use in beneficial ways for multiple reasons. First, these materials are much more expensive to clean to make them safe enough to put back into the environment, or clean enough to place in areas that will have human contact. Also, even if the materials have been properly cleaned the public still does not support the use of material that was once contaminated to be used in their respective local areas. The contamination level can factor into the EBU score that we place on certain projects using the contaminated materials. The fact that these problem materials are used will most likely benefit the EBU as it is making the environment cleaner by cleaning these materials. On the other hand it can negatively impact the EBU because of the public's resistance to use the material, making it a much more difficult project to implement.

2.13 The Importance of Public Education on Dredged materials

In Northern California, the Port of Oakland did a study to identify a regional upland dredged material reuse/rehandling facility for the San Francisco Bay area. As part of this project, they did a study to see the marketability of the dredged materials and how well it would sell to private companies in the San Francisco Bay area. The results of the survey showed that there was very little enthusiasm in the industrial and commercial communities to utilize dredged material as a

resource, especially with NUAD (Not-Suitable for Unconfined Aquatic Disposal) material. Due to fear of contamination in the material, industrial users did not see a large user base for it. Most companies in the local construction community falsely believed that the NUAD material was “hazardous” because of their misinterpretation of the NUAD label. The study concluded that an effort needs to be made to educate the public on the real risks of NUAD and SUAD materials so they will understand and embrace the appropriate uses of them (Krause). It is a positive thing that the national focus and focus in local communities is on pollution prevention and safety, but it is also very important that ideas for dredged waste usage are not shot down immediately simply because of possible hazards. The need to use dredged materials itself is an environmental issue because simply making huge landfills of it would cause problems to the local environment (Mullins). With the growing public education, dredged materials will be used more in the future.

Good communication is necessary to overcome negative perceptions and build trust between the industry, client, regulators and stakeholders. Fear of contamination and environmental risks leads to the “not in my back yard” attitude. This attitude can be overcome by explaining policy, listening to stakeholders’ fears, paying attention to actual environmental risks, developing programs that raise awareness amongst stakeholders and government agencies, and by involving them all at an early stage of the project (Bray). By viewing dredged material as a resource and finding suitable uses for it, we can change the perception of dredged material into a more positive light. This can lead to win-win situations. The necessary dredging of the port, harbor or waterway is accomplished and an added value of a restored beach, new natural habitat or other use is achieved (Bray). We already have to dredge, so by showing the public that it’s in our collective interest to use this material in a beneficial way we all win.

2.14 Conclusion

Dredging is an essential function that ensures smooth transportation through waterways as well as improving the overall standard of living by improving beaches and their contributions to public work projects. The constant challenge is what to do with the dredged material. There are many possible uses of the material and different projects available. In order to rate the different projects it is important to include not only the simple financial costs and benefits, but also the environmental effects. In order to quantify the environmental effects of a project and objectively measure its value versus other projects we are trying to develop an Environmental Benefit Unit (EBU). The main objective of the project team will be to develop detailed and accurate EBUs that will definitively measure the costs and benefits of dredging. The EBUs will then be used to determine the soundness of potential dredging projects so that time and resources can be effectively allocated.

Unfortunately there are many negative effects of dredging, such as the spread of toxins and the invasion of marine animal homes. Research is constantly occurring to provide technological, legal, and economical solutions to these problems, but a common theme in dredging operations seems to be that the more solutions generated to alleviate these problems, the more unexpected adverse effects spring up and add onto the already growing list of issues. By using the EBU to measure these complex factors we will be to mitigate these unexpected deterrents so that economic growth and environmental sustainability can be maintained for as long as possible.

Chapter 3 General Approach

3.1 Methodology

3.1.1 Systems Design Process (SDP)

The systems decision process is a 4-step problem solving methodology utilized at the United States Military Academy. The four steps consist of Problem Definition, Solution Design, Decision Making, and Solution Implementation. The SDP is a continuous cycle: even though a solution may have been finalized by the project team, it is critical to step back to the Problem Definition phase to ensure that the solution will continue to meet the problem requirements in the future.

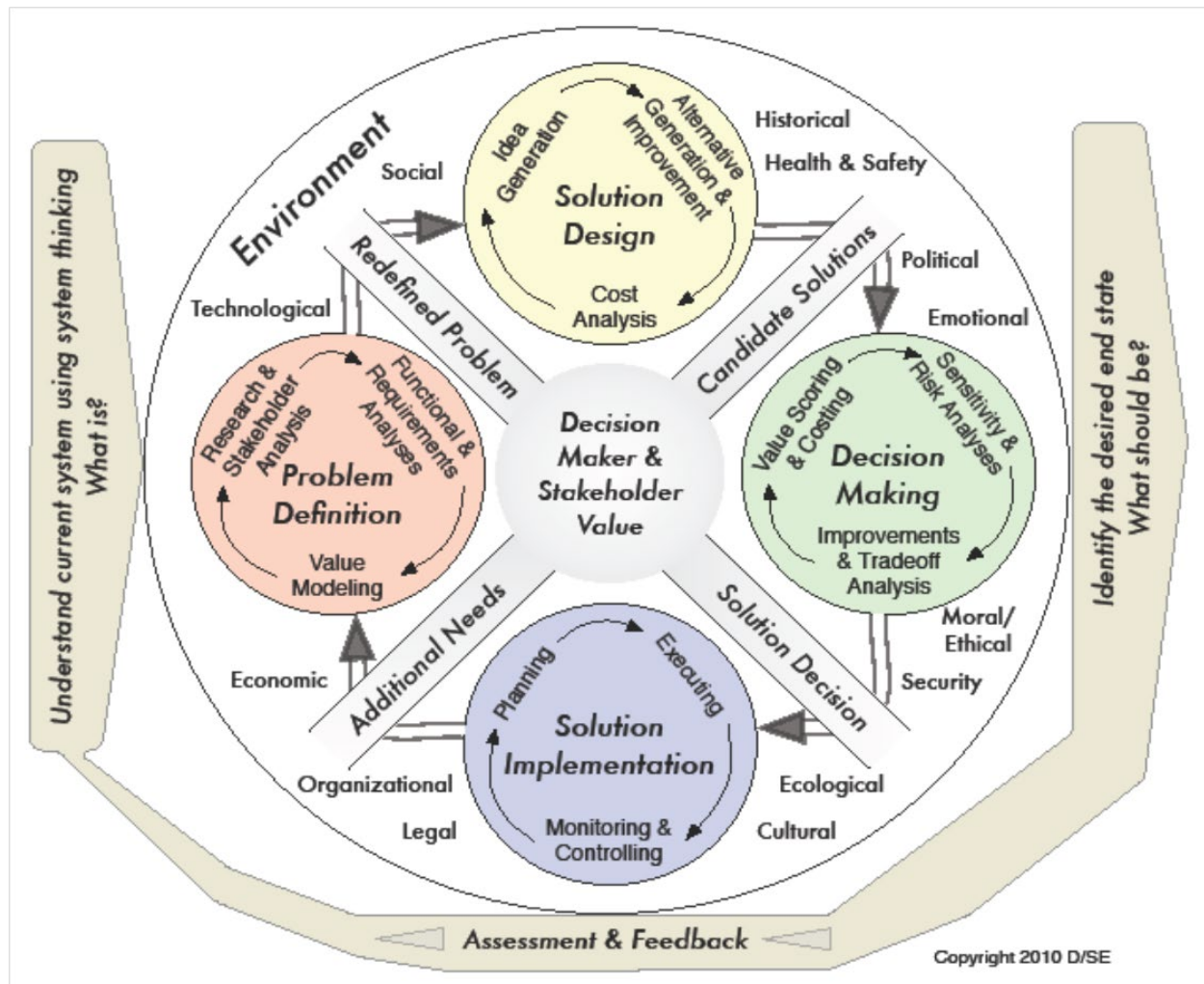


Figure 1: Systems Decision Process

The first step of the SDP, known as Problem Definition, serves three main functions: Stakeholder Analysis, Functional Analysis, and Value Modeling. The reason the Problem Definition phase is highlighted in red is because it is important to stop at this phase and take extra precaution in developing the problem statement. If a project team were to continue seeking a solution to the problem at hand and realize in the middle of the SDP that it was addressing the wrong problem, much time and resources would have been lost in vain.

Stakeholder Analysis consists of conducting interviews and a variety of survey methods to gather as much information as possible in order to completely address the stakeholders' needs within the scope of the problem. Interviews can be conducted over phone, e-mail, or in person. Some surveying techniques are through internet surveys, discussion panels, and live surveys. Surveys can help the project team collect raw data that can be physically measured and compared. Stakeholder Analysis is complete once a Findings, Conclusions, and Recommendations Table is fully produced. This table presents all the information collected from the stakeholders, any conclusions drawn from that information, and recommendations on how to go forth with this newfound information.

