

New Applications and Practices for
Beneficial Uses of Dredged Material

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Abstract

Beneficial uses of dredged material have been practiced for many years. In recent years, a concerted effort to apply beneficial uses to natural resources and environmental projects has been made. To accomplish highly precise elevations, find best uses for very fine-textured material, provide multi-purpose habitats to encourage species abundance and diversity, and other technical requirements, a number of environmental and engineering field techniques have been identified, developed, tested, and/or modified. This has especially so for dredged material used for wetland restoration and creation purposes, where geotextiles, bioengineering, and special planting techniques have been used.

Introduction

Since the 1930's, many millions of hectares of wetlands have been restored, created, enhanced, and/or managed by various public agencies, including the U.S. Army Corps of Engineers. This work has been centered at the US Army Engineer Waterways Experiment Station (WES).

Technical information on engineering structures, wetland-friendly equipment, methodologies (including computer data bases), and techniques has been developed under various research programs and hands-on management. A number of publications are publicly available with technical information regarding wetland restoration and creation (Environmental Laboratory 1978, 1986; Federal Highway Administration 1990; Kusler and Kentula 1989; Landin 1992a, 1992b, 1992c, 1993; Landin et al.

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1989, 1993; Landin and Smith 1982; Soots and Landin 1978; U. S. Army Corps of Engineers 1985, 1989a 1989b; USDA Soil Conservation Service 1992). Engineering examples included in these publications are beneficial uses of dredged material, geotextiles, protective aquatic-interactive structures, sediment diversion into. and construction modifications, hydrology and elevational modification technology, flow-altering gates' and structures, and bioengineering. Readers are encouraged to obtain these publications for further information.

In addition, the National Academy of Sciences tasked two committees of scientists and engineers to identify and examine wetland restoration, protection, and creation technology, one in freshwater systems (National Research Council 1992) with the other focusing on coastal systems (National Research Council 1994). Both include information on dredged material beneficial uses, especially the latter, coastal book.

Environmental success in a beneficial use project is defined as achieving the stated goals and objectives, based on agreed-upon replacement values of the lost or degraded environmental resource. To successfully accomplish wetland restoration and creation, engineers, scientists, and managers must use their expertise and experience in multi-disciplinary efforts that include coordination, communication, cooperation, and often, cost- and work-sharing (Landin 1992a, National Research Council 1994).

The Role of the U. S. Army Corps of Engineers

The Corps has restored, created, protected, and/or managed several hundreds of thousands of hectares of wetlands since the early 1970's. These wetlands resulted from Corps project activities, and included:

(1) wetlands created or restored using dredged material beneficially; (2) lands acquired and restored as wetlands for mitigation of Corps projects; (3) degraded wetlands surrounding Corps projects that were restored and are now managed; (4) greentree reservoirs and moist soil units in association with Corps projects; (5) shoreline wetlands built on Corps reservoir projects; and (6) joint interagency wetland projects in which the Corps was an active partner. The majority of these projects included either land- or water-based dredging.

Most Corps wetland restoration and creation projects were developed with primary functions of shoreline and sediment stabilization, erosion control, and fish and wildlife habitats as objectives. Other

functions addressed in various Corps wetland projects include water quality improvement, recreational values, contaminant stabilization, and cultural resources. The Corps has found that there are four essential technical factors required for achieving success:

- (1) Correct hydrology or elevation (stable water supply),
- (2) Suitable soil/substrate for biotic success,
- (3) Protection from wind, wave, and wake energies, and
- (4) Correct plant species and propagule selection and installation.

Some examples of selected Corps beneficial uses wetland projects are given in Table 1.

The Corps' multiple mission responsibilities of dredging for navigation, dredging for flood control, wetland regulation and protection, and national defense give it numerous opportunities to carry out wetland restoration and creation, always in conjunction with other federal and state agencies, and project partners and sponsors, and usually with local citizens groups. Because of these projects, the Corps has developed expertise in both engineering and environmental technology for accomplishing successful wetlands work, as well as developed a common sense approach to restoration procedures (Landin 1992a).

