IMBEDDING SUSTAINABILITY INTO DREDGED MATERIAL MANAGEMENT

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ABSTRACT

In 1994, the U.S. Green Building Council (USGBC) introduced a 69-point LEED (Leadership in Energy and Environmental Design) ranking system to quantify levels of project adherence to sustainability. The basic system is designed to balance the environmental, social and economic needs (the Triple Bottom Line) of the built environment for present and future generations. The author has modified and extended this system to port development and operation. This paper will show how the LEED system can be applied to dredging and dredged material management. In particular, a LEED-type ranking system applicable to the seven components of any DMMP: in-situ management, dredging, processing, transport, off-site placement, minimization, and beneficial use is discussed.

A "STAR Diagram" approach was used to help select the more sustainable options as they apply to the seven DMMP components. The STAR Diagram approach identifies relevant impact topics and scores the alternatives from zero (poor) to nine (excellent), depending on their level of adherence to sustainability. Key dredging impact and sustainability topics include the following areas:

1. Dredging (4 Rs): R_1 = Resuspension of material during dredging
R_2 = Release of contaminants during dredging
R_3 = Residual contaminants remaining after dredging
R_4 = Risk assessment
2. Sustainability (4Es): E_1 = Environmental impact (P_1 = Planet)
E_2 = Economics or cost/benefits (P_2 = Prosperity)
E_3 = Equity or social progress (P_3 = People)
E_4 = Equality (G = Generational Continuity)

In applying the 4 Rs and 4 Es, an ARMA (**A**void impacts, **R**educe impacts, **M**itigate impacts, and **A**daptive management system is used. A recent New York Harbor dredging project (North Cove) is used to illustrate how these sustainable dredging components can be applied to dredged material management. Key North Cove dredging features include minimization of dredging days (using 15 CY bucket and two 1,200 CY barges per day, total dredging of 25,000 CY, or 19,114 cm) to reduce energy consumption and bottom/water column disruptions, costs, while achieving social progress. The use of this holistic approach promotes early stakeholder involvement and builds consensus and innovative thinking.

Keywords: Environmental impact minimization; NY Harbor; Dredging; Sustainability; Green/LEED application; STAR Diagram

INTRODUCTION

This paper illustrates how a sustainable framework based on the U.S. Building Council LEED (Leadership in Energy and Environmental Design) developed to rate buildings and renovations can be applied to dredging and dredged material management. LEED includes six categories: site, water, energy, material, environmental quality, and innovation. Using a recent new York Harbor dredging project (the North Cove in the Lower Hudson River), the paper uses examples of optimizing dredged production and upland placement to minimize environmental impact and reduce costs while contributing to social progress; the three components of sustainability

A brief overview of the LEED framework is initially described, followed by a listing of major dredging issues. In describing the five dredging activities, the paper deals with the application of the Triple Bottom Line – TBL

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(environmental impact and enhancement, economic considerations, and social progress) to dredging applications based on the North Cove and other NY Harbor dredging projects. A STAR Diagram is used to assess levels of adherence to sustainability among options.

THE TRIPLE BOTTOM LINE

Although the concept of sustainability was formalized in the late 1980s and early 1990s, several sustainable principles and attributes were introduced more than 25 years ago. A recent review of the U.S. National Policy Act (NEPA) of 1969 revealed that one of the primary elements of NEPA was "to use all practicable means… (to) fulfill the responsibility of each generation as trustee of the environment for succeeding generations." Several years ago, the Eco Twins (Economy and Ecology) was introduced and discussed their coexistence (Abood, 2001). The World Business Council for Sustainable Development added social progress to the Eco Twins and the Eco Twins became triplets. This is often referred to as "the triple bottom line or TBL" forming the three pillars of sustainability: Environmental Enhancement, Economic Growth, and Social Progress. It should be noted that these pillars are the primary components of any sustainable development and emphasize resource and energy conservation, safeguarding the health of occupants and users, and protecting and enhancing the natural environment while ensuring multi-generational continuity (Abood, 2008).