Functional Analysis presents an outline of the functions a system will be designed to perform in order to achieve the system's objectives. This stage is critical because it identifies all the functions the system must perform in order to fully address the problem at hand and create a base from which solution ideas can be developed. One technique which is common is creating a Functional Hierarchy. A Functional Hierarchy relies on an affinity diagram which collects ideas into logical groupings for a specific purpose. At the top, the main objective function of the project is placed. Falling under it are the system functions, which are broken down further into sub-functions.

The last phase of the Problem Definition stage is Value Modeling. This phase provides the project team an initial methodology for evaluating candidate solutions. One technique for conducting this phase is through a Qualitative Value Model, which describes the stakeholder qualitative values, which consist of the fundamental objective, functions, objectives, and value measures. This technique also utilizes an affinity diagram. At the top the fundamental objective is placed, and beneath it are the objectives, the functions, and value measures. Value measures are scales to assess how well the project team attains an objective. Value measures usually start with words such as "maximize," "minimize," or "optimize" to capture the most ideal outcome of the objectives.

Solution Design is the second stage of the SDP and its primary phases are Idea Generation, Alternative Generation, and Solution Enhancement. The third stage, Decision Making, consists of Solution Scoring, Sensitivity Analysis, and Value-Focused Thinking. The last stage, Solution Implementation, consists of Planning for Action, Execution, and Assessment and Control. Once again, it is important to remember that the SDP is a continuous cycle and even with a finalized solution developed, going back to the Problem Definition stage will only serve to expand knowledge on the system and provide critical and helpful feedback.

3.2 System Boundary

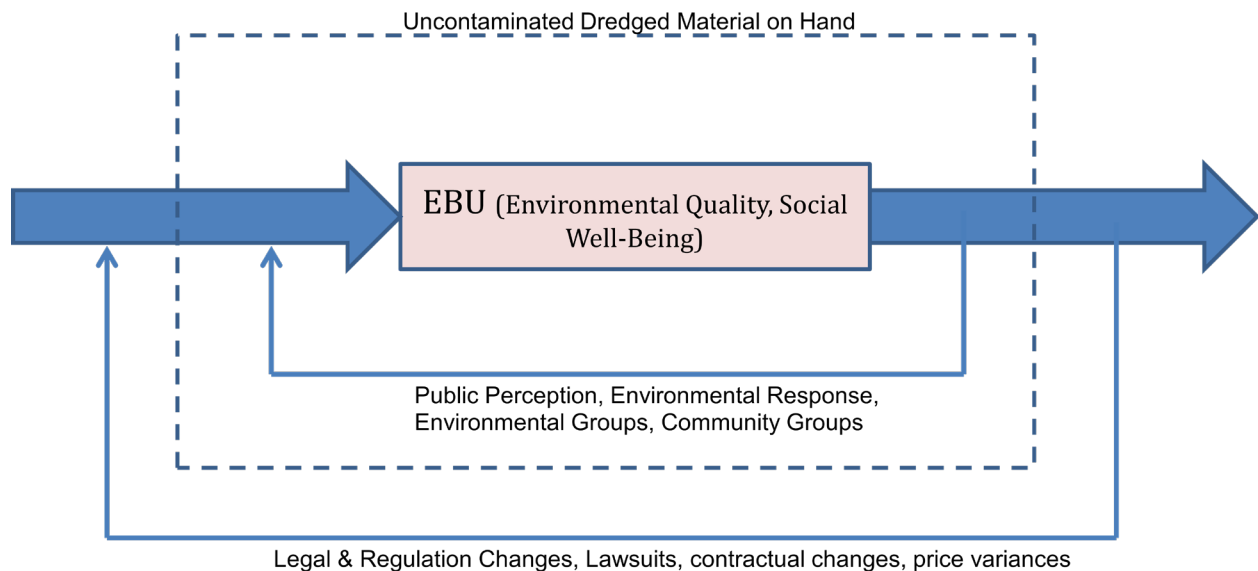


Figure 2: System Boundary

The figure above represents the boundary of the system that is an environmental benefit unit. The creation of the EBU is our primary objective, while the system is bounded by the assumption that only uncontaminated dredged material will be processed and the system will start once the material is ready to be transported. While we may have some control over public perception and environmental groups, which represent internal feedback, things outside our boundary, the external feedback, such as legal and regulation changes and price variances, we will not have as much control and influence over. The feedback is the most important part of the system because it allows the decision makers to identify any issues or problems that need to be adjusted.

The system boundary's significance lies in its search for simplicity. The problem at hand, which is to create an EBU, is an extremely difficult one with hundreds and thousands of factors that come into play. What the system boundary does is narrow the scope of our project so that we have a clear starting point and a direction in which to take this project. The system boundary also helps in shaping and developing the initial problem statement because we understand our objective and what limitations we have placed in order to reach that objective.

3.3 Facts and Assumptions

In the context of this project the facts are that Federal Standards will manage byproduct in the cheapest way that meets permit requirements. Based on that fact, the cost of transportation is extremely expensive and greatly limits beneficial use of dredged material. The standard for this

project will mainly be looking into the four accounts as published in the Federal Register. Another fact that is important to take in consideration is that most of the time dredged material placement goes where it is available and not necessarily where it is most beneficial (i.e. fish breeding will not be disturbed for placement). An important fact gathered from the primary decision maker is that the only expenses in the project will be the placement of the dredged material and no part of the actual dredging project will be taken into account. Also, there is currently no EBU available; that is, there is no existing simple number generator that will allow our stakeholders to evaluate and compare projects by a numerical value that could greatly assist in prioritizing projects.

This leads to the overall assumption that the process created will start when the dredged material is already removed and ready to be transported. Another assumption made for the purpose of this project include that there is no contaminated dredged material. Also, Long Island, NY will be the main location studied and the process created will serve as an example for other areas in the United States. Given that stakeholder input is so important, a survey was created for Long Island but there are not enough resources to gain a sample size of statistical significance, so the small sample size will serve as a representation of Long Island.

The facts and assumptions go hand in hand with the system boundary because it is yet another method of simplifying our problem and clarifying our objective so that we can develop a clearly-defined problem statement. We list all the facts and assumptions so that we can place certain limitations on our project that will allow us to delve into the development of the EBU without worrying about the myriad of factors that affect the beneficial uses of dredged material.

3.4 Identification of Risks

An important aspect of the systems approach is risk analysis. We analyzed the potential risks present in the entire process of dredged material placement operations starting with the planning of projects and ending with the final placement of the material. By defining each risk, the category it would fall into, its potential impact, and its likelihood, we can better understand the overall scope of the project and have a solid understanding of the challenges that will have to be addressed. Most importantly, by analyzing the risks we have an understanding of what can be done to mitigate them, and shape our policies and procedures to address the risks. Our risk analysis table shows the aspects of each risk, and the following risks were considered the most important to discuss.

Table 1: Identification of risks associated with uncontaminated dredged material on hand.

<u>Risk</u>	<u>Category</u>	<u>Impact</u>	<u>Likeli- hood</u>	<u>Mitigation</u>
Lack of Available Projects	Systemic	High	Low	Create list of all potential projects. Determine how much material can be used at site. Have contingency sites on hand.
Over Budget	Financial	Medium	High	Proper planning and cost estimations. Conduct PCIs and PCCs on all equipment. Ensure all legal areas are taken care of.
Suspension of Sediment in water During Placement	Environmental	Medium	Medium	Conduct proper analysis before placement. Get environmental groups involved in the beginning. Use of silt curtains and ensure barges and hoses are not leaking sediment
Leakage/Spillage During Transportation	Environmental	High	Low	Standard operating procedures for clean-up. Prior inspection of equipment. Continuous inspection of material containment.
Contaminated Waste	Systemic	High	Medium	Proper testing of material before dredging operation. Material engineering review during IPRs
Breach of Contract	Legal	Medium	Low	Thorough scheduling, realistic time, resource, and financial requirement planning
Breaking Local Laws/Regulations	Legal	Medium	Medium	Extensive knowledge of local laws/regulations. Peer review by legal advisors.
Unfit Material Composition	Systemic	High	Low	Proper testing of material before dredging operation. Material engineering review during IPRs

We face the first risk of a possible lack of available projects before the material can even be dredged. If this occurred the impact would be very negative as we would most likely have to dump the material somewhere due to lack of available storage space. This would have a negative environmental impact, and no economic or social benefits. The likelihood of this occurring is low, but in order to mitigate it further we can always have a list of the potential projects in the area, determine how much material can be used at the site, and have contingency sites on hand.