Engineering and environmental monitoring is necessary to collect baseline data prior to, during, and following dredging and project construction; to document wetland chronology and actions; to use monitoring measurements to determine success rates; and to justify conducting similar wetland projects at future sites (Landin 1992a, 1992b, 1993). Long-term management responsibilities must be determined for new wetlands because they can fail if not maintained or managed, especially in early years.

Geotextile Tubing Applications

Americans have used geotextiles in conjunction with dike construction for many years; Europeans have also used woven geotextiles for a technique called geotubes that has now been tested on a number of wetland sites in the United States (Fowler and Sprague 1993). A geotube can be constructed to be any desired width, length, and height, and is either sewn together in the factory or on-site. It can be made of either tightly woven or non-woven materials to accomplish different purposes. Geotubes typically have one or more small cylindrical openings on the top to be filled from a 15- to 20-cm hydraulic dredge pipe. All geotubes are filled on-site because they are too heavy and unwieldy to move.

Table 1
Selected Wetland Projects Using Dredged Material Technology

Project	Hectares	Owner
Pointe Mouillee, Western Lake Erie, MI	1,862***	Michigan DNR*
Tennessee-Tombigbee Waterway, TN, MS, AL	64,914**	Miss. & La. DNR, FWS***
Delta National Forest, Yazoo Basin, MS	810+	US Forest Service
Gaillard Island, Mobile Bay, AL	526	Ala. State Docks
Southwest Pass, Lower Mississippi River, LA	3,238+	State of LA
Weaver Bottoms, Upper Mississippi River, MN	2,025	FWS
Riverlands, Middle Miss. River, Missouri/Illinois	2,025+**	Corps of Engineers
Snake River, Jackson Hole, WY	1,214+	State of Wyoming
Kenilworth Marsh, Anacostia River, Washington, DC	20+	Nat. Park Serv.
Miller Sands Island, Lower Columbia River, OR	55	FWS
Jetty Island, Puget Sound, WA	20+**	Port of Everett
Soma Baylands, San Francisco Bay, CA	162+**	CA Coastal Comm.
San Joaquin River Wetlands, CA	15	State of Calif.
Stern Neck, Chesapeake Bay, MD	8	FWS
Lilee Sanctuary, Rhode Island	20+	State of RI
Hard-Miller Island, MD	445	State of Maryland
Barren Island, MD	40	State of Maryland
Pea Patch Island, PA	8**	State of PA

* Department of Natural Resources
 ** habitats primarily wetlands; also some open water, uplands
 *** US Fish and Wildlife Service

Early versions of such materials were used at wetland sites built in Galveston Bay, TX, in 1973 to protect from a 42-kilometer wind fetch and in Core Sound, NC, in 1979 to build two wildlife nesting islands fringed with planted saltmarsh. These were 3 x 1.2 x 0.9 meters, filled with small hydraulic dredges with sand, and stacked to form breakwaters in the configuration desired for wetland protection. In the 1980's, 15 x 0.9 x 0.9 meters geotubes were used to protect newly planted seagrass beds, with varying success. Smaller geotubes also were tested in that same time period. By the 1990's, geotubes were being designed and tested for wetlands and for dike repair that were custom-made to accommodate the project. Non-woven geotubes are two layers thick and filled with water; the resulting breakwaters are considered temporary, to be removed once the project has stabilized. These were tested and used successfully at Kenilworth Marsh in Washington, DC in 1992-93 (Landin and Patin 1993).

Woven geotubes have now been refined to hold fine-textured material as well as sand, a very important improvement. Typically, many wetland projects are in silts or clays, and in the past such material oozed through woven geotextiles. Better fabric construction and texture allows fine-grained sediments to be layered into the geotubes, where it consolidates to densely-packed mud. The Corps has tested these successfully in Mobile Bay, Chesapeake Bay, the lower Mississippi River (Louisiana), and two locations in the Texas Intercoastal Waterway (Chasten et al. 1993, Fowler and Sprague 1993). In Mobile Bay, the geotubes were used for dike repair. In other locations, wetlands were planted behind the geotubes.