In June 1992, the UN Conference on Environmental Development defined the concept of "sustainability" as: "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs." In 1993, the U.S. Green Building Council, a national non-profit organization, was established, and in 1994 it developed the LEED rating system. LEED assigns up to 69 points earned for favorable site and building design measures (USGBC, 2006). LEED covers six categories, and a project is either "certified" if it receives up to 26 points, or assigned one of the following ranks: Silver (at least 33 points); Gold (up to 39 points); Platinum (at least 45 points).

A brief description of the main features covered by these LEED categories, with dredging activities in mind, and corresponding points, is given below:

1. ***Sustainable Sites*** (14 points): The emphasis here is to optimize site utilization, reduce project footprints, restoration of urban/brownfields sites for dredged material placement, in-place sediment management, and reduce environmental impact.
2. ***Water Efficiency*** (5 points): The emphasis here is to encourage water conservation, use of gray water, and innovative water management technologies.
3. ***Energy & Atmosphere*** (17 points): The emphasis here is to achieve a minimum energy need and optimize dredging performance and encourage the use of dredge-generated diesel fuel alternatives.
4. ***Materials & Resources*** (13 points): The emphasis here is to minimize the need for virgin material (capping), use of engineered material (e.g., processed dredged material), sediment management, and beneficial use of sediments.
5. ***Environmental Quality*** (15 points): The emphasis here is to encourage optimal air quality, continuous air quality monitoring, spill prevention, aquatic habitat enhancement, waste reduction, threatened species protection, dredging minimization, and material transportation.
6. ***Innovation*** (5 points): The emphasis here is to promote process and design innovation, use holistic integrated processes and procedures, allow for continual improvement and flexibility and promote early collaboration, consensus and inclusion.

In order to apply these principles to dredging activities, it is convenient to group them into the following four sustainability building blocks:

- ***Sustainable Planning***: Pre-dredging studies to ensure that we preserve for future generations our current range of choices by lessening our environmental footprint and optimizing our rate of return while improving our quality of life.
- ***Sustainable Construction***: The USGBC LEED list is appropriate here if a dredging project involves building and renovation.