The financial risk of being over budget would have a moderate impact on the project because it is assumed that more funds can be used if absolutely necessary. Unfortunately this could turn

into a common problem so minimizing this problem as much as possible is important. The best way to do this is through proper planning and a thorough cost estimation of the project before it begins. Conducting proper inspections and checks on the equipment and materials keeps cost lower. Also, ensuring that all legal aspects of the project are taken care of is important to avoid lawsuits and fees which drive up costs.

When the material is transported there is a risk of leakage and spillage into the water or land in the area. This environmental risk could have very bad effects on the area depending on the seriousness of the spill and the delicacy or importance of the habitat it was leaked into. Unfortunately, this problem has a medium likelihood, as it could be a fairly common occurrence, to different degrees of damage. The best way to mitigate this risk is by having a standard operating procedure for the clean-up of spills if they do occur. This will minimize the damage done. Also, the continuous inspection of equipment, as mentioned before, will result in fewer accidents, spills, and leaks.

Chapter 4

Stakeholder Analysis

4.1 Stakeholder Analysis Methodology

4.1.1 Stakeholders

The system decision process (SDP) relies heavily on the problem definition phase. If the problem is not correctly defined, then the rest of the project will not be headed in the right direction and the project group will be forced to back track. A main part of creating a defined problem is stakeholder analysis and research. Once the project group learns the values of the stakeholders, they can create solutions using value focused thinking and end up with the best solution possible. For this project the decision maker is ERDC because they are funding the project and will decide how to implement the EBU. The user of the EBU will be USACE because they will be the stakeholder actually using it to decide where to place dredged material. The consumer will be the general public and port authorities because they will be receiving the EBU values as a way to prove which dredged material placement areas are the best. The first phase of creating the EBU was to conduct research. Every aspect of dredging and understanding the background of the main stakeholders were divided amongst the group members and each person wrote their own literature review. After having an understanding of the dredging process, the group began to interview stakeholders from ERDC and USACE in order to find their values and what they hoped to achieve through an EBU. During the interview process the group took a tour of the New York Harbor in order to get firsthand experience of what a dredging operation entails. In order to get the values of the general public (our test site being Long Island, NY) a survey was sent out among local communities. All the values and findings were placed into a Findings, Conclusions, and Recommendations Matrix in order to organize and better show all the information gained during this phase of the SDP. Below is a list of all the stakeholders that helped define an EBU throughout the entire SDP.

Monte Greges

Chief, Dredged Material Management Section Operations Support Branch Operations Division

Peter Wepler

Chief, Coastal Ecosystem Section

Environmental Analysis Branch

Planning Division

Thomas Shea, PMP

Acting Chief, Harbor Programs Branch

Programs and Project Management Division

Lisa Baron

Project Manager, Harbor Program Branch

Programs and Project Management Division

COL Boule
District Commander
USACE NY

William A. Martin, P.E.
Supervisory Environmental Engineer
Chief, Environmental Engineering Branch

John Childs
ERDC Researcher

4.1.2 Survey

The people who live in the areas where the dredging operations are occurring as well as the people who live in the areas where the dredged material placement projects will potentially be located are considered important stakeholders in this whole process. They do not have the most knowledge on the subject, but they will be the most immediately affected by the projects because of their proximity. The opinions and thoughts of the people living in the areas where the projects are located are also very important because they will have a large impact on whether the project will occur or not. Their support is essential because if they are strongly against any particular project and protest it then it will be very difficult for the project to ever take place. For this very same reason, environmental groups are very important as well. If they oppose any specific project strongly enough then that project will probably not take place. Because we do not want the politics behind project placement to interfere with the project selection process, working with the local communities and environmental groups rather than against them is essential. In order to gain some insight into the feelings of the public and environmental groups on dredging and dredged material projects we sent out a survey. The survey was sent specifically to people in Long Island, New York because that was our test site. We wanted to analyze the thoughts and dynamics of one specific area about dredging before we branched out. We also sent the survey out to environmental groups.

The survey consisted of eight questions, which aimed to gain a sense of how those people living in Long Island felt about dredging, dredged material, environmental issues, environmental priorities, economic priorities, social priorities, and finally the idea of an EBU. (The actual survey is in appendix B.) Seeing their thoughts and priorities directly influenced the value measures which we chose to base our model off. This will be discussed in further detail in section 4.4. There were a total of thirty four individuals who responded to the survey. Their results can be summarized in the following analysis.

Question 1 asked to name the top concerns about utilizing dredged material for beneficial use in local communities.

The results were:

The answers varied, but can be condensed as: waste/contamination (20 people), Cost (10 people), effects on the ecosystem (9 people), and appearance (4 people).

Question 2 asked:

How would you feel about using this dredge waste in your hometown to create parks, levees, and many other beneficial projects as long as the dredging material is uncontaminated?

The results were:

		Response Percent	Response Count
Strongly Agree		38.9%	14
Agree		41.7%	15
Neutral		13.9%	5
Disagree		2.8%	1
Strongly Disagree		2.8%	1

Question 3 asked:

Do you feel the benefits in the form of better navigational waters and flood control are worth the environmental impact of dredging operations?

The results were:

		Response Percent	Response Count
Strongly Agree		11.1%	4
Agree		25.0%	9
Neutral		36.1%	13
Disagree		19.4%	7
Strongly Disagree		8.3%	3

Question 4 asked to please rank the categories above from 1 to 7 with 1 being the most significant to your concerns and 7 being the least.

The results were:

	Response Average	Response Total	Response Count
Habitat restoration and development; Show Responses	2.35	80	34
Beach nourishment; Show Responses	3.71	126	34
Parks and recreation; Show Responses	3.79	129	34
Agriculture, forestry, horticulture, and aquaculture; Show Responses	3.24	110	34
Strip-mine reclamation and solid material management; Show Responses	5.09	173	34
Construction/industrial development; Show Responses	4.76	162	34
Multiple-purpose activities. Show Responses	5.00	170	34

Question 5 asked:

How high of a priority do you think economic efficiency and saving money is as far as dredging operations and material placement/disposal are concerned?

The results were:

		Response Percent	Response Count
Very Important		44.4%	16
Important		36.1%	13
Neutral		2.8%	1
Unimportant		11.1%	4
Very Unimportant		5.6%	2

Question 6 asked:

In terms of dredging operations and material disposal how much do you value the importance of reducing environmental impacts?

The results were:

		Response Percent	Response Count
Very Important		63.9%	23
Important		13.9%	5
Neutral		16.7%	6
Unimportant		2.8%	1
Very Unimportant		2.8%	1
		answered question	36
		skipped question	0

Question 7 asked:

How do you feel about the idea of an Environmental Benefit Unit?

The results were:

The answers varied, but can be condensed as: Great (8 people), Good (18 people), Indifferent (4 people), and Bad (2 people).

Question 8 asked:

How would you put value in an EBU (Environmental Benefit Unit)? Or in other words, how would you measure the environmental impacts of using dredged material?

The results were:

The answers varied, but can be condensed as: Number of species affected (7 people), environmental benefits and negativities (8 people), and effects on people in the area of the dredged material placement projects (5 people). Many individuals did not really understand the question or could not think of a good value measure.

4.2 Finding, Conclusions, and Recommendations

4.2.1 Findings

Every level of stakeholders identified costs as the number one concern when it came to the beneficial use of dredged material placement. The stakeholders who work for USACE stressed the importance of cost because of their understanding of the process. A higher cost project has a lower chance of being selected than a cheaper project despite the benefits a project might provide. The reasoning behind this mindset is that comparing projects based on benefits is difficult because there is no current EBU to standardize the evaluations. This makes it easier to choose a project based on the cost/benefit analysis alone. A project, which beneficially uses dredged material compared to ocean dumping, will have the potential for additional costs. These costs may include additional transportation costs and the development costs for whatever project it is being utilized for. It will also require additional people to plan, coordinate, and implement beneficial projects compared to simple waste disposal.

The stakeholders also provided input on potential objectives, which were used in our qualitative value model. Suggestions for objectives include aesthetics, water benefits, tax revenue, jobs created, and habitat creation. These objectives are important, but their importance will vary throughout the country. Wetlands may be more important on the East Coast than the West Coast. Therefore, we will need to develop a model that allows the different districts to place value on what types of terrain and animals are more important to that region. By conducting a survey, several additional objectives were identified. Placing value on certain species depending on whether they were endangered, protected, or vital to the ecosystem.