The use of such flexible fabrics have added a new dimension to wetland stabilization technology. Geotubes can be built and filled with dredged material to the exact contour and configuration needed for the wetland. The largest tested to date have been 152 x 6 x 3 meter; however, they can be: (1) designed to be larger or smaller, (2) stacked and layered, (3) form rings to be filled for an island creation, (4) used detached from the shoreline, and (5) sewn to allow high and low spots after filling to better accommodate intertidal flow. The Corps is currently planning a number of other geotube dredged material wetland projects. Resource agency response has been very positive, and the US Fish and Wildlife Service (USFWS) and the State of Maryland are cost-sharing several of these projects in Chesapeake Bay, including Aberdeen Proving Ground shorelines, Poplar Island, and Barren Island.

Innovative Breakwaters and Bioengineering

Other innovative breakwaters tested by the Corps include detached riprap designs coupled with dredged material placement (usually 30 meters of riprap spaced with 30 meters of open water) that can be positioned parallel to, at an angle to, or perpendicular to a coastal, lake, or reservoir shoreline. They can also be placed in an alternating, staggered design in high wave energy or frontal energy situations; placement using this design was found to trap more sediment for marsh protection in coastal Louisiana than a design using a single row of detached riprap breakwaters. Location and placement depends upon current movement, sediment type, project objectives, and wave/wind energy requiring dissipation. Riprap can also be used adjacent to eroding shorelines, with slope gradation of the dredged material behind it which is planted with typical streambank or slope vegetation. It should be noted that riprap can cost as much as 10 times more than geotubes and typical bioengineering techniques.

Bioengineering is the use of traditional engineering techniques coupled with wetland and shoreline plantings. Bioengineering also typically uses less hard structures and focuses on use of biodegradable erosion control matting, removable structures or features such as floating tire breakwaters. Plantings are typically reinforced with closer spaced-plant, or plants enclosed in burlap tubes, or biodegradable pots, or bundled together as live cuttings. Living fences made from driven double-rowed wooden stakes filled with cuttings, plant material bundles which are buried in the substrate, brush mattresses, and fences made of Christmas trees which trap sediment are just four of the bioengineering techniques that have been tested by the Corps in both reservoirs and on the Gulf coast. These techniques are often used by the Corps in conjunction with dredged material placement (Allen 1990, 1992).

Low-cost, Low-Maintenance Design and Construction

Because public wetland projects tend to be underfunded beyond project construction, it is extremely important to design and build wetlands that are low-tech, low-cost, and that require little maintenance to remain viable. This can easily be accomplished using dredged material. A wetland that is designed to routinely require manpower to provide water to the wetland, to regulate water levels and elevational changes, and to mow, prune, and otherwise manage vegetation is very labor intensive and requires funding in each year's budget.

Therefore, Corps wetland projects stress use of native vegetation, having a permanent natural water source (or a well-built low-maintenance impoundment structure), allowing natural colonization of vegetation where possible, and as little earth-moving as possible using traditional methods. It is much less expensive and more efficient, for example, to restore wetland elevations with bottom sediments using a hydraulic dredge than by trucking large quantities of upland fill into the project site. The Corps has used dredged material to restore wetland elevations using hydraulically placement many times; examples include seven wetlands in the San Francisco Bay system, several sites in Chesapeake Bay, and the coastal marshes of Louisiana (US Army Corps of Engineers 1985, Landin et al. 1989). It is also more likely to be successful, because wetland seed banks exist in fine-textured bottom sediments (Environmental Laboratory 1986).