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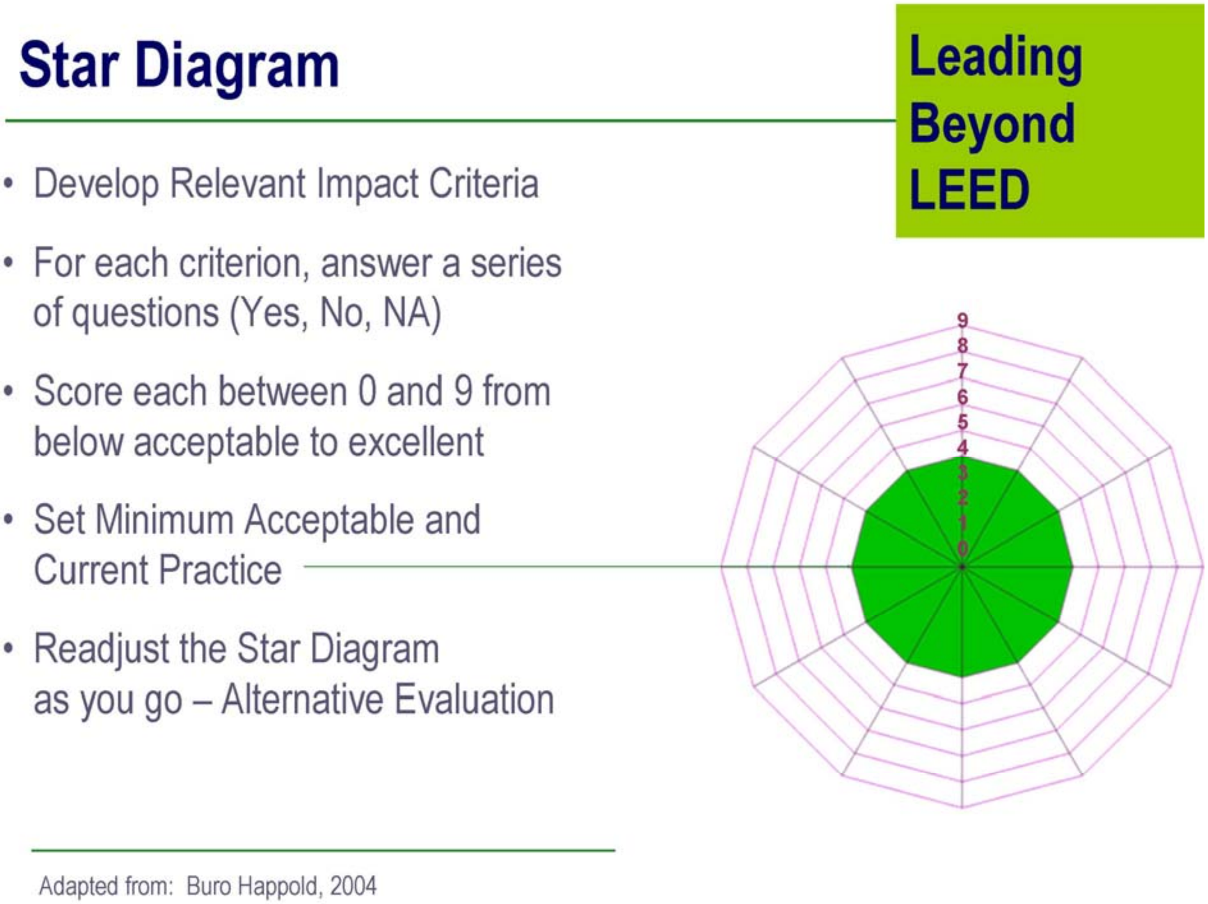
- ***Sustainable Operations***: These are covered generically by LEED and focus on resource conservation and environmental impact minimization via Green Standard Operating Procedures (SOPs), innovative material processing and transport.
- ***Sustainable Social Structures***: The focus here is on improving our quality of life and maximizing a project's benefit/cost ratio (BCR) or rate of return, e.g., using appropriate dredging minimization and beneficial use of dredged material. Sustainability-induced life-cycle savings (lower energy utilization, water and infrastructure conservation, emission reductions, O&M costs reduction and savings from more increased productivity yielding a BCR of over 10:1 over 20 years and offset the initial sustainability premium of 2% (Abood, 2006).

STAR DIAGRAM

Sustainability requires a "whole system" approach. A "STAR Diagram" may be used to show how sustainability principles and attributes can be used in a semi-quantitative way to select a more sustainable option.

The approach employed including identifying a set of selected relevant impact issues and scoring the alternatives from 0 to 9 depending upon their level of adherence to sustainability. The rating system ranges from 0 to 3 for significantly below minimum acceptable practice to 9 for excellent sustainability compliance. Intermediate levels include: Current Practice (5), Very Good Practice (7), and Best Practice (8). These levels can be related to the LEED rating system used for buildings by assigning Silver to Very Good Practice, Gold to Best Practice, and Platinum to Excellent Practice. Figure 1 illustrates this approach:



Star Diagram

Leading Beyond LEED

- Develop Relevant Impact Criteria
- For each criterion, answer a series of questions (Yes, No, NA)
- Score each between 0 and 9 from below acceptable to excellent
- Set Minimum Acceptable and Current Practice
- Readjust the Star Diagram as you go – Alternative Evaluation

Adapted from: Buro Happold, 2004

Figure 1. STAR diagram approach.

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Figure 2 presents a STAR Diagram example used to compare two cooling water alternatives. Key impact issues can be used in this comparison, including Aquatic Impacts, Air Quality, Cultural, Land Use, Energy, Noise and Vibration, Construction Impact, Impact on Infrastructure and Cost. This system produces "STAR Diagrams" providing a bird's eye view depicting impact levels by alternative (see Figure 1) depicting an intake sustainability performance comparing two water withdrawal options (open cycle and closed cycle).