Social concerns were identified as another primary concern. From the users of the system the communities are very important in this process because they have the ability to delay projects or potentially reject projects from occurring. The results from our survey were sporadic regarding the acceptance of dredged material projects near their residences. This is most likely the result of misperceptions that dredged material is a dirty, contaminated material. There were fears of odors, water contamination, and a decrease in the aesthetics of the local area. In order to reduce this misperception it is vital to get as many environmental groups and communities involved in the process from an early stage.

4.2.2 Conclusions

From the stakeholder analysis, many themes kept reoccurring throughout the interviews, surveys, and research. The main themes were economic, environmental, and social impacts. These themes are almost identical to the four accounts that are national economic development, regional economic development, environmental quality, and social-well being. The economic related themes are accounted for in the cost/benefit analysis that is the current method for selecting a project. The environmental quality and social well-being will be further developed in a functional hierarchy as an important function of dredged material placement.

The social well-being aspect is a good function, but will be hard to quantify for a number of reasons. The community where the project will take place is not an isolated system. It may be

hard to quantify what is the result of the project compared to changes occurring from change in the economy. It will be hard to quantify the second and third order effects of a project due to the complexity of the system.

4.2.3 Recommendations

In order to create an EBU the four accounts of the Principles and Standards must be utilized along with various stakeholder inputs and evaluated by a projects lifecycle and a risk analysis.

4.3 Functional Hierarchy

The main function which must be addressed and from which all sub-functions arise is Beneficial Use of Dredged material. The first main sub-function is Identify Composition of Material. This is broken down further into determining whether the material is sand, silt, bedrock, or clay. Next is Gain Legal Permission, which consists of adhering to state, regional, and national regulations in order to conduct dredging operations while abiding to laws and constraints. Prioritize Projects can be done by a ranking system based off of ERDC's (Engineering Research and Development Center) top eleven beneficial use projects.

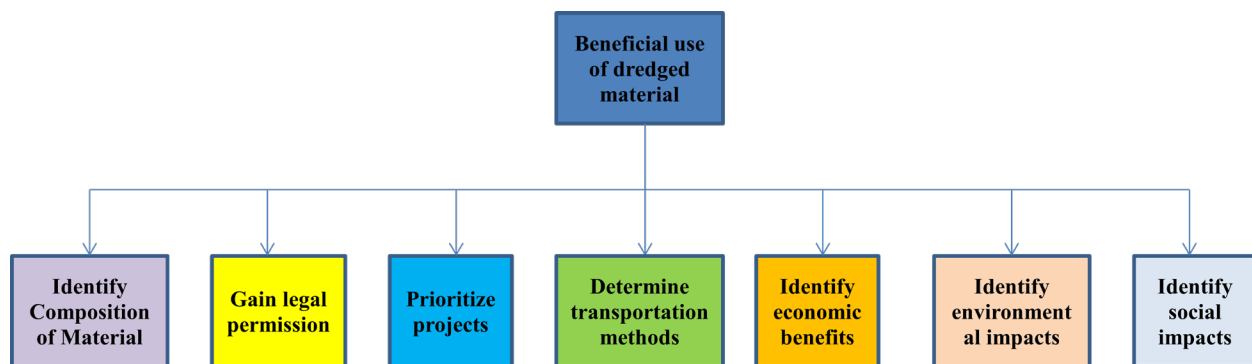


Figure 3: Functional Hierarchy with the fundamental objective and functions.

The next main sub-function is Determine How to Transport Material. This can be broken down into choosing land or water based transport and then calculating the variable cost of transporting the material based on which method was selected. Another sub-function is Identify categories of economic benefit. This is done by calculating the economic benefit, which will require quantifying in \$/unit for each category, then calculating the total dollar value of the selected project.

Identify Environmental Impacts is broken down into categorizing the environmental impacts, and then ranking the impacts within their respective categories based on stakeholder analysis. The final sub-function is Identify Risks. When identifying risks, one must quantify social wellbeing, determine detection, likelihood, and severity of each risk, then determine the mitigation method

for each risk. In order to quantify social wellbeing, this sub-function is further broken down into acquiring public responses from environmental groups or regions, determining the value measures for varying levels of public support, and finally rank ordering the social benefits based on the level of public support for each category.

4.4 Qualitative Value Model

The purpose of a qualitative value model is to identify the value measures which will be used to evaluate the different candidate solutions. The qualitative value model consists of four levels which include the fundamental objective, functions, objectives, and value measures. The fundamental objective is the most important part of this model as it will guide any further analysis. The fundamental value for our capstone is establishing an EBU in order to facilitate the decision maker with important decision making information.

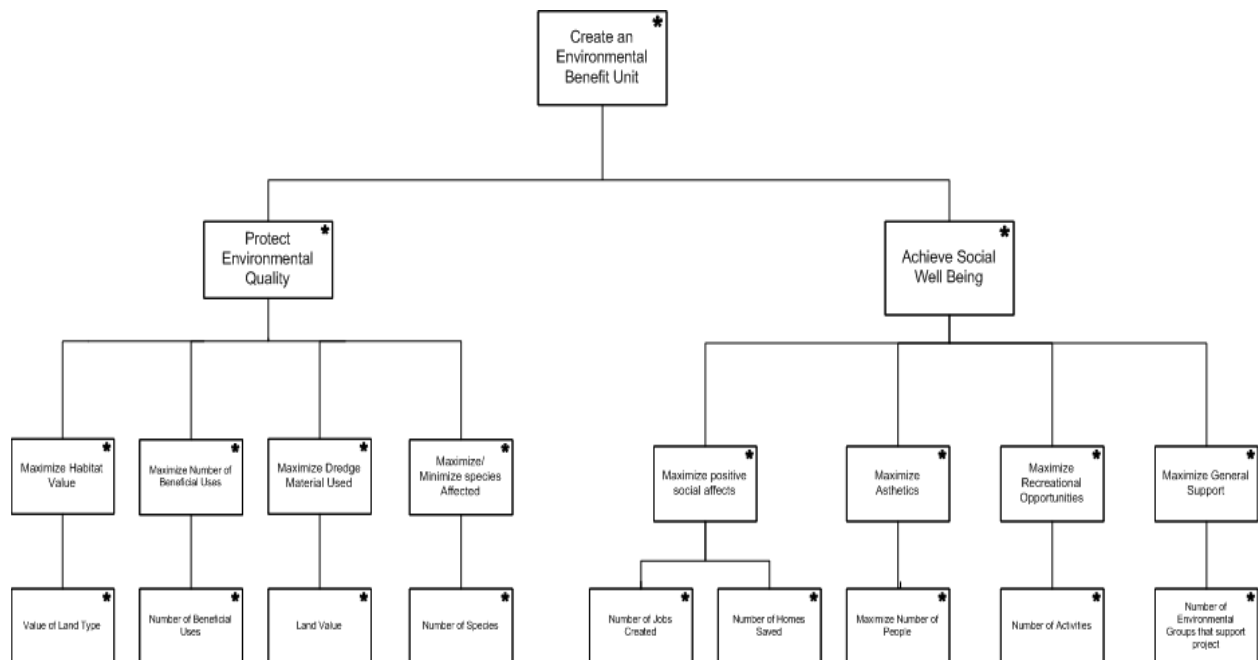


Figure 4: Qualitative value model

There are multiple sub functions of the EBU which are based off of the four accounts. The environmental quality and social well-being are the primary functions in our qualitative value model and these were drawn from the functional hierarchy. These are both relevant to the EBU because between these two functions the environment and the human interaction with the environment is taken into account. If we were to simply model the environmental function without the social well-being projects with sole environmental benefits would outweigh projects which have multiple benefits. The objectives for these two functions are difficult to identify because of the variety of projects which are available for dredged material placement. By

conducting stakeholder analysis we have identified several objectives which are important to all of the stakeholders involved. The first objective is to maximize the number of species that will benefit from a project while minimizing the number of species which will be harmed. In addition to identifying the species we wanted to also focus on maximizing the number of each species assisted while still minimizing the number of animals harmed. The definition of harm in our objective is limited to the impact on the environment and does not include the impact of the food chain. An additional objective places more emphasis on endangered species, protected species, and species that are vital to the ecosystem. Our final objective is to maximize land restoration. This objective will rely on different regions placing value on different types of terrain as every region has different priorities. For the basis of this project we will work with the New York land priorities.

