Building more sustainability into Great Lakes dredged material management

It's time to shift from confined disposal to processing and reuse

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CFIRE National Center for Freight & Infrastructure Research & Education

Top left and bottom: Erie Pier CDF at the Port of Duluth/Superior. Top right: Bayport CDF at the Port of Green Bay.
Cover: Erie Pier CDF at the Port of Duluth/Superior.

Why confined disposal is no longer a sustainable approach to dredged material management at Great Lakes ports and harbors

How to manage sediment dredged from Great Lakes harbors and navigation channels continues to be one of the stiffest challenges to maintaining a sustainable dredging program for the Great Lakes marine transportation system.

Natural sedimentation in river mouth harbors and connecting channels, sand and sediment drifting across harbor mouths, and erosion from storms, among other sources, require the U.S. Army Corps of Engineers (USACE) to remove from three to five million cubic yards of material a year from Great Lakes waterways, ports and harbors to maintain commercial and recreational navigation. While 37 percent of the dredged material is placed in the open waters of the lakes, currently some 45 percent is deposited in purpose-built "confined disposal facilities," or, CDFs.

These facilities, of which there have been 45 built by the Corps in Great Lakes harbors since the mid-1970s, were created to contain dredged sediment, much of which was contaminated with industrial pollutants. Over the past four decades 23 of these CDFs have been filled to capacity, capped and many converted to other uses. Confinement of contaminated sediments, together with the elimination of virtually all point sources of contaminated discharges into Great Lakes waters, have contributed greatly to improved water quality, as well as helping support safe, reliable marine transportation. Today there are 22 active CDFs left in the Great Lakes and they are estimated to be, cumulatively, about 80 percent full. Yet, navigation dredging needs remain constant and will likely increase at some point to address a longstanding dredging backlog created by budget shortfalls.

In its 2012 Dredged Material Management Strategic Plan, the Corps acknowledged the crisis of diminishing CDF capacity, noting that building new CDFs, is becoming increasingly unlikely. "Constructing a new CDF is typically considered a last option; costs can range from $30-$60/cubic yard compared to fill management ($7.50-$20/cubic yard) or beneficial reuse ($2.50-$20/cubic yard). Based on the high cost of construction, acquiring funding is very difficult."

Given the above cost advantages of CDF fill management and beneficial use, and the sustainability these recycling practices build into a dredged material management approach, they are prominently included in the plan as "potentially viable approaches for managing dredged material without building new CDFs…"

Above: Ground penetrating radar was used by researchers at the Port of Milwaukee confined disposal facility as one tool to identify physical characteristics of the material in specific sectors of the facility.

Left: Professor William Likos and his research team from the University of Wisconsin-Madison took core samples of dredged material from the Milwaukee CDF for further analysis on its engineering properties.

What is a “processing and reuse facility?”

CDFs built by the Corps at Great Lakes harbors in the late 1970s and 80s at a cost of almost $1 billion were constructed in various shapes, methods and sizes. Each CDF has a non-federal partner, such as states, municipalities or port authorities. Ownership of the material placed in CDFs varies on a site-by-site basis. Ownership of the material is important where there is potential for use of the material as a commodity with value. Because circumstances can vary significantly among CDF project sites, this discussion of processing and reuse does not take up the issue of legal ownership of a reclaimed dredged material, but rather the general economic, practical and environmental aspects involved.

All Great Lakes CDFs were initially envisioned and designed to be final resting places for material dredged from navigation channels. Now that CDF capacity is so severely limited, however, and that the dredged material being placed into them is so much cleaner thanks to the virtual elimination of industrial point source pollution in the Great Lakes, efforts have intensified throughout the region to reclaim usable dredged material from CDF sites and capitalize on its value as a commodity, rather than dispose of it as a waste.

Several CDFs are thus starting to be gradually modified to allow material to be removed and utilized in a more sustainable, beneficial way. This movement has contributed to the emergence of a new design concept, the “processing and reuse facility,” or PRF.

In the Geological Engineering lab at the University of Wisconsin, graduate researcher Hua Yu blended samples of raw dredged material from the Milwaukee CDF with varying amounts of fly ash as a stabilizer.

CDFs can be converted to PRFs using a number of methods. The processing function can be as simple as dewatering and segregation of similar material into stockpiles. Additional processing may involve separation of certain grain sizes, such as separating out coarse (sandy) material from fine silts and clays. Sometimes the raw dredged material requires additional processing such as the addition of soil amendments such as organic material or waste water treatment plant by-products. Specific research was conducted recently (see below) on the potential use of fly ash as an additive. The object is to produce a processed material matching material specifications for such uses as construction and highway projects, mineland restoration and landfill cover.

Processing may be done either by mechanical or hydraulic grain size separation in the CDF, or by selective placement methods into separate sections (individual cells) of the existing CDF during initial material placement into the CDF. Typically, the first stage of processing is the separation by material type or grain size and by the dewatering of the material. Then it is tested and stockpiled prior to removal out of the CDF. Material testing is done to help facilitate matching of the material to the specific needs of the end user.

The design of the actual CDF can also be modified to facilitate mining of the material from the facility, processing and reuse. The addition of haul roads and the division of the entire CDF into cells can provide more efficient user access to the material and reduce material handling and transportation costs.

Converting an existing CDF into a PRF produces multiple winners, including the Corps and the federal taxpayers; the Great Lakes marine transportation system, and the end users of a readily available new commodity. While the Corps has limits on its ability to “process” or actively market the dredged material for beneficial use, it is a key partner with the port and local agencies to promote the beneficial reuse of the CDF material. The more material taken out of the PRF, the more capacity remains for less re-useable dredged material.

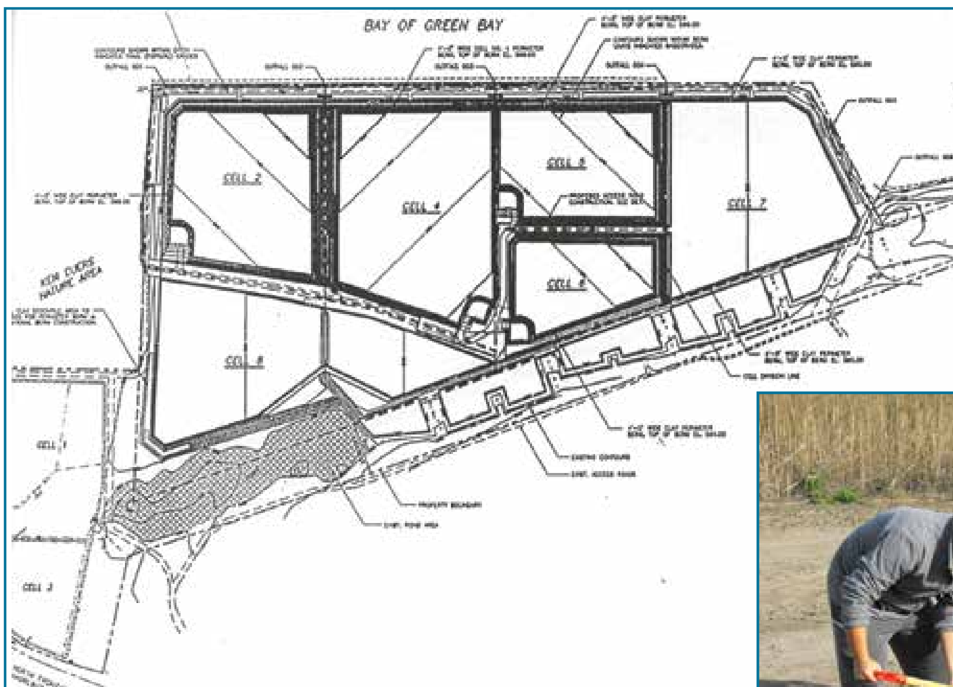
It should be noted that some ports use the term “recycling” instead of “reuse” when referring to a PRF. However, most ports prefer “reuse” as “recycling” may infer that the available material requires additional processing such as with the recycling of glass bottles or aluminum cans. Processed dredged material can be both.

Case Study: Bayport CDF at the Port of Green Bay

The Corps typically dredges approximately 150,000 to 200,000 cubic yards of navigation channel material per year at the Port of Green Bay from its 18-mile long navigation channel. In 1994, there were two CDFs available for placement of dredged material, the original County Bayport facility and the USACE-constructed Renard Island CDF. Renard Island is a typical offshore island-designed USACE CDF that contains significantly contaminated dredged material and is now closed. The original Bayport facility had filled two 400-acre sites with cleaner dredged material over forty years. In order to better manage the material for beneficial reuse, the county enlarged the Bayport facility by adding six new cells; four for initial dredged material placement and dewatering and two cells for stockpiling and storage until suitable beneficial uses can be found. Haul roads to facilitate the access to each cell by construction equipment separate the cells.

The new arrangement is the County's 100-acre PRF with a 2.5 million cubic yard capacity. Material from the portion of the Fox River/Green Bay that must be confined is placed in the County's Bayport facility. Material from each year's dredging cycle is typically placed into one cell and then allowed to dewater for two to three years before being moved to one of the two holding cells.

The Port of Green Bay and Brown County have been very active in promoting the beneficial use of its dredged material and have used it in several demonstration and construction projects.



Left: The Bayport CDF at the Brown County Port of Green Bay has a multi-cell configuration that allows material from each dredging cycle to be dewatered and stored for potential later removal and reuse.

Below: Samples were taken by University of Wisconsin researchers from one of the Bayport cells for analysis and characterization to assess the dredged material's suitability for beneficial use.

Left: It does not take long for the nutrient-rich dredged material placed in the Bayport facility to sprout new life.

Case Study: Erie Pier CDF at the Port of Duluth/Superior

Erie Pier is a fully operating example of a PRF. The Corps typically dredges approximately 100,000 to 125,000 cubic yards of navigation channel material per year from the Twin Ports of Duluth, Minnesota and Superior, Wisconsin. Originally built by the Corps as an 89-acre conventional CDF in the late 1970s, Erie Pier was designed for an original 10-year life holding approximately 1.1 million cubic yards. To date, the PRF has had approximately 2.25 million cubic yards of dredged material placed into it. This extended life has been due in part to raising the interior dikes to hold additional material, to a better-than-expected material settlement volume and the removal and reuse of approximately 250,000 cubic yards of coarse dredged material.

Above: The Erie Pier design is shown with an off-loading dock at the bottom corner, interior holding areas for useable material, and dikes with haul roads for accessibility around the perimeter.

Erie Pier's transformation from a CDF to a PRF has been gradual over the past 10 years through multiple phases of fill management, which allowed the Corps to continue to place dredged material in the facility well after its original 10-year design life. Initially, raw dredged material was off-loaded by barges into one corner of the facility where it was then hydraulically separated using existing water in the CDF. The coarse sand-size material would settle out almost immediately while the finer silt and clays traveled down a sluice-way with the water into the interior of the CDF. The Corps' dredging contractor would push the coarse material over the Erie Pier property line on to Port of Duluth property. The port could easily stockpile the coarse material and then sell it to local construction companies. The PRF transformation continued with the construction of an elevated dredged material off-load platform and haul roads around the exterior of the CDF and into the PRF interior to facilitate dewatering and stockpiling of the finer types of material. Because the port owns the material in this CDF, the port would test the stockpiled material for typical material chemical and physical characteristics and the search begun for suitable beneficial use of the finer material stockpiles.

Several demonstration projects using the finer materials have been completed including mineland reclamation, road construction, landfill cover, topsoil creation for golf courses and parks as well as in-harbor habitat restoration.

Above: Some 250,000 cubic yards of sediment dredged from the Duluth-Superior Port Authority harbor have been removed from Erie Pier for road construction, mineland reclamation, landscape restoration and other uses.

Left: Using a sluice-way, finer silts and clays are transported to interior holding areas in the Erie Pier processing and reuse facility, leaving coarse materials to be stockpiled and eventually removed for beneficial use.

New research on stabilizing dredged material to make a more usable product

On March 13-14, 2013, the University of Wisconsin-Madison-based National Center for Freight and Infrastructure Research and Education (CFIRE) sponsored a summit in Louisville, Kentucky on the beneficial use of dredged material. The summit, facilitated by Gene Clark of the University of Wisconsin Sea Grant Institute, and Great Lakes marine transportation consultant David L. Knight, featured examples of beneficial use projects from around the country. It also included a technical framework for recycling dredged material developed by William J. Likos, Ph.D., a professor in the Department of Civil and Environmental Engineering at UW Madison.

As a follow-up to the summit, CFIRE supported a further effort by Likos, collaborating with Clark and Knight, to explore approaches to characterizing, and potentially processing or amending sediment contained in Great Lakes CDFs for specific beneficial use applications. The ensuing project, "Integrated strategy for beneficial use of dredged materials in the Great Lakes," was initiated in 2014 and considered three CDFs at Great Lakes ports in Milwaukee, Green Bay and Duluth-Superior. Field work was conducted at the Port of Milwaukee, and included a special examination of combining fly ash with raw dredged material mined from the CDF to meet certain beneficial use specifications.

Underlying the research was the fact that material in most existing Great Lakes CDFs is largely uncharacterized and can be highly heterogeneous with respect to its physical properties. Without knowing with some precision what types of material are available from CDFs – and where specific types are located within a facility that receives material from varying locations - it is difficult to market them to potential users, and to address the current disconnect between the wealth of potential construction materials that are available and potential users of these materials. Likos posited that effectively addressing this disconnect could have a major impact toward solving the disposal capacity crisis for dredged material management, reducing construction costs, and realizing the environmental advantages of reclaiming a sustainable material resource.

Likos' work included a comparison of the engineering properties of raw dredged material mined from the Milwaukee CDF and the same dredged material stabilized by adding fly ash. The use of fly ash as a binder is attractive because fly ash is an industrial by-product that is relatively inexpensive compared with cement and lime. About 50 million tons of fly ash is produced annually in the United States, of which over 20 million tons is used in engineering applications. Self-Cementing Class C fly ash, which has relatively high calcium oxide content, has been shown to significantly improve the engineering properties of both inorganic soils and organic soils and is thus considered an effective stabilizing agent for a large quantity of construction applications.

As part of Likos's analysis, raw dredged material (RDM) was blended with 10%, 20%, and 30% fly ash and cured for 2 hours, 7 days, and 28 days. Results showed that blending the material with fly ash reduced plasticity and improved its engineering properties. Increasing fly ash content increased the maximum dry unit weight and reduced the optimum water content of RDM-fly ash mixtures. For any curing time, the undrained shear strength of the stabilized material increased linearly with the increasing fly ash content. Freeze-thaw cycles only slightly reduced the strength of the stabilized material, indicating that they are durable to freeze-thaw processes likely encountered in field beneficial use applications. Additional testing of the stabilized dredged material produced values comparable to those of gravel and crushed stone, and places the product in "good" to "excellent" rating categories for mechanical characteristics viable for beneficial use as subgrade or embankment fill.

In general, Likos found, use of Class C fly ash can significantly improve the engineering properties of dredged materials. Use of fly ash as a stabilizer not only offers a feasible and effective way for using high volume of dredged materials, but also reduces the burden of storage and disposal of the fly ash. Economically, coal fly ash stabilization is cheaper than stabilization with the conventional materials such as cement and lime. Based on the results of this study, raw dredged material with fly ash higher than 10% and curing time longer than 7 days can be used as roadway subgrade fill.

Sustainability is the ultimate goal

By more aggressively identifying property characteristics of raw dredged material placed in existing confined disposal facilities at Great Lakes ports and harbors, and thus assessing potential for beneficial use of the material, CDFs can be converted from disposal sites to processing sites to support a more sustainable, forward-looking, and value-added navigation dredging program.