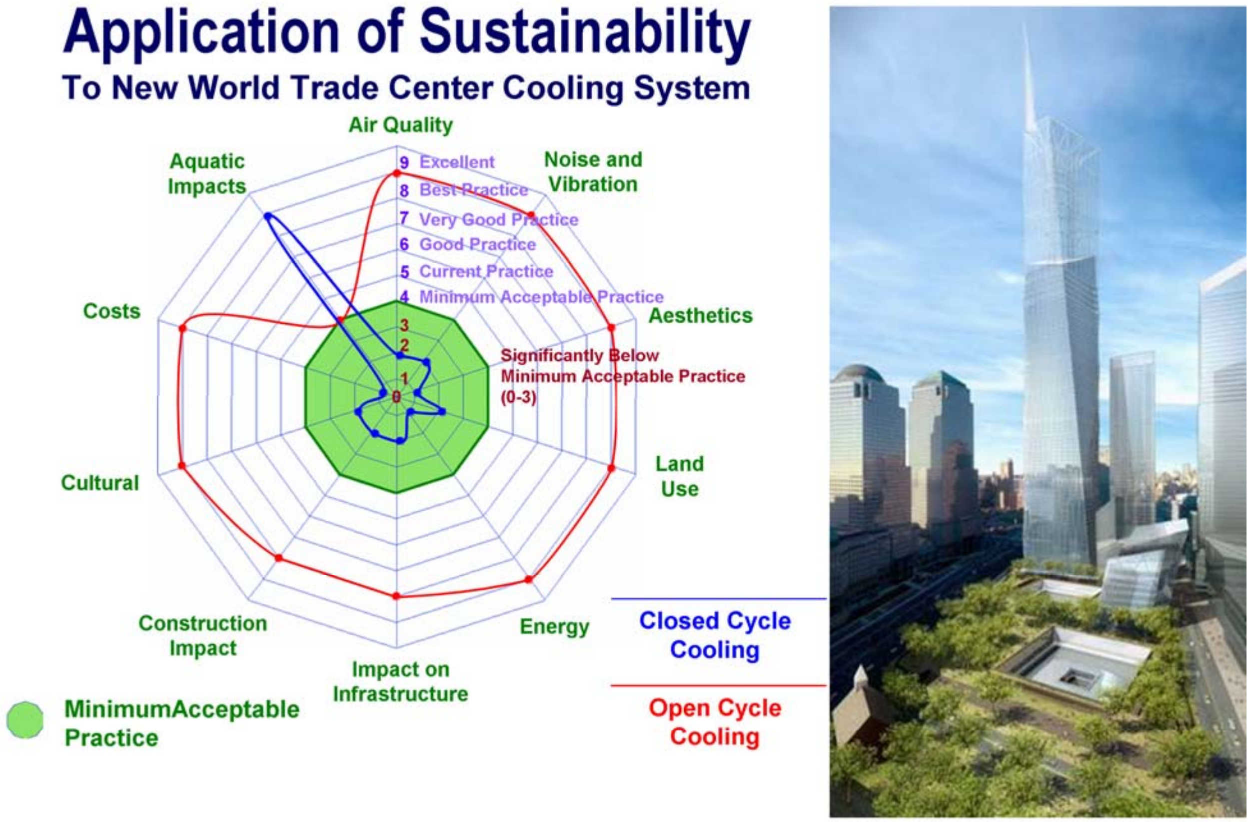


Figure 2. STAR diagram application.

For the two alternatives illustrated in Figure 2, wind rose-type "STAR Diagrams" connecting impact scores were developed. In ranking impact, points were assigned to reflect the extent of environmental impact, conservation and cost. For example, because closed-cycle cooling requires use of drinking water for cooling tower makeup water, it violates a sustainability principle (water conservation). Similarly, cooling towers produce blowdown discharged to city sewers, require more electricity, resulted in substantially higher costs and produced vapor plumes, and therefore, received fewer points in these areas. On the other hand, open-cycle cooling requires withdrawal of Hudson River water for cooling, resulting in more fish impacts due to entrainment and impingement of aquatic organisms.