The social well-being objective will be harder to quantify because it is difficult to measure the second and third order effects. Drawing from our stakeholders we have identified four objectives which have an impact on the overall society. The first objective is no minimizing any negative social effects created by the placement of dredged material. This will encompass several value measures in order to create a wide base to deal with the variety of projects which will be modeled. The second objective is to maximize the educational, cultural, and recreational opportunities created by the placement of dredged material. This is included in order to account for projects such as parks and wildlife preserves. Another objective function is the maximization of the aesthetics in the area. Our final objective is to maximize public support. This will be the most difficult objective to quantify and will most likely be done by using a surveying technique.

4.5 Redefined Problem Definition

At the completion of the first stage of the SDP is important to stop and allow the stakeholder an opportunity to evaluate and critique the new problem definition. As a group the problem definition is then molded into a definition which will solve the problem at hand. The problem definition for the EBU changed considerably from the beginning of the project into this definition. Our goal is to develop a quantifiable EBU by evaluating the social well-being and environmental quality related to beneficial uses of dredged material in order to evaluate the environmental value of a project.

Chapter 5

Value Measures

The next step of the process is creating the value measures which will be the standards by which each project is evaluated. After conducting stakeholder analysis a list of value measures were created and presented to USACE and ERDC and from there the value measures were changed and manipulated so that they would produce an EBU that would quantify aspects of a project that are important to USACE, ERDC, and the General public. The final value measures are explained below.

Habitat Value: This value measure is broken down into different types of habitats that wildlife will benefit from through dredged material. Through stakeholder analysis, the team will be able to determine which habitats provide greater value and need higher priority.

List of Beneficial Uses: This value measure is simply a list of different beneficial uses of dredged material. This list provides organization and classification for project managers to prioritize a given list of projects so those of higher priority will be given resources for completion.

Amount of Dredged Material Used: This value measure provides different ranges of dredged material used in cubic yards. This helps understand the optimal amount of dredged material in a numerical sense and may differ based on the location it will be used at. This value gives project implementers an identifiable value to be placed on different locations and how much dredged material needs to be allocated for specific situations.

Number of Species Assisted: It may seem that the more species that are assisted the higher the value, but in most cases, all species cannot be accounted for. The reason this value is necessary is because it places a numerical value on what number of species assisted will be acceptable for each project to ensure the project implementer will meet project objectives as well as satisfy third parties.

Number of Threatened and Endangered Species Assisted: This value is a bit different from the value above in that it *only* addresses those species that are threatened or endangered. This value is critical because these species are obviously at a greater danger of extinction and need higher priority. Having a pre-determined number of species to assist for each project will ensure that project implementers will meet project objectives.

Homes Protected: This value is meant to measure that amount of homes positively affected by the dredging project. This means that it can be protected from erosion, flooding, or any other environmental risk. This is valued by number of homes and not value of homes because a person's home is a basic life necessity and therefore should have equal value.

Aesthetics: This value is meant to measure the people who are, on average, affected everyday by a change made to the aesthetics of an environment. It should be an average based on 3 mile radius of the project.

Jobs Created: This value is a measure of how many jobs are created that are at least a year long. This can be both jobs created from the dredging operations, as well as the final project itself (i.e. a golf course creates jobs). This value is a good measure of a positive influence on the lives of people in the community and also the local economy.

Group Support: Through the survey we found that environmental and community groups do not feel they are included in the decision making efforts for dredging projects. After talking to USACE, we realized that if there is group support for a project there will most likely be funding as well, which is a huge benefit for projects. Therefore, it is important to maximize the number of groups and communities in support of a project.

Recreational Opportunities: This value measure represents the number of activities that each project will provide to individuals in the area based on a list of clearly defined activities/activity categories. This is important because it stresses the interaction with the individuals and the project results. This aspect of societal interaction is one of the points that we want to stress with social value.

Chapter 6

Solution Design

6.1 Idea Generation

During the Problem Definition Stage of the SDP the end result is a redefined problem statement. This enables a path forward to the Solution Design Phase and into actually developing a Model. The qualitative value model established objectives and value measures which will be essential in the model. The social and environmental objectives and the value measures associated with each will be used to developing a solution to the current problem.

During the brainstorming sessions and reviewing the stakeholder analysis a large problem arose. The creation of a national model for measuring the environmental benefit unit was the main focus, but without breaking the model down to a district level would result in a model that represented the problem on a national level, but would be useless when implemented in different areas of the country. This problem was countered with the creation of an alternative, district level model. Having a model for the national level and the district level would allow a comparison to be conducted, identifying the similarities and differences in the creation of an EBU. The New York District Corps of Engineers will be the primary district analyzed in this report.

Chapter 7 Decision Making

7.1 Value Scoring

The Value Scoring takes the stakeholders from ERDC and the New York District and these experts first prioritize the value measures to gain a basic understanding of the importance of each value measure. The importance for each is mostly based on their current methods for ranking projects. Once the list is created the stakeholders at ERDC and the New York District were asked to associate a level of importance (high, medium, or low) on every value measure. Once the stakeholders associated their importance with each value measure, the next step was determining the variability for each measure. The variability is ranked similarly to the stakeholders' importance. The variability is important as it prevents a value measure with limited options (go/no go) from heavily impacting the EBU. The result is an incomplete swing weight matrix seen below in table 2 which is a tool for assigning weights for the value measures.

Table 2: ERDC Swing Weight matrix prior to the values being inputted.

Swing Weight Matrix (National Model)				
Variability in Value Measure	Stakeholder's Importance			
		High	Medium	Low
	High	Homes Protected Dredge Material Used	Species Assisted	Aesthetics
	Medium	Jobs Created Number of Groups Supporting Project	Recreational Activities	
	Low	T&E Assisted Beneficial Uses	Habitat Value	

Pictured above is a tool created to assist the decision makers with assigning appropriate weights. The table is designed so the value measures in the upper left hand have the highest score and then decrease as the value measures become less important and decrease in variability. The result of both ERDC and the New York District are pictured below in table 3 and table 4.

Table 3: ERDC swing weight matrix with the associated values

Swing Weight Matrix (National Model)					
Variability in Value Measure	Stakeholder's Importance				
		High	Medium	Low	
	High	Homes Protected 100 Dredge Material Used 95	Species Assisted 85	Aesthetics 35	
	Medium	Jobs Created 70 Number of Groups Supporting Project 60	Recreational Acti 55		
	Low	T&E Assisted 58 Beneficial Uses 40	Habitat Value 38		

Table 4: New York District swing weight matrix with associated values

Swing Weight Matrix (NY District Model)					
Variability in Value Measure	Stakeholder's Importance				
		High	Medium	Low	
	High	Homes Protected 100 Dredge Material Used 95	Species Assisted 60	Aesthetics 50 Jobs Creat 40	
	Medium	Contaminant Reduction 70	Groups Supporting the Project 55 Recreational Activities 45		
	Low	Beneficial Uses 65 T&E Assisted 60 Habitat Value 65			

By analyzing the scoring associated with these values as seen in table 2, table 3, and figure 4 several important similarities and differences can be immediately recognized. The number of homes protected and the dredged material used received an equal score, but the other value measures were either slightly or vastly different.