Plant Materials and Propagation

Plant species and materials are integral components of successful beneficial uses wetland projects. Through literature searches, laboratory, greenhouse, and field tests using various wetland species under controlled fertilizer, soil, and propagule treatments, the Corps has developed lists of plant species suitable for such projects (Allen 1992; Allen and Klimas 1986; Environmental Laboratory 1978, 1986; Landin 1978; US Army Corps of Engineers 1985). The corps uses its environmental team members to determine what plant species are best to meet project objectives and how they should be planted and maintained.

It should be noted that the simpler the planting requirements and the smaller the size of the propagule, the less expensive planting will be. However, plant materials are generally one of the least costly components of a dredged material wetland project; dredged material/soil/sediment transport, land acquisition, protective breakwaters, and earth-moving in site preparation are the most costly components.

Monitoring

Monitoring is goal/objective driven; in dredged material beneficial uses wetland projects, goals and objectives are determined based on functions and values lost, degraded, and/or needed. Monitoring is necessary to collect baseline information, to document activities and chronology of the project, and document success or failure and the need for mid-course correction, and to justify building a similar wetland project in the future. The identification and use of

Statistically-valid measurements for each component (e.g.; fish, invertebrates, wildlife, water quality, soils, structural integrity, elevations) sets a standard for the success of the project that should be a consensus determination by all technical team members. These in turn will help establish project success criteria (Landin 1992a, 1992b, 1993).

As an example of a Corps dredged material wetland project based on the above information, Kenilworth Marsh on the Anacostia River in Washington, DC, had goals and objectives to: (1) to restore freshwater intertidal wetlands in a degraded lake system; (2) to place the Anacostia River flood-control maintenance material beneficially; (3) to enhance the recreational and educational aspects of Kenilworth; and (4) to use low-cost, low-maintenance techniques for accomplishing the restoration project. Engineering and environmental designs and construction were based on those four points; monitoring focuses on both engineering and environmental integrity, as well as how well the site has recovered for educational canoe trips, birding, and other passive recreational activities. Success criteria include full vegetation cover of planted species after one growing season with continued survival and reproduction, self-maintenance of new wetland elevations, and self-maintenance of newly-cut canoe trails. Data from Kenilworth are being used to design and build a similar wetland at Kingman Lake, also in the Anacostia River (Landin and Patin 1993).

Summary

Dredged material beneficial use projects with natural resource objectives, especially those involving wetlands, are multi-disciplinary and require cooperation and partnership with other agencies. A common sense approach and procedure has been developed by the Corps that covers the basic requirements for achieving success. Engineering and environmental technology for wetlands has been identified, tested, refined, and applied by the Corps for over two decades. Geotextiles, non-traditional breakwaters, bioengineering, plant material requirements, and monitoring needs and logic are very important to success. Numerous examples of successful Corps wetlands involving dredged material placement have been built, with a number of other wetland projects in planning and coordination stages.

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Bibliography

Allen, H. H. 1990. Biotechnical Reservoir Shoreline Stabilization. Wildlife Resource Notes 8(1) : 1-11. US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Allen, H. H. 1992. Design and Construction Requirements for Establishment Herbaceous Wetland Vegetation. WRP-TN VN-EM-3.1. US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Allen, H. H. and C. V. Klimas. 1986. Reservoir Shoreline Revegetation Guidelines. TR E-86-13. US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Chasten, M. A., J. D. Rosati, J. W. McCormick, and R. E. Randall. 1993. Engineering Design Guidance for Detached Breakwaters as Shoreline Stabilization Structures. TR CERC-93-19. US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Environmental Laboratory. 1978. Wetland Habitat Development with Dredged Material: Engineering and Plant Propagation. TR DS-78-16. US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Environmental Laboratory. 1986. Field Guide for Low-Maintenance Vegetation Establishment and Management. IR R-86-2. US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Federal Highway Administration. 1990. A Guide to Wetland Functional Design. Report No. FHWA-IP-90-010. Office of Implementation, Research, Development, and Technology, McLean, VA: Federal Highway Administration.