The diagram area depicting the open-cycle alternative rating shown in Figure 2 is substantially greater than its closed-cycle counterpart, signifying that the open-cycle cooling system is the preferred alternative due to its better adherence to sustainable design principles.

DEREDGING & SUSTAINABILITY

Figure 3 provides an overall DMMP framework (Abood et al., 2008). For illustration, only three DMMP topics and their sustainability aspects are discussed below.

Figure 3. Dredged material management framework.

Because dredging involves water column deepening and bottom habitat modifications, it can also be used to enhance habitat value, a key sustainability component. Manageable factors influencing habitat value are also impacted by dredging, including those listed below.

- Water depth
- Bottom topography
- Substrates/sediment type
- Sedimentation rates
- Water quality
- Current velocity
- Light regime
- Wave energy regime
- Surface area and texture for in-water structures

The following list presents eight dredging-related features that apply to two LEED categories.
Potential LEED Points – Examples:

- Beneficial use of sediments
- Minimization of habitat loss
- Minimization of environmental impact
- Enhancement of aquatic life
- Innovative dredging, processing and transportation
- Placement impact minimization (SOPs)
- Dredge-generated air emissions
- Dredge-generated diesel fuel alternatives

These elements provide additional opportunities to achieve sustainability standards for dredging activities. Based on this assessment, dredging operations could incorporate the following overall standards to achieve sustainability:

a. Identify, avoid and minimize anticipated adverse impacts on aquatic resources
b. Incorporate into the design impact minimization (built-in) features
c. Assess the magnitude, importance and persistence of anticipated adverse effects, including whether it is short-term and naturally reversible, or long-term and/ or irreversible.
d. Develop on-site and/or off-site mitigation measures to compensate for unavoidable long-term and/ or irreversible adverse environmental impacts.
e. Incorporate BMPs to minimize construction, operation and maintenance effects.
f. Include pre- and post-construction monitoring program to confirm the accuracy of anticipated impacts and to guide the implementation of mitigation plans.

The following list generalizes these elements and illustrates how ARMA (impact Avoidance, Reduction of impact, Mitigation of unavoidable impacts and Adaptive management) can be applied to dredging:

- Avoidance of anticipated impacts
- Reduction of impacts via alternative analysis
    - Incorporate built-in minimization factors
    - Assess impact/magnitude and persistence (long and short-term)
    - Incorporate BMPs to minimize construction and O&M impacts
- Mitigation of unavoidable impacts
    - On-site
    - Off-site
- Adaptive management
    - Pre- and post-construction monitoring
    - Guide mitigation implementation
    - Verify and correct mitigation

Dredging Minimization

A number of schemes are available to minimize the volume of materials to be dredged from shoreline port facilities, thus reducing disposal volume and dredging-related impacts (Abood et al., 1999). These schemes represent a key sustainable dredging component and include:

- ***Short-term options***, e.g., reprofiling operations in which sediments from high deposition spots in berths are dragged to depressions in lower spots
- ***Long-term migration options***, e.g., subsurface berms or air bubblers deployed around berths and interpier areas.

A list of minimization methods described in Abood et al., 1999 is given below:

Passive Systems		*Active Systems*
Sedimentation basins	Impervious barriers	Air bubblers
Submerged silts	Basin entrance & alignment	Water jets
Structures (wings/dikes)	Facility design	
Previous barriers	Modifications/flow training	

Ultimately, these schemes divert the sediments from interpier and berthing areas to the faster moving and deeper channels. Most of these are site-specific and require detailed knowledge of circulation and sedimentation patterns. Such minimization concepts can be imbedded into most dredging projects.

Beneficial Use of Dredged Material

Figure 3 lists six categories of beneficial use applications. Some of these have been applied, while others are being studied. Details of these applications are given elsewhere (COE, 2007). Beneficial use examples resulting from aquatic placement is given below:

- Maximizing favorable habitat conditions
- Improving circulation/water quality
- Restoring borrow pits
- Providing substrate diversity
- Reducing sediment sources
- Minimizing sedimentation
- Reducing contaminant dispersal
- Creating mudflats
- Enhancing SAV beds
- Controlling invasive species
- Minimize future dredging

While most of these “sustainable” aspects are being advanced, there are several barriers to the wide beneficial use applications. However, there is a wide range of potential solutions to address these barriers (Abood, 2001). However, incorporation of as many of these applications adds sustainability to dredging projects.