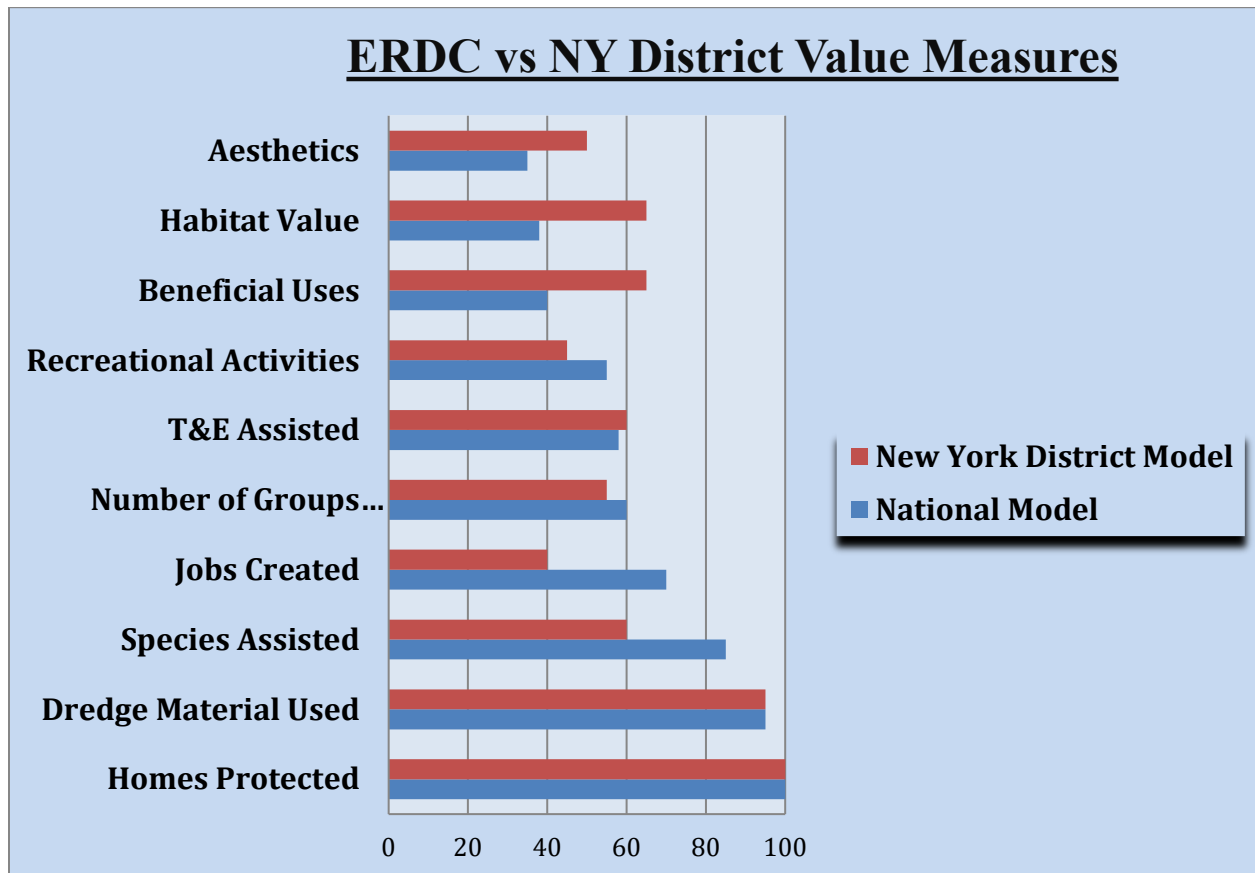


Figure 5: Comparison between the New York District Model

Once the Swing Weight table has been created the values are then summed and a weighted average is applied as seen in table 5. The weighted averages will then be used to weight the value measures in order to place a higher value on more important measures.

Table 5: ERDC and NY District Stakeholders provided their educated opinions on how important each value measure is resulting in weighted value measures.

	National Model		New York District Model	
Value Measures	SH Input	Weighted Value	SH Input	Weighted Value
Homes Protected	100.0	15.7%	100.0	15.7%
Dredge Material Used	95.0	14.9%	95.0	15.0%
Species Assisted	85.0	13.4%	60.0	9.4%
Jobs Created	70.0	11.0%	40.0	6.3%
Number of Groups Supporting Project	60.0	9.4%	55.0	8.7%
T&E Assisted	58.0	9.1%	60.0	9.4%
Recreational Activities	55.0	8.6%	45.0	7.1%
Beneficial Uses	40.0	6.3%	65.0	10.2%
Habitat Value	38.0	6.0%	65.0	10.2%
Aesthetics	35.0	5.5%	50.0	7.9%
	636.0	100.0%	635.0	100.0%

The weighted values are then applied to the resulting value of each value measure. The returned values for each measure will be summed and the result is an EBU

7.2 Model Analysis

While the actual EBU is important the critical analysis will be more important as this model is a mere intermediate step to achieving a true national model. The next step is to take a project which has already been completed and observe the similarities and differences between the New York and the ERDC model.

Table 6: The ERDC District EBU model of the Brownfield Bayonne Golf Course.

Project Name	Brownfield Bayonne Golf Club
Material	Clay

Value Measures	Raw Data	Raw Value	National Model
Habitat Value	No habitat	0.00	0.00
Beneficial Uses	Parks and Recreation	80.00	5.03
Amount of Dredge Material used	1,000,000	90.00	13.44
T&E Assisted	0	0.00	0.00
Maximize # of species assisted	1	40.00	5.35
Benefits of Construction (Homes Protected)	0	0.00	0.00
# of Jobs Created	75	60.00	6.60
Aesthetics (People effected)	1,000	100.00	5.50
# of Recreational Activities Created	1 thru 5	60.00	5.19
Number of Groups Supporting The Project	10	100.00	9.43
Total EBU			50.55

Table 7: The New York District EBU model of the Brownfield Bayonne Golf Course.

Value Measures	Raw Data NY District	Raw Value	District Model
Habitat Value	No Habitat	0.00	0.00
Beneficial uses	Strip Mine Reclamation and Solid Waste Mgmt.	80.00	8.19
Amount of Dredge Material used	1,000,000	100.00	14.96
T&E Assisted	0	0.00	0.00
Maximize # of species assisted	1	10.00	0.94
Benefits of Construction (Homes Protected)	0	0.00	0.00
# of Jobs Created	75	70.00	4.41
Aesthetics (People effected)	1,000	100.00	7.87
# of Recreational Activities Created	1 thru 5	60.00	4.25
Number of Groups Supporting The Project	10	100.00	8.66
Total EBU			49.29

There are several important key factors which can be identified in the Brownfield Bayonne Golf Course. The beneficial uses value measure is actually different between the two models. This is as a result of the golf course having multiple uses. For projects with multiple uses the raw data which returns the highest data will be used. The weighted values which are returned for the beneficial uses are also vastly different despite the raw value being the same. This is based on the different weights associated with the value measure. The species assisted is also largely different as pictured in the above tables. If a national model is even feasible the value measures

with such differences across the nation must either be removed entirely from the model or modified to become better suited for each district.

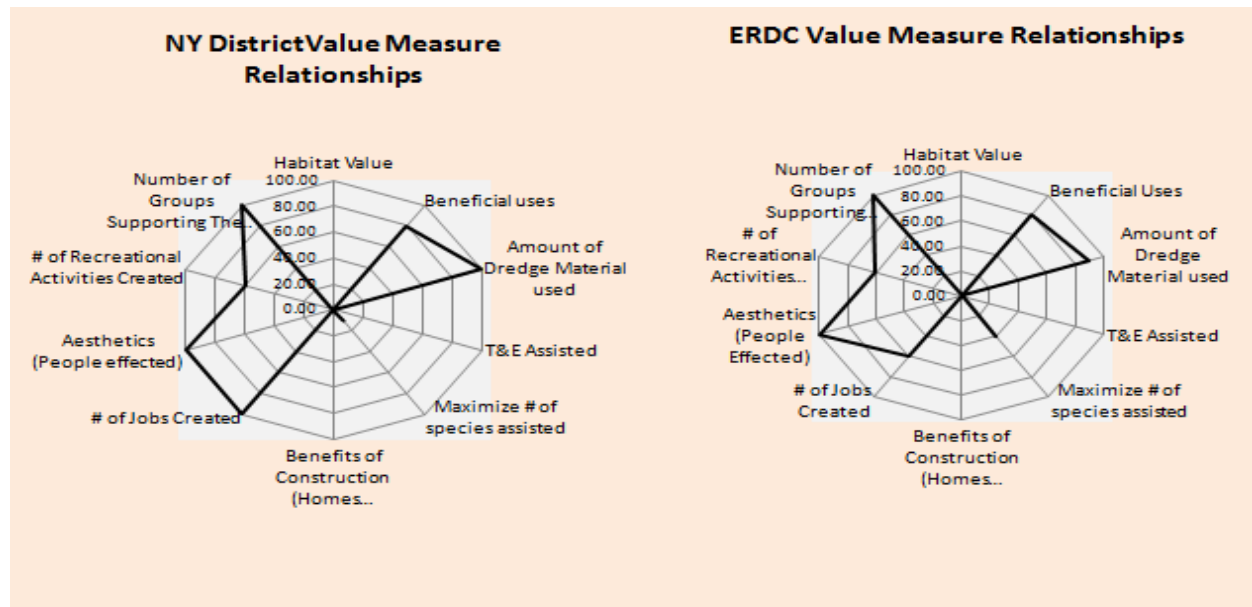


Figure 6: The Radar Charts are showing the relationships of the NY District Model and ERDC models in regards to the Brownfield Bayonne Golf Course.

Chapter 8 Bibliography

Works Cited

Baron, Lisa. Personal Interview. 27 Sept 2011.

Beach Nourishment and Protection. Washington, D.C.: National Academy, 1995. Print.

Brannon, James M. "Evaluation of Dredged Material Pollution Potential." Aug. 1978.

Bray, Nathan. Dredged Material as a Resource: An Information Update from the IADC- Number 1. 2009.