Fowler J. and C. J. Sprague. 1993 Dredged Material Filled Geotextile Containers. IN pp. 2415-2428 ASCE Proc. Coastal Zone '93 Conf., New Orleans, LA.

Kusler, J. A. and M. E. Kentula, Editors. 1989. Wetland Creation and Restoration, the Status of the Science. Island Press, Washington, DC.

Landin, H. C.. 1978. Annotated Tables of Vegetation Growing on Dredged Material in the United States. MP D 78-7. US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Landin, M. C.. 1992a. Achieving Success in Wetland Restoration, Protection, and Creation Projects. IN Proc. 4th International Wetlands Conference, Columbus, OH, in press.

Landin, N. C.. 1992b. How, When, Where, and What to Monitor, and Why it Matters. IN pp. 142-147 ASCE Proc. Ports '92 Conference, Seattle, WA.

Landin, M. C. 1992c. Need, Construction, and Management of Dredged Material Islands for Wildlife. IN, J. B. Herbich, Editor, Handbook of Dredging Engineering. McGraw-Hill Inc., New York, NY. pp. 81-100.

Landin, M. C. 1993. The Role of Technology and Engineering in Wetland Restoration and Creation. IN Proc. National Wetland Engineering Workshop, St. Louis, MO, August 1993. Technical Report WRP-RE-06, in press. US Army Engineer Waterways Experiment Station, Vicksburg, MS. 250 pp.

Landin, N. C., E. A. Dardeau, and N. P. Rollings. 1993. Guidelines for Wetland Restoration and Establishment for Mitigation. Draft Technical Report D-93-, in review. US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Landin, H. C. and H. K. Smith. 1982. Reclamation of Wetlands. IN, Research on Fish and Wildlife Habitat. EPA-600/8-82-022. US Environmental Protection Agency, Washington, DC. pp. 195-207.

Landin, H. C., P. R. Patin, and H. H. Allen. 1989. Dredged Material Beneficial Uses in North America. IN pp. 821-832 Proc. 12th World Dredging Conference, Orlando, FL.

Landin, N. C. and T. R. Patin. 1993. Innovative Wetlands in Urban Settings Using Dredged Material. IN pp 109-112 ASCE Proc. Water Management in the 90's Conf., Seattle, WA.

Landin, M. C., J. W. Webb, and P. L. Knutson. 1989. Long-Term Monitoring of Eleven Corps of Engineers Habitat Development Field Sites Built of Dredged Material, 1974-1987. Technical Report D-89-1. US Army Engineer Waterways Experiment Station, Vicksburg.

National Research Council. 1992. Restoration of Aquatic Ecosystems. National Academy Press, Washington, DC. 552 pp.

National Research Council. 1994. Restoring and Protecting Marine Habitat: The Role of Engineering and Technology. National Academy Press, Washington, DC. 193 pp.

Soots, R. F. and N. C. Landin. 1978. Development and Management of Avian Habitat on Dredged Material Islands. Technical Report DS-78-18. US Army Engineer Waterways Experiment Station, Vicksburg, MS. 98 pp.

US Army Corps of Engineers. 1985. Beneficial Uses. EM 1110-2-5026. Engineers, Washington, DC. 298 pp. Dredged Material Office, Chief of Engineers, Washington, DC. 298 pp.

US Army Corps of Engineers. 1989a. Environmental Engineering for Coastal Protection. Engineer Manual 1110-2-1204. Office, Chief of Engineers, US Army Corps of Engineers, Washington, DC.

US Army Corps of Engineers. 1989b. Environmental Engineering for Flood Control Channels. Engineer Manual 1110-2-1205. Office, Chief of Engineers, US Army Corps of Engineers, Washington, DC.

USDA Soil Conservation Service. 1992. Wetland Restoration, Enhancement, or Creation. National Engineering Field Handbook. EFH-1A. USDA Soil Conservation Service, Washington, DC.