SUSTAINABILITY RANKING

The above-described dredging categories dealt with only three of the seven components of dredged material management shown in Figure 3. Figure 4 illustrates how the dredging impacts 4 R’s can be coupled with sustainability’s 4 E’s or 3 P’s and G. Figure 5 shows how the same approach can be applied to the other four DMMP components. Figure 5 presents examples ranging from the least to the most sustainability features as they apply to DMMP. STAR Diagrams may be used to select the most sustainable option.

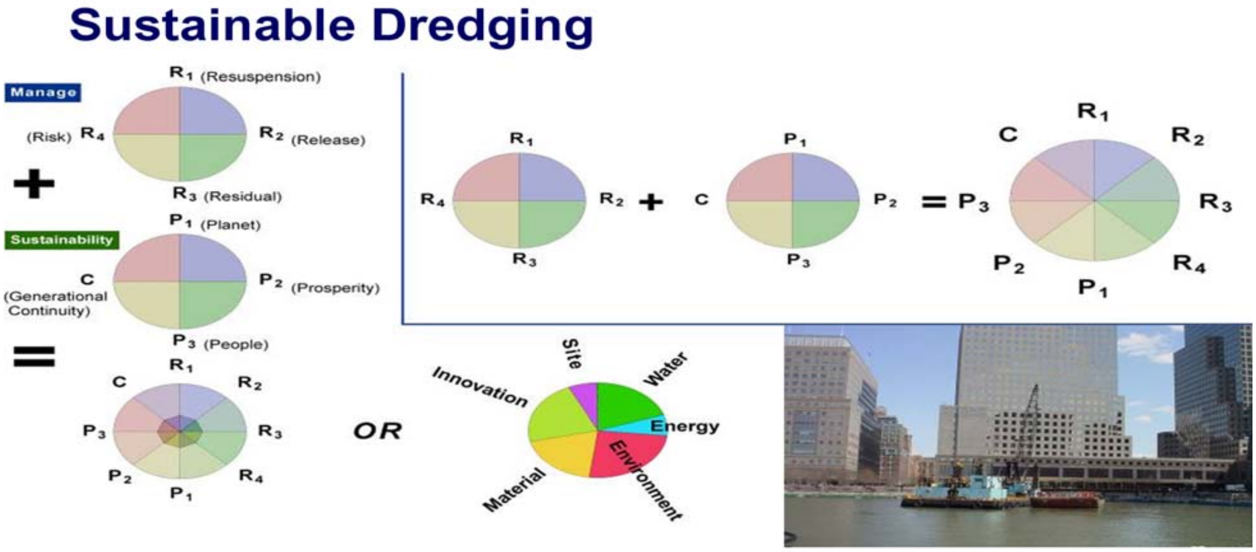
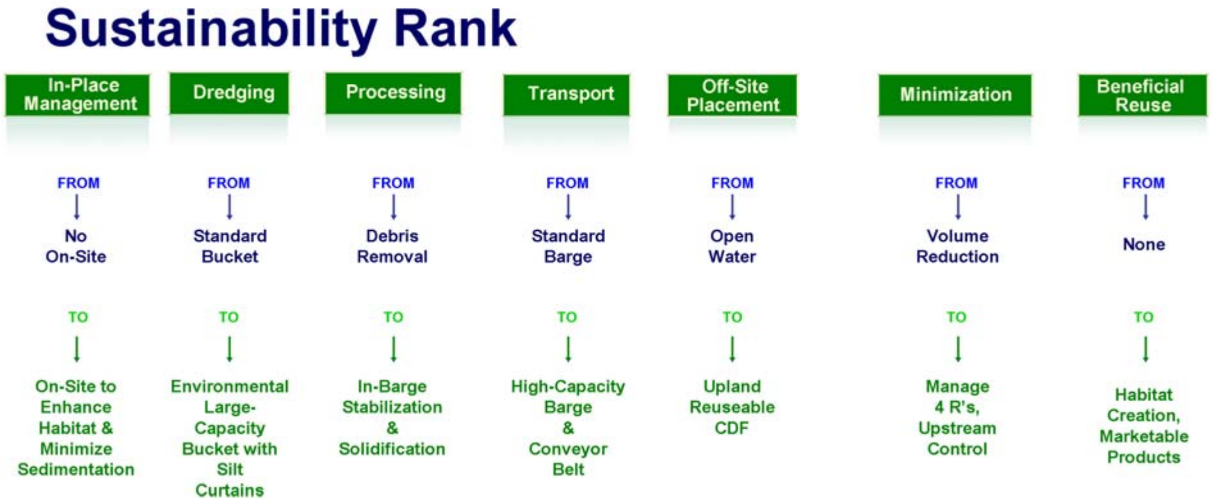


Figure 4. Coupling dredging with sustainability.



	In-Place Management	Dredging	Processing	Transport	Off-Site Placement	Minimization	Beneficial Reuse
FROM	No On-Site	Standard Bucket	Debris Removal	Standard Barge	Open Water	Volume Reduction	None
TO	On-Site to Enhance Habitat & Minimize Sedimentation	Environmental Large-Capacity Bucket with Silt Curtains	In-Barge Stabilization & Solidification	High-Capacity Barge & Conveyor Belt	Upland Reuseable CDF	Manage 4 R's, Upstream Control	Habitat Creation, Marketable Products

Figure 5. Applying sustainability to dredging.

CASE STUDY – NORTH COVE

In order to prepare the North Cove Marina, along the southern tip of Manhattan Island, NY, for the Volvo International Yacht Race in 2006, the Battery Park City Authority contracted to dredge some 25,000 cubic yards (19,114 CM) from the basin in an environmentally sensitive manner. The entire project, from permit application through preparation of certificate of completion, took less than six months.

Key permit requirements included:

- Volume = 24,200 CY (3.1 acres x 16-ft + 2-ft), or 18,502 CM
- No dredging from November 15 to April 15
- Use closed (environmental) bucket
- Hoist speed <2 fps, or <61 CM/sec
- Use silt curtains (removal for navigation limited to slack +/- 1 hr)
- No barge overflow, no decanting within cove before 48 hrs
- Notify COE 15 days prior to dredging

In addition, the project included several additional “Green Features” such as:

- Using a large bucket (15 CY, or 11.5 CM) to maximize bucket “bites” and therefore minimize the number of dredging days and bottom habitat disruption and plume
- Using two large barges (900 CY, or 688 CM) twice per day to minimize transportation impacts while reducing costs
- Completing the project in a record time to ensure that New York City can compete against other marinas by having the basin read before May 6, 2006. This added a “social progress” component to the project
- Using the dredged material as a landfill cover (Freshkills) to gain a beneficial use advantage)
- Adhering to plume containment provisions and protecting nearby intakes using silt curtains
- Dredging to 18-ft, or 5.5 meters, to minimize future dredging events

These six features are not usually required by dredging permit SOPs, but represent sustainability features to provide an added Green Value to most dredging projects.

CONCLUSIONS

Dredging is considered sustainable if it incorporates, in a holistic manner, continued environmental, social and economic growth. A number of features dealing with dredging have been presented in this paper and are related to a LEED-type system. The six LEED rating system categories were used as a frame-of-reference. A more quantitative sustainability rating system specifically designed to deal with dredging has been proposed.

A semi-quantitative approach (“STAR Diagram”) has been used to measure sustainability adherence extent so that a preferred design alternative can be selected. In many cases, this snapshot overview can be made interactive and stakeholders can be involved in assigning sustainability ranks to different alternatives. Although more sustainability SOPs are needed to refine the approach presented in this paper, embedding sustainability features into most dredging projects can only promote stakeholder collaboration, consensus and innovative.

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