"Chapter Three: History of Water Resources Planning." In *Planning Manual*, by Yoe, Charles E; Orth, Kenneth D. IWR Report 96-R-21. pp. 31-52. US Army Corps of Engineers, Rightholder Public Domain, 1996.

Chiarenzelli, Jeff, et al. "Do Large-Scale Remedial and Dredging Events Have the Potential to Release Significant Amounts of Semi-volatile Compounds to the Atmosphere?" Environmental Health Perspectives 106 (1998): 47-49.

Childs, John L., Sebastian Degens, and David Ashton. "Regulatory Requirements For Beneficial Use of Dredged Material In An Upland Environment." Port of Portland (2002).

"CHL - Dredging." *Coastal and Hydraulics Laboratory Home Page*. Web. 11 Sept. 2011. <<http://chl.erdcl.usace.army.mil/dredging>>.

Clarke, Douglas. "A risk-informed decision framework for setting environmental windows for dredging projects" Science Direct. 15 September 2008. 21 August 2008. <<http://www.sciencedirect.com/science/article/pii/S0048969708004804>>

Clausner, James. "Current Dredging Research at ERDC." Engineer Research and Development Center (2009). <http://aapa.files.cms-plus.com/SeminarPresentations/05_ExecMgmt_LA_C_Clausner_James.pdf>

Cohen, Marsha. "Dredging: the Facts." International Navigation Association (2005).

Dabney, T. G. *The Improvement of the Lower Mississippi River*. Nashville: Press of Marshall & Bruce, 1912.

Delaware Estuary. "Restoration and Beneficial Use." Regional Sediment Management Plan (2010).

"Demonstration Project on Dredging and Marsh Development Using a Flexible Dustpan Dredge at Head of Passes/Southwest Pass Mississippi River." June 2004. Web. 11 Sept. 2011. <<http://el.erd.usace.army.mil/elpubs/pdf/trchl04-3.pdf>>.

Dredging Coastal Ports: An Assessment of the Issues. National Research Council. National Academy Press 1985.

Dredging Information System. 10 February 2011. CEIWR-NDC. 21 August 2011. < <http://www.ndc.iwr.usace.army.mil/dredge/dd10cos1.htm> >

Elias, Vince. "U.S. ARMY CORPS OF ENGINEERS ANNOUNCES SIGNING OF INTERAGENCY AGREEMENT TO RESTORE SALT MARSH IN JAMAICA BAY", QUEEN, N.Y. 21 Sep. 2009.

Environmental Advantages of Inland Barge Transportation." US Department of Transportation, Maritime Administration. 22 Oct 2011. < <http://www.irpt.net/irpt.nsf/LinksView/EnvironmentalAdvantages0c3a.html> >

EPA. "Final Environmental Impact Statement for the Designation of Dredged Material Disposal Sites in Central and Western Long Island Sound, Connecticut and New York." U.S. Environmental Protection Agency. Boston (2005).

Great Lakes Dredge & Dock - Home Page. Web. 10 Sept. 2011. <<http://www.glidd.com/>>.

Greene, Karen. "Beach Nourishment: A Review of the Biological and Physical Impacts" Atlantic States Marine Fisheries Commission. 19 Aug. 2003

Herr, Eric. "Delaware Dredging Battle" DFM News online. 25 February 2011. 21 August 2011. < http://www.delawarefirst.org/1_government_and_politics/delaware-river-dredging-battle-continues-state-delaware >

Improving Transportation. The US Corps of Engineers. 24 Oct 2011.

<<http://www.usace.army.mil/History/Documents/Brief/15-conclusion-biblio/conclusion.html>>

Johnson, Michael. "Hudson-Raritan Estuary Environmental Restoration Feasibility Study, Jamaica Bay."

Krause, Paul R. Ph.D. "The Beneficial Reuse of Dredged Material for Upland Disposal". 24 April, 2000.

Krenkel, Peter A. *Dredging and Its Environmental Effects: Proceedings of the Specialty Conference, Mobile, Alabama, January 26-28, 1976*. New York: American Society of Civil Engineers, 1976.

Lorentz, W.P., T.J. Estes, A.J. Bednar, G.R. Lotufo, S.E. Bailey. 2011. *Guidance for USACE dredging projects affected by oil spills*. ERDC/ EL TN-11-?. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

Meyer Nehls, R. Environmental Impacts to marine species and habitats of dredging for navigational purposes. Biodiversity Series. OSPAR Convention, 2004.

Mitigating Shore Erosion along Sheltered Coasts. Washington, D.C.: National Academies, 2007. Print. *Sediment Dredging at Superfund Megasites: Assessing the Effectiveness*. Washington, D.C.: National Academies, 2007.

Mullins, Gary W. and Neuhauser, Hans "Public Education for Protecting Coastal Barriers" May, 1991.

Murray, L.A. "Progress in England and Wales on the development of beneficial uses of dredged material." 2nd International Conference on Dredging and Dredged Material Placement. Part 1 (of 2), Lake Buena Vista, FL, USA, 11/13-16/94; pp. 644-653. 1994

National Dredging Team. "Dredged Material Management: Action Agenda for the Next Decade." 25 Jan. 2001.

National Research Council. "Sediment Dredging at Superfund Megasites: Assessing the Effectiveness." The National Academy of Sciences. Washington, DC (2007).

OSPAR. "Environmental Impacts to marine species and habitats of dredging for navigational

purposes.” Biodiversity Series. Oslo and Paris Commission (2004).

Patin, T.R. “Proceedings of a Round Table on Reclaiming and Managing Lakes in Illinois” 10 October 1980.

Rodrigue, Jean- Paul. “The Port Authority of New York and New Jersey: Global Changes, Regional Gains, and Local Challenges in Port Development. Les Cahiers Scientifiques du Transport Feb. 2004.

S.E. Boyd, H.L. Rees, C.A. Richardson, “Nematodes as Sensitive Indicators of Change at Dredged Material Disposal Sites, Estuarine, Coastal and Shelf Science”, Volume 51, Issue 6, December 2000.

"Selection of Dredging Methods as a Method of Minimizing Maintenance Dredging Impacts." *UK Marine SACs Info Net*. Web. 11 Sept. 2011. <http://www.ukmarinesac.org.uk/activities/ports/ph5_3_3.htm>.

Sheall, Ivan L. “Reducing Costs and Improving the Industry: Goals of the Dredging Research Program of the United States.” Journal of Coastal Research 7 (1991): 535-42.

Sparrevik, Magnus, et al. “Use of Life Cycle Assessments To Evaluate the Environmental Footprint of Contaminated Sediment Remediation.” Environmental Science & Technology (2011).

"The Four Rs of Environmental Dredging:." <http://el.erd.usace.army.mil/elpubs/pdf/trel084.pdf>. ERDC, Feb. 2008. Web. 10 Sept. 2011.

“Transportation.” Water Encyclopedia. 2011. Advameg. 2 Sept. 2011. <http://www.waterencyclopedia.com/St-Ts/Transportation.html>

Trautline, John Cresson. *The Civil Engineer Pocket-Book*. (New York: Wiley and Sons) 1906.

Tsinker, Gregory P. *Port Engineering: Planning, Construction, Maintenance, and Security*. Hoboken, NJ: Wiley, 2004.

United States Army Corps of Engineers HQ. The United States Army. 10 Sept. 2011. <http://www.usace.army.mil/about/pages/mission.aspx>

USACE1. “Beneficial Use of Dredged Material For Marsh Preservation In the Vicinity of Greens

-
- Lake Galveston County, Texas.” United States Corps of Engineers. Galveston, Texas (2007).
- USACE2. “Beneficial Uses of Dredged Material.” United States Corps of Engineers. Washington, DC (1987).
- USACE3. “FY 2010 Analysis of Dredging Costs.” United States Corps of Engineers (2010).
- USACE4. “Identifying, Planning, and Financing Beneficial Use Projects Using Dredged Material.” Beneficial Use Planning Manual (2007): 1-80.
- USACE5. "USACE Education: Navigation - What Is Dredging." *USACE Education Center*. Web. 10 Sept. 2011. <<http://education.usace.army.mil/navigation/dredging.html>>.
- USACE6. “US Waterborne Activities in 2009” Chart. Fact Card 2010. 7 Sept. 2011. <<http://www.ndc.iwr.usace.army.mil/factcard/temp/factcard10.pdf>>
- “USA River Map.” Maps of the World. Map XL 20011. 2008. 6 Sept 2011 <<http://www.mapsofworld.com/usa/usa-river-map.html>>
- US Army Research and Development Center. August 2009. US Army Corps of Engineers. 21 August 2011. <http://www.erd.usace.army.mil/pls/erdcpub/docs/erdc/docs/Fact_Sheet-ERDC.pdf>
- Wayne R. Munns Jr., Walter J. Berry, Theodore H. Dewitt, “Toxicity Testing, Risk Assessment, and Options for Dredged Material Management, Marine Pollution Bulletin.” Volume 44, Issue 4, Apr. 2002.
- Weinstein Michael P, Lee L Weishar. “Beneficial Use of Dredged Material to Enhance the Restoration Trajectories of Formerly Diked Lands.” 10 Apr. 2002
- Weishar, Lee L, Beneficial use of dredged material to enhance the restoration trajectories of formerly diked lands, *Ecological Engineering*, Volume 19, Issue 3, Sep. 2002
- What is Dredging?. 23 April 2002. US Army Corps of Engineers. 21 August 2011.<<http://education.usace.army.mil/navigation/dredging.html>>
- Why is Dredging Necessary for Navigation and Trade? Nov 2007. Port Technology. 23 Oct 2011. <http://www.porttechnology.org/images/uploads/technical_papers/PT39-03.pdf>
-

Wilson, Joe. "Overview of Corps National Dredging Program and Regulations." United States Corps of Engineers (2005).

