ERDC TN-DOER-C24
December 2001

Determining Recovery Potential of Dredged Material for Beneficial Use – Debris and Trash Removal

PURPOSE: Dredged material stored in confined disposal facilities (CDFs) often contains significant amounts of trash and debris. Removal of this trash and debris is usually necessary to upgrade the material before it can be put to alternate beneficial uses and free up disposal facility capacity. This technical note describes equipment and techniques that may be used for the removal of these materials. It is one of a series of DOER technical notes on Determining Recovery Potential of Dredged Material for Beneficial Use, about methods of extending the life of CDFs by removal of the dredged material for beneficial use.

BACKGROUND: The management of dredged material in CDFs is of increasing concern due to the shortage of CDF capacity. Stringent regulatory requirements and environmental concerns make the opening of new sites a long and difficult procedure. The useful life of existing CDFs may be extended by the removal and beneficial use of the dredged materials. In the United States, it is estimated that nearly 90 percent of the 300 to 400 million cubic meters of sediment dredged each year is considered uncontaminated and is therefore a candidate for alternative beneficial uses (Winfield and Lee 1999). Beneficial uses include production of construction fill material, sand, and gravel, and use in land reclamation and constructed wetlands.

Debris and trash are not inherently toxic as they consist of natural materials such as boulders, stones, and parts of trees, as well as anthropogenic (man-made) objects including metal, glass and plastic objects, discarded tires, used wood products including railroad ties, cable, wire, shopping carts, and concrete debris. Debris and trash removal is therefore likely to be incorporated into contaminated as well as uncontaminated dredged material processing.

Confined Disposal Facility Practice. Confined disposal is the placement of dredged material within diked CDFs via pipelines or other means. CDFs may be constructed as upland sites, nearshore sites with one or more sides in water (intertidal sites), or island containment areas. Design objectives for CDFs are to provide adequate storage capacity for meeting dredging requirements and to maximize efficiency in retaining the solids.

Dredged material in a CDF is a complex matrix. The composition of the dredged material reflects the characteristics of the contributing watershed; the location of the site (rural, urban, industrial, coastal, or inland); the history of contamination in the watershed; and many other factors such as the type of dredging equipment employed and prior dredging history of the site. Although dredged material is typically analyzed in detail prior to placement into a CDF, many physical, chemical, and biological processes continue depending upon the prevailing environmental conditions (e.g., precipitation, temperature, and biogeochemical factors).

Before any consideration of method and/or equipment for the removal of debris, the general conditions and history of the CDF and the current chemical and physical properties of the contained

materials should be established. The characterization and testing of dredged materials prior to consideration of possible beneficial uses are discussed in detail in Winfield and Lee (1999) and Olin-Estes and Palermo (2000).

Dredging is conducted with either mechanical dredges or hydraulic dredges. Mechanical dredges are classified as bucket (including clamshell, orange-peel, and dragline) or dipper. Typical hydraulic dredges are plain suction, dustpan, cutterhead, hopper, and sidecast. Dredge types and methodologies are discussed in general references such as Headquarters, U.S. Army Corps of Engineers (HQUSACE) (1983); U.S. Army Corps of Engineers/U.S. Environmental Protection Agency (1992); and Herbich (2000).

Mechanical dredges are capable of removing and lifting relatively undisturbed loads of bottom materials that may contain trash and large items of debris. Hydraulic dredges, which add several volumes of water for each volume of sediment removed, can transport items that are pumpable, including, for cutterhead dredges, pieces of cut rock (HQUSACE 1983). A CDF filled from mechanical dredges is likely to have both debris and trash mixed with the dredged material, while a CDF filled from hydraulic dredges is less likely to have debris, but may have trash mixed with the dredged material. Most maintenance dredging of Federal navigation channels is carried out by hydraulic dredges (HQUSACE 1983). Many CDFs, however, are filled by mechanical dredges.

Figure 1. Debris found during dredging (photo courtesy of Saugus River Watershed Council)

The term debris as defined in this technical note refers to large items such as railroad ties, tires, steel cable, boulders and large stones, and demolition parts such as reinforced concrete (Figure 1). Trash describes smaller items that find their way into dredged material such as plastic, metal, glass or wood.

Many existing CDFs are filled to capacity or are rapidly approaching their design limits. In many cases, debris and trash must be separated from the dredged material prior to its reclamation for beneficial use. Separation of debris and trash from dredged material presents technical and economic problems because the process must handle large volumes at low cost. The Corps policy for dredged material from Federal navigation projects calls for disposal in the least costly, environmentally acceptable manner, which is consistent with sound engineering practices (Engler et al. 1988).

Beneficial Uses of Dredged Materials. Many beneficial uses of dredged materials have been developed. The range of possible beneficial uses is discussed in detail in HQUSACE (1987a) and Winfield and Lee (1999). Reclaimed dredged material can be used in upland, wetland, or aquatic environments. In addition, other waste materials that are in themselves unsuitable for beneficial use such as fly ash, alkaline wastes, and spent lime may be added to dredged material to produce useful and desirable products. For example, biosolids and yard waste have been blended with dredged material to produce agriculture topsoil suitable for public uses such as sanitary landfill cover. Figure 2 shows removal of extraneous plant rhizomes and clods in manufactured topsoil from dredged material, yard waste, and biosolids at the Toledo, OH, CDF.

For some uses, debris and trash may be acceptable components of the dredged material. Examples are use as fill for washouts, development of solid structures for fish habitat, and the construction of islands. However, most of the potential beneficial uses of dredged material require that the debris and trash be removed.

Figure 2. Portable truck-mounted trommel screen for removing extraneous plant rhizomes and clods in manufactured topsoil from dredged material, yard waste, and biosolids at the Toledo CDF (photo courtesy of Corps of Engineers)

DIVERSION OF DEBRIS AND TRASH STREAMS DURING DREDGING OPERATIONS: From an economic and operations standpoint, it is advantageous to divert unwanted materials from the process stream at the earliest point. Currently, the Corps of Engineers requires that the dredging contractor be familiar with the channel and include debris and trash removal in the original dredging bid. This includes the price of handling debris and trash and the diversion of those waste streams before entering the CDF. This is usually a matter of the contractor identifying areas with interfering debris and/or trash and using a clamshell dredge or log hooks and grapples to capture the bulk of the debris. Collected debris is often separated from sediment using a barge-mounted grizzly and deposited on a separate barge for proper disposal prior to the dredging phase.

On high-profile, contaminated, and/or complex sites, more sophisticated, investigative equipment may be employed to assess the nature and location of the debris before dredging. Examples of equipment used in these surveys are Dual Frequency Side-Scan Sonar, Multi-Beam Sonar Survey System, Sub-Bottom Profiling Sonar System, and Remotely Operated Vehicle (ROV) with sonar, lights, and video (TAMS Consultants, Inc., 2000). Once the material and location are defined, the best means to remove, separate, test, and dispose of the material can be determined.

During the dredging operation, rakes and other specialized attachments can be used to remove weed masses, trash, and debris (Figure 3). Specialized systems have also been developed to capture floating debris (Figure 4). Additionally, hydraulic dredging equipment has been designed with dredge head variations specifically to handle routinely encountered wood and rock debris. On some dredges, a basket surrounding a rotating cutterhead removes and rejects oversize material, clay balls, and wooden debris from the bedded deposit. Some types of mechanical dredges use a "chain ladder" cutterhead; the traveling chain has cutting prongs that dump oversized materials away from the pumping zone. Still others attach rings and bars to fracture the rock and wood debris encountered.

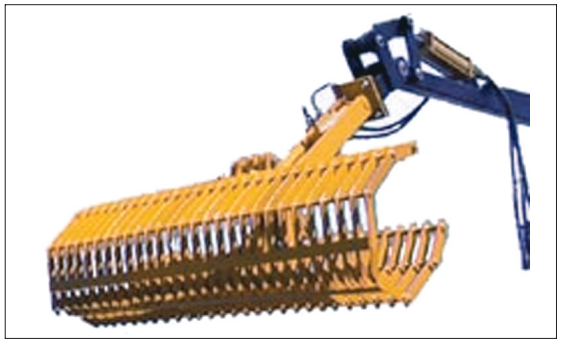

Figure 3. Weed rake (photo courtesy of Keene Engineering, Inc.)

Using these techniques minimizes the amount of large debris entering the CDF. Smaller debris that passes the dredge head can be separated as it enters the CDF or can be handled with ongoing CDF management activities. The removal of debris during dredging operations has been found to cause minimal loss of production volume or time; the reduction in throughput due to lessening the area at the intake pipe is well offset in the savings in the downtime for cleaning the dredge pump (Personal Communication, July 2001, V. Buhr, J. F. Brennan Company, La Crosse, WI).

Figure 4. TrashCat™ System (photo courtesy of UMI, L.L.C.)

RECLAMATION OF MATERIAL FROM CDFs: The steps employed in reclamation of dredged material from a CDF are similar to those involved in typical construction activities including logistical planning, land clearing and site preparation, material preprocessing, and postprocessing activities. Major elements of these activities are discussed in the following paragraphs.

Project Logistics. Before work at the CDF site can begin, consideration must be given to the logistic requirements for the equipment, transportation, and personnel that will be required. The debris and trash removal processing equipment may require additional area, utilities, and site preparation. Diesel fuel storage for heavy equipment may also be desirable. The site and processes used will require proper permitting from the local and regional regulatory agencies.

Depending upon the location of the CDF, support facilities for operator personnel may need to be secured. Such facilities might include office areas; change-out rooms, showers, and portable toilets; and meal preparation and sleeping quarters. Utilities such as electric power, water (potable and process), sewer connection, and communication facilities may require upgrading or initial installation.

If sufficient space is not available at the CDF, the operations may need to be carried out at a remote site. If space is available, additional parking areas, haul roads, rail spurs, or barge docks may need to be sited and constructed. If the debris and trash cannot be removed as it is reclaimed, storage facilities may be required. If additives such as lime or fly ash are to be used, facilities for the storage of the additives and products may also be necessary. Proper management and disposal of solid or liquid waste streams and excess process water will be required.

Figure 5. Weed growth in CDF (photo courtesy of Great Lakes Commission)

The Special Case of Vegetation. As the CDF dries out, vegetation quickly develops. Left unmanaged the vegetation can become a major operations problem (Figure 5). This topic has been covered extensively in Lee (2000). These problems can include invasive noxious weeds, unwanted woody habitats, and vegetative cover that itself generates considerable wood wastes prior to reuse of the dredged material. CDF managers employ a variety of techniques to control vegetation. Woody vegetation is often hand cut using simple chain saws on an as-needed basis.

Noxious weeds can be a major problem if left uncontrolled. For example, purple loosestrife invaded the Erie Pier CDF in Duluth, MN (Figure 6). The growth was so significant that, during several demonstration projects to reuse dredged material, 0.9 m (3 ft) of sediment had to be stripped along with the plant material to assure that seeds were not in the recovered material (Personal Communication, July 2001, E. M. Parzych, U.S. Army Engineer District, Detroit). Alternate means of vegetation control are being assessed at the Erie Pier CDF now, including periodic mowing and herbicide usage.

Figure 6. Purple loosestrife (photo courtesy of Corps of Engineers)

Land Clearing and Site Preparation. Land clearing and site preparation are usually necessary to prepare a suitable location for the reclamation equipment to be set up, provide roads and parking facilities, and clear utility pathways. The initial activities typically consist of clearing, grubbing, and stripping the land including the complete removal of all standing and fallen trees, brush, vegetation, and similar debris. Site preparation is usually not possible at CDFs until the dredged material has dried and consolidated sufficiently to allow tracked vehicles and equipment access to the site.

Grubbing consists of the removal of belowground material that could interfere with subsequent operations, including stumps, roots, buried logs, and other material. Stripping consists of removal of low-growing vegetation and, in some cases, the organic topsoil layer (HQUSACE 1987b). If trees are small, they may be cleared by wheeled tractors and bush hogs; otherwise crawler tractors and/or bulldozers may be required. Trees and heavy brush may be chipped to provide mulch or cellulose for manufacturing topsoil, hauled to other disposal sites, or left to decay.

Preprocessing. Preprocessing refers to the alteration of dredged material to prepare it for processing. The removal of large debris and trash is often the first step in getting the CDF site ready for reclamation.

Dewatering or drying of the CDF material is often necessary so that it can be worked and support processing equipment. Most dredged material is hydraulically dredged and placed in the CDF as a high-water-content slurry. A high-water-content material does not lend itself to some types of beneficial use. For example, if topsoil is to be reclaimed from fresh dredged material, dewatering will usually be necessary prior to addition of soil amendments. Generally, dredged material in a CDF has been at least partially dewatered before reclamation of the material is attempted.

In many cases, dredged material in CDFs does not need accelerated dewatering and drying operations. Preprocessing is more likely to involve altering the physical structure of the dredged material to make it easier to run through processing equipment or support heavy equipment. For example, in some cases the dredged material may tend to form large clods and chunks of soil when tilled. In some situations, mixing in sand, vermiculite, lime, cellulose, or sewage sludge may improve the texture of the dredged material so that it can be processed more readily.

Material Processing. The actual processing of dredged material usually involves an equipment train that is assembled from several different individual stages of processing equipment. Several examples of treatment trains that include trash and debris removal are described later in this note. Cost of transporting debris and trash removed during dredged material processing may become a significant cost item as disposal sites become farther from the processing site (Graalum, Randall, and Edge 1999; Arthur D. Little, Inc., 1998).

In some cases additional processing may be needed to satisfy the requirements of a specific market. For example, gravel may be washed to make it suitable for a user who intends to use it as a feed supply to an asphalt plant. By contrast, the gravel may not need to be washed if it is to be used for constructing walkways on all-weather paths in a park.

Material having high silt and clay may by improved by adding sand, lime, and organic matter (cellulose and biosolids) to improve the friability of the soil, making it more amenable for use by landscapers and homeowners. In some instances, lime kiln dust, fly ash, or portland cement is added to increase the usefulness of material with a high silt and clay content by reducing the water content and improving the structural strength of the fill. Such products have been used to make dredged material suitable for landfill cover.

EQUIPMENT USED IN DEBRIS AND TRASH REMOVAL: Physical separation techniques are used in sediment remedial alternatives to remove oversized material and debris to produce an acceptable feed material for subsequent handling and treatment. The most common types of equipment vary from the simple mechanical removal with construction equipment to the use of a grizzly, shredders, trommel or vibrating screens, or spiral or mechanical classifiers for smaller debris. Hydrocyclones are often found in treatment streams, but are useful mainly for smaller particles in the 40- to 400-µm range and are not covered here. These technologies may also be used to separate the sediments into two or more fractions based upon physical properties or characteristics. In so doing, the quantity of material requiring additional treatment or confined disposal may be reduced. Typical attributes of these types of equipment are listed in Table 1.

Table 1
Operational Specifications for Debris Separation Equipment (from Olin et al. (1999))

Technology	Maximum Feed Size, cm	Target Separation Range, cm
Mechanical removal	Unlimited	>60
Grizzly screens	Unlimited	>2
Trommel screens	4	0.006 to 0.055
Vibrating screens	30	0.001 to 2.5

Mechanical removal may be used to separate large debris using mechanical dredging or construction equipment. During the dredging operation, large debris can be separated from the bulk of the dredge material with a clamshell dredge or backhoe. This requires a skilled operator and a place to store the debris. For a land-based operation the debris may be separated and placed in a bin or dumpster for storage and transportation. Conventional earthmoving equipment that may be used for handling

and rehandling of sediments between other components could also be used for separating large debris.

Most treatment trains include coarse separation using grizzly screens as an initial treatment step. Grizzlies are the simplest and coarsest devices for removing small debris. Grizzly screens are made up of inclined parallel iron or steel bars spaced from 2 cm to 30 cm. The material to be screened is loaded either directly by bucket or front-end loader, or may fed by conveyer. Objects larger than the spacing of the bars are separated into a separate stream that may be treated or disposed of independently. Grizzly screens are very rugged and require little maintenance.

Trommel screens are used to remove gravel, rocks, or trash 1 to 10 cm in diameter. The most common configuration consists of a rotating, slightly inclined cylinder of sturdy wire mesh. They may be used as a second stage after a grizzly or as a first stage, depending on site ore material characteristics. Trommels have much lower capacities as only part of the screen surface is used at any given time. They are rugged and inexpensive and generally require little maintenance. Grizzlies and trommels are frequently used to remove small debris and are useful in sediment processing to capture driftwood, junk, or large rocks that would foul or damage other processing equipment.

Vibrating screens act by putting the screen in either a reciprocating, gyrating, or vibrating motion. They are used to make wet or dry separations. Particle size separation depends on the cloth chosen for the screen. They are often stacked to produce multiple-sized product streams. They do, however, have very limited throughput, particularly when there is a large amount of material near the size of the mesh opening. Blinding of the screens is a frequent problem but can be controlled with a "ball tray," which is a tray of hard rubber balls that continually bounce against the underside of the screen to dislodge stuck particles. The screen is subject to extreme wear and requires frequent replacement, especially in those with smaller openings. A trommel and vibrating screen were used as the first stages in the Assessment and Remediation of Contaminated Sediments Program demonstration at Saginaw, MI (U.S. Army Engineer District, Detroit, 1994).

EXAMPLES FROM SITES USING EQUIPMENT TRAINS INCLUDING DEBRIS AND TRASH REMOVAL: Some field experience has been gained in the collection and removal of debris and trash from CDFs. The following examples illustrate the range of techniques that have been planned for or used at CDFs with varying qualities of dredged material and differing beneficial end uses. The examples cover applications to dredged material in CDFs as well as freshly dredged sediment. Some of the examples focus on proposed processes that have not yet gained operating experience.

Example 1 – Bayport CDF. The Bayport Confined Disposal Facility (Green Bay, WI) site is being used in a field demonstration to develop management approaches to recover CDF storage capacity. It is a dredged material handling site designed with innovative cells to facilitate dewatering and rehandling of the dredged material. The facility has dewatering cells with the capacity to dewater 438,855 cu m (574,000 cu yd) of dredged material at any one time. The demonstration employed a "power screen," which consists of a grizzly, a shredder, a conveyor, and a shaking screen (Fig- ure 7a). The equipment is rated at 23-46 cu m (30-60 cu yd) per hour.

a. Power screen

b. Debris in material excavated from Cell 5

c. Clay clumps in Cell 5 material after drying

d. Screened material

Figure 7. Bayport CDF (photos courtesy of Corps of Engineers)

A front-end loader feeds the power screen. The spacing on the bars of the grizzly is approximately 50 mm (2 in.). The shaking screen is equipped with a coarse screen to exclude rocks and other large debris (chunks of asphalt were the most commonly observed coarse debris) and a 25-mm (1-in.) harp screen, which consists of parallel wires. The harp screen is reported to be more effective than a mesh screen for cohesive materials. However, the wires tend to spread during screening, passing larger particles through the screen than the nominal wire spacing. The power screen is designed for processing topsoil at less than 10 percent moisture.

Two types of material were processed. Material was excavated by backhoe, and some of the material contained debris, including large blocks of concrete (Figure 7b). The material from one area had 50 percent moisture (weight water/total weight) at the time of excavation. This material was stockpiled for drying for 4 to 6 weeks prior to processing through the power screen. The moisture content was reduced to 24 percent at the time of processing. Figure 7c illustrates the formation of hard clay clods that developed during the drying period. The second material had a higher

percentage of sand and only 2 days after excavation was processed at a moisture content of 25 percent. Figure 7d illustrates the character of the underflow.

The clay content presented operational problems during the demonstration project. It was thought that the clay clumps could be broken up on the grizzly using the loader bucket, but this was largely ineffective. Clumps too large to pass through the bars of the grizzly slid off the grizzly onto the ground (Figure 7c). A more effective approach might have been to use a grizzly with larger bar spacing (15-20 cm (6-8 in.)) followed by a log roller to break up the material to an acceptable size.

Material that effectively passed through the grizzly was sampled and taken back to the laboratory to test for oversize material in the product underflow. Some material was retained on the 38-mm (1-1/2-in.) screen from the material that took the longest to dry (approximately 0.7 percent of the total material weight), and on the 25-mm (1-in.) screen (approximately 2.6 percent of the total material weight). None of the screened sandy material exceeded the nominal screen spacing. Material substantially larger than 38 mm (1-1/2 in.) was effectively screened out prior to the harp screen.

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Example 2 – Dutch Pilot Plant. This example is developed from a pilot plant test by Dutch investigators of a proposed process that included separating debris and trash from dredged material (de Kreuk, de Kreuk, and van Muijen 1998). The Dutch pilot plant discussed in this example was tested to determine whether a pulsating bed separator could operate satisfactorily and at lower cost than a hydrocyclone to produce product streams from dredged material. The process was then scaled up into a proposed system that would produce several product streams from dredged material. The proposed process layout is shown in Figure 8. The key pieces of equipment are described in the following paragraphs.

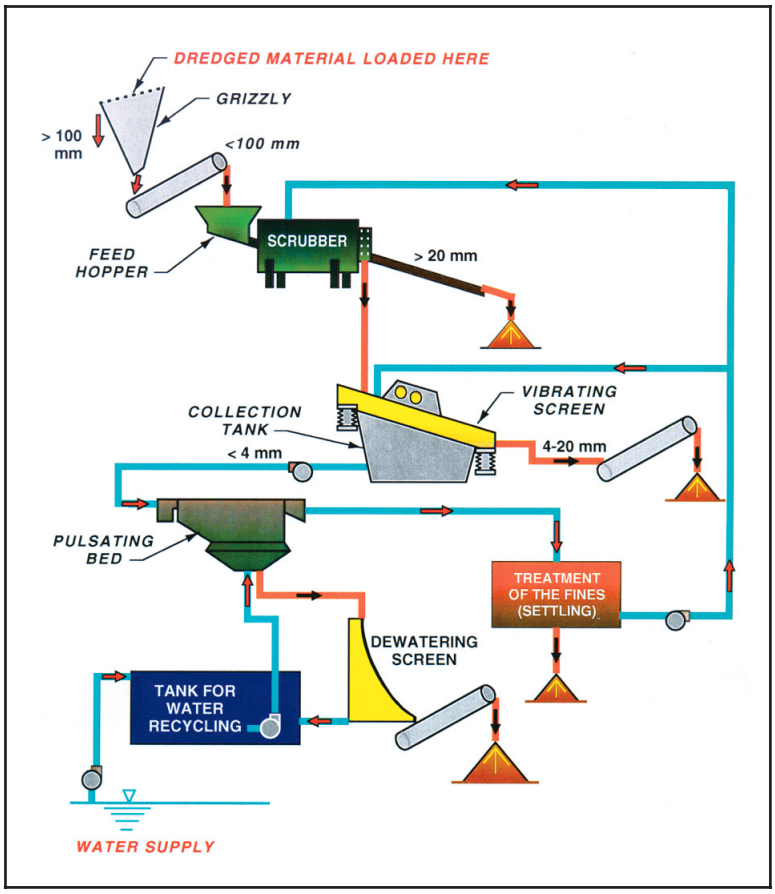

Figure 8. Dredged material processing plan and equipment layout for separating debris and trash from dredged material (adapted from de Kreuk, de Kreuk, and van Muijen 1998)

Grizzly separator. A grizzly separator removes debris and trash that is larger than 100 mm in size.

Rotating screen scrubber. A rotating screen scrubber produces two product streams, one with a size greater than 20 mm, and the other less than 20 mm in size. The material greater than 20 mm is expected to be useable without further processing. The fraction less than 20 mm in size undergoes further processing.

Vibrating screen. A vibrating screen separates the <20-mm material into two further fractions: one fraction between 4 and 20 mm in size, and the second fraction less than 4 mm in size. The <4-mm fraction is sent to the pulsating bed separator where it is separated into two additional product streams.

Pulsating bed separator. A pulsating bed separator is fed with the <4-mm stream from the vibrating screen. The pulsating bed separator separates this material in two ways, by density and by size. In this way, organic material may be separated from mineral material that has a similar size. The lighter material is sent to a sedimentation basin, while the mineral material is sent to a dewatering screen. Another alternative, for contaminated material, is to send the contaminated organic material to a bioremediation treatment process.

Dewatering screen. A dewatering screen separates the mineral matter from water, producing a product stream that is ready for use.

Sedimentation basin. A sedimentation basin separates the fine organic material and some fine mineral matter from water. There was no discussion about the use of chemical or polymer coagulants and flocculants to aid in the sedimentation process.

The Dutch authors emphasized in their discussion of the pulsating bed separation process that it might have some advantages over the hydrocyclone in that it was expected to consume less energy to operate and to require less process water.

Example 3 – New York and New Jersey Area Material Handling. This example is developed from information on beneficial use of freshly dredged sediment from the New York and New Jersey area. Three cases are presented for which there is operating experience for beneficial uses of processed dredged material: one of the cases discusses use of dredged material for strip-mine reclamation in Pennsylvania, and two of the cases discuss use of dredged material for construction fill.

Figure 9. Grizzly (photo courtesy of Marine Equipment Company)

Construction and Marine Equipment Company site. Dredged material was processed prior to being sent by rail cars to Pennsylvania for use in strip-mine reclamation (Oweis 1999, Appendix I). Mechanically dredged sediment from the municipal marina in Perth Amboy, NJ, was offloaded with a bucket dredge at a dock, passed through a grizzly to remove debris, then mixed with coal fly ash in a pug mill. Pug mills are easily disabled by debris, and as Figure 9 shows, tires, timbers, and some other large pieces of debris were removed by the grizzly.

Jersey Gardens Mall site, Elizabeth, NJ. Dredged material was used as fill material to construct approximately 526,000 m^2 (130 acres) of parking lots at a shopping mall in New Jersey (Oweis 1999, Appendix I). Fresh dredged sediment was mixed with portland cement and used for structural fill under parking lots to raise the elevation above the 100-year floodplain. Sediment was mechanically dredged from various sites, barged to an off-loading facility adjacent to the mall site, mixed with portland cement (8 percent by weight) in a pug mill, and trucked to the construction site. Initially, dredged material was offloaded from the barges hydraulically, but debris and trash clogged the pumps. Eventually, pipeline transport of the dredged material was abandoned.

Problems with trash and debris resulted in a redesign of the transportation system for getting dredged material from the barges to the pug mill. Debris and trash were also a problem at the pug mill and had to be removed prior to processing.

Port Newark, Seaboard site. Dredged material from the Arthur Kill Federal Navigation Channel and from Port Newark was used as fill material at the Seaboard site after portland cement was mixed with the dredged material (Oweis 1999, Appendix I). Mechanically dredged sediment was placed in scows and transported to a dockside processing facility in Port Newark. The processing facility consisted of silos for storage of portland cement, a conveyor for transfer of portland cement to the scows, and a backhoe equipped with a rotary mixer (Figure 10).

Figure 10. Backhoe-mounted rotary mixer

Debris and some trash were removed prior to the addition of portland cement by drawing a rake attached to a backhoe through the dredged material while it was still in the scows. Portland cement was mixed (8 to 12 percent by weight) with the dredged material in the scows by a backhoe-driven rotary mixer at dockside. The scows were then moved to the Seaboard site and the processed dredged material was used as fill material. Site use is expected to be light industry and warehouses. The backhoe-mounted rotary mixer used in this project was not as sensitive as a pug mill to debris and trash, although large items, such as tree trunks, railroad crossties, etc., still had to be removed.

Example 4 – Erie Pier CDF, Duluth, MN. The 86-acre Erie Pier CDF in Duluth Harbor, built in 1980, is currently approaching maximum capacity (Figure 11a). The Detroit District has numerous activities underway to extend the life of the facility. The material is mechanically dredged from the St. Louis Harbor and Duluth Harbor Bay region and offloaded at the Erie Pier CDF (Figure 11b).

The site has several conditions that make it a good example of dredged material recovery and reuse. The material is approximately 50 percent sand of very little contamination making it a realistic site for material reuse. The vegetative cover that has been a problem in the past is beginning to be controlled effectively with material reuse in mind. Severe winter weather conditions present a variety of operational constraints that must be considered when planning reuse projects. And finally, two recent treatment demonstration projects were completed; early results are available.

a. Aerial view

b. Off-loading dredged material

Figure 11. Erie Pier CDF (photos courtesy of Corps of Engineers)

For a number of years the Corps of Engineers has used the process of "soil washing" at the Erie Pier CDF to separate sediment particles by size and make some of the material available for use (Personal Communication, July 2001, D. Zande, U.S. Army Engineer Disrict, Detroit). Contaminants are often associated with particular sediment types – usually finer grain sizes and organic materials. Dredged material is off-loaded from barges with trackhoes and slurry pumps into a sloping "bowl" area of the CDF, allowing the coarser or cleaner material to settle out as the fines are carried away with the water. The coarser material is then excavated and sold for use as construction material. On an annual basis approximately 76,000 cu m (100,000 cu yd) of material is dredged and placed in the CDF in late summer. Roughly one third to one half (depending on the dredging location) of the sandy material is recovered in the winter for reuse. In CY 2000, the material dredged was almost exclusively clean sand due to the location of the dredging projects that year. This high-quality sand was off-loaded into a separate stockpile for direct loading onto trucks with no washing. This enabled the recovery and sale of approximately 191,000 cu m (250,000 cu yd) of clean material for use at the nearby Bayfront Festival Park construction site. This freed up significant CDF capacity and allows for more space for options in managing the material.

Mine reclamation feasibility study (Personal Communication, July 2001, E. M. Parzych, U.S. Army Engineer Disrict, Detroit). A small-scale study was conducted to determine the suitability of clayey fill to be used for reclamation of mined lands 113 km (70 miles) to the north of Duluth. This study was valuable because of the lessons learned in material handling.

- The first consideration was the presence of purple loosestrife, a non-native invasive noxious weed, at Erie Pier (Figure 12a). It is a very hardy perennial that can rapidly degrade wetlands, diminishing their value for wildlife habitat. It is extremely difficult to eradicate since a single adult plant can disperse 2 million seeds annually. Prior to recovery of clayey material for processing, the Corps as a precautionary measure removed the first 0.9 m (3 ft) of material. Since then, mowing and herbicides have been used routinely to combat this species, which is now somewhat under control.
- The second site constraint was trafficability onsite and offsite. The CDF was not trafficable in September 1999; equipment bogged down in the CDF. In February 2000, 2,300 cu m

a. Purple loosestrife

b. Loading material for mine reclamation

Figure 12. Mine reclamation feasibility study

(3,000 cu yd) of material were excavated and stockpiled until April when the material could be processed onsite and the roadways opened to heavy truck traffic (Figure 12b). This entailed handling the material three times, making the technology economically infeasible. A railway adjacent to the site that transfers ore from local mines daily has empty returns. Therefore, the addition of a small rail spur to the site is being evaluated.

The process stream included shaker screens, a hydrocyclone, and a belt filter press. The processing produced a material that was applicable for use in mine land reclamation.

Sand washing demonstration project (Benner, Wu, and Zanko 2001): A demonstration project was designed to treat different types of materials found at the Erie Pier CDF to produce a coarse product (cyclone underflow) that contained less than 12 percent by weight particulates finer than 200 mesh (75 microns). The full report was not available at the time of publication of this technical note; therefore, an overview of the materials handling is discussed, and the physical and chemical laboratory analyses and postprocessing are not presented.

A backhoe fed material from the CDF to the processing plant (Figure 13). Material first passed over a grizzly screen with 15-cm (6-in.) by 1.2-m (4-ft) slots to remove any large rocks or other tramp material. The grizzly undersize went via a series of conveyor belts to a double deck vibrating screen equipped with 25-mm (1-in.) square mesh top screen and 6-mm (0.25-in.) square mesh bottom deck. The main purpose of the double deck screen was to break up clay balls and to remove rocks and vegetation. Water sprays were added to the top deck to assist in breaking up the clay balls. Oversize materials from the two decks were combined and treated as a waste product. Screen undersize and the bulk of the water flowed to a sump where the slurry was pumped to an agitation tank. From the tank, the slurry was pumped to two parallel 25-cm- (10-in.-) diameter Krebbs hydrocyclones. The cyclone overflow was channeled to a series of settling ponds to remove suspended solids and the clear water recycled to the plant. The cyclone underflow was removed by front-end loader and stockpiled for processing through the belt filter press.

Maintaining consistent feed to the unit was a constant problem. Clay balls contained in the feed proved to be more difficult to disagglomerate than expected. Additional wash sprays and belting

Figure 13. Sand washing demonstration processes (photos courtesy of Corps of Engineers)

Figure 14. Vibrating screen with water spray wash and belts to break up clay clods (photo courtesy of Corps of Engineers)

that were placed over the upper screen deck to improve the breakup of the clay balls did not solve the problem (Figure 14). Vegetation from the CDF presented additional problems. It plugged the feed hopper, passed through or sloughed off the grizzly, and generally caught on the top deck, blinding the screens. These problems caused an increase in the volume of oversized material that was discharged and frequent shutdown to clear the various components, greatly limiting the feed rate.

Four CDF material samples were run in the demonstration. Sample 1 was a predominantly sandy material. Little material was rejected by the grizzly, mostly large rocks and occasional wood, but no junk, tire, or scrap metal. The screen oversize consisted primarily of clay balls, rocks, vegetation, pieces of wood, pieces of coal, and taconite pellets. There were a few fishing lures and line, but very few bottles or cans. It was estimated that 70 percent, by volume, of the total material processed as sample 1 was useable sand and 7 percent was oversize from the grizzly and screens. Of the material that was cast off the screens, it is estimated that 65 percent was misplaced material contained in the clay balls.

Sample 2 was fine sediment material selected from the CDF. Little material was rejected by the grizzly. The majority of the grizzly oversize was vegetation and a few rocks, but much less than sample 1 due to the natural separation processes within the CDF. The screen oversize again was predominantly clay balls and vegetation. There was a relatively large amount of vegetation (sticks

and branches), some rocks, coal and taconite pellets, and few cans or bottles. From sample 2, 30 percent of the material was useable sand. It was estimated that 75 percent of the oversize from the screened material in sample 2 was misplaced material contained in the clay balls.

Sample 3 was aborted due to the breakdown of the front-end loader and inability to transport the material to the process unit. The limited run exhibited the same characteristics of the second sample. Sample 4 was a reprocessing of the cyclone underflow from samples 2 and 3. This sample, of course, had no debris problems.

Several conclusions resulted from the study. Fines-rich dredged material can be processed with typical mineral processing equipment to make fines/coarse separation and a saleable coarse product. To produce a potentially saleable soil-type product (a fine sand/silt/clay filter cake), preprocessing to overcome the "clay ball" phenomenon would be necessary. If only a sand fraction is being produced, the clay balls actually reduce the settling area needed in the CDF. Postproject discussions suggested that a combination of grizzlies, shredders, scrubbers, and/or log washers could be successful in breaking the clay clumps.

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Example 5 – Equipment Demonstration at Jones Island CDF. Dredged material at Jones Island CDF in Milwaukee Harbor was heterogeneous in physical and chemical composition because it had come from waterway sources containing industrial discharge, spills, and urban runoff from a wide area over many years. An onsite phytoremediation treatment technology pilot project required screened material to be placed in lined treatment cells. Debris at the site included wood, brick, tires, concrete, and rocks to 30 cm (12 in.) diameter. The CDF had fully trafficable berms. A conventional backhoe was used to excavate material from the CDF and to sort out the very large debris and boulders. The material was transported to a location near the treatment cells.

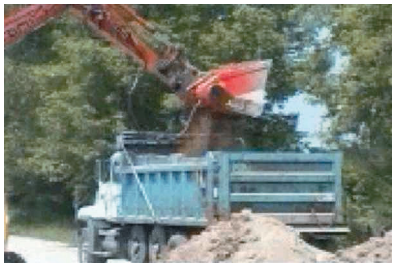