Woodhouse W. W., Seneca, Broome. *Marsh Building with Dredged Spoil in North Carolina*. North Carolina State University, Agriculture Experiment Station, 1972. Print

Yozzo David J., Pace Wilber, Robert J. Will, Beneficial use of dredged material for habitat creation, enhancement, and restoration in New York–New Jersey Harbor, *Journal of Environmental Management*, Volume 73, Issue 1, Oct. 2004

Appendix A

Stakeholder Analysis

	Findings
COL Boule	Environmental Projects must take into account Principles & Standards, which consist of the 4 accounts (National Economic Development, National Environmental Restoration, Regional Economic Development, Social Impact)
	Presently, the govt. selects projects based on cost/benefit analysis and resources come from federal and state governments as well as funding from private companies
	Every environmental project has a local, regional, and national stakeholder
	We need to look for ways to incentivize companies to make it cheaper to decontaminate
	Value Scoring Option: identify characteristics with the dredged material and find what is possible <i>with</i> that material type
	The increased contamination of dredged materials has made it more costly to make use of its benefits
	The public perception is not favorable of dredged material b/c of past contamination and misunderstanding; problems: moving a problem from 1 place to another; citizens don't want contaminated waste in their backyards
	Depending on where you are in the country, your environmental priorities will differ
	Creating environmental-friendly uses of dredged material involves more stakeholders that are willing to dedicate time and resources
	Vision 2020 is a NYC Comprehensive Waterfront Plan (sustainability plan)
	USACE's goal is no tradeoffs; win-win (knock out both economic and environmental aspects of problem all at once instead of dealing with an even bigger problem in the future)
John Childs	Cost of transportation severely limits beneficial uses of dredged material; dredging isn't at the top of nation's priorities
	The Environmental Benefit Unit (EBU) is difficult to define
	Currently the primary goal of dredging is navigation; 3 different alternatives for managing dredged material are water disposal, upland disposal, and beneficial use
	Cubic yards is currently the most common method of measurement for units of dredged material
Lisa Baron	Federal standard says it will manage the byproduct in the cheapest way that meets the permit requirements
	USACE has 11 target areas and the material goes to wherever is available - eventually rank the targets

	Stakeholder values - esthetics, water benefits, additional taxes, jobs, economic revenue, habitat benefit, protecting real estate, water quality, fishery, eco tourism/recreations
	Potential inputs for EBU are: environmental priority, number of people it will benefit and how beneficial it is, revenues/ taxes generated, cosmetic effect of area, and environmental benefits (cleaner water, wildlife impact)
	Federal standard of \$19 per cubic yard of dredged material
	Several different costs associated w/ dredging: dredging, transportation, treatment, G&A, overhead
	Currently the New York District has 11 key targets that they created using stakeholder analysis, they use dredged material mainly on these projects because they have been predetermined as most important
	Dredging will be stopped if they cannot find an affordable way to place dredged material- this will greatly hurt the economy
	There is currently a Cost Benefit Ratio of 2.5
	They currently use two separate contractors for placement then building
	Often times the dredged material goes to where is available and not necessarily the most beneficial spot because there is not dredged material storage
	Things to consider when creating an EBU: Esthetics, Characterize water benefits, additional tax benefits, jobs, economic revenue, habitat benefits, protecting real estate, improve fishery, human health, ecotourism, and recreation
	Often times there is resistance from communities because they believe it is just a diluted material
	Need to create a comparative restoration ration.
	Very hard to set up contractors for working with dredged material storage or use because there is not guarantee that dredged material will be constant
Survey Concerns with dredged material being used in communities	Toxins and odors which are emitted throughout the process
	The storage requirements for the dredged material prior to use.
	Concern that the material is used for its best use and highest fashion
	The creation of a false science for justifying the EBU
	Are there any contaminants in the water
	What is the environmental impact of using the dredged material
	Would the use of dredged material economically benefit my community
	Is there any harm done to the environment
	Will the materials be safe and effective in the long run
	Environmental Safety Cost Lifespan of process
	What is the environmental quality of the material
Survey	Will there be additional costs to tax payers
	The more stakeholders the better it will be. Current studies to not include enough

What is your opinion of an EBU	groups.
	The majority of interviews believe it is a good idea
	Hesitate to attempt to quantify the EBU because it will be difficult to do so accurately
Survey How would you place value on an EBU	Long term effectiveness
	The amount of recreation areas created
	Evaluate this based on the amount of animals affected, the type of animal affected, and the severity of this to the ecosystem
	Analyze everything from the jobs created, to the green space created, and the amount of material directed away from landfills

Appendix B

Survey

1. Dredging is the excavation of bottom sediments from shallow seas and rivers to keep waterways deep enough to be navigable by ships. This is essential for our economy because large amounts of goods are transported through waterways across the nation and overseas every day. Unfortunately it is often difficult to find a use for the large amounts of sand, bedrock, clay, and other dredged material taken from the bottoms of waterways. Our team is currently doing a project to measure the environmental benefits of the most popular uses of dredged materials. As a stakeholder your input is very important to our research. Please read the following question and answer accordingly. What are your top three concerns about utilizing dredged material for beneficial uses in your community?

2. Dredging is a necessary task in order to maintain navigation on the waterways. As a result of dredging operations there is a large amount of dredge waste produced which must be discarded. How would you feel about using this dredge waste in your hometown to create parks, levees, and many other beneficial projects as long as the dredging material is uncontaminated?

- ☒ Strongly Agree
- ☐ Agree
- ☐ Neutral
- ☐ Disagree
- ☐ Strongly Disagree

3. Dredging has historically caused a variety of environmental problems. One major problem is suspension of sediment in the water, which can suffocate fish. Do you feel the benefits in the form of better navigational waters and flood control are worth the environmental impact of dredging operations?

- ☐ Strongly Agree
- ☐ Agree
- ☒ Neutral
- ☐ Disagree
- ☐ Strongly Disagree

4. The US Army Corps of Engineers lists seven categories for beneficial uses of dredging. Please rank the categories above from 1 to 7 with 1 being the most significant to your concerns and 7 being the least.

Habitat restoration and development;	
Beach nourishment;	
Parks and recreation;	
Agriculture, forestry, horticulture, and aquaculture;	
Strip-mine reclamation and solid material management;	
Construction/industrial development;	
Multiple-purpose activities.	

5. How high of a priority do you think economic efficiency and saving money is as far as dredging operations and material placement/disposal are concerned

- ☐ Very Important
- ☐ Important
- ☐ Neutral
- ☐ Unimportant
- ☐ Very Unimportant

6. In terms of dredging operations and material disposal how much do you value the importance of reducing environmental impacts?

- ☐ Very Important
- ☐ Important
- ☐ Neutral
- ☐ Unimportant
- ☐ Very Unimportant

7. As part of our project we are trying to create an EBU (Environmental Benefit Unit) in order to objectively measure which uses of dredged materials are best for the environment. By creating an EBU we can quantify the environmental value during the Cost Benefit Analysis process. This will allow USACE to evaluate projects based on environmental impacts and not solely on cost. How do you feel about the idea of an Environmental Benefit Unit?

8. How would you put value in an EBU (Environmental Benefit Unit)? Or in other words, how would you measure the environmental impacts of using dredged material?

9. For the purpose of understanding geographical correlations, please provide your home address?



Department of Systems Engineering

United States Military Academy
West Point, New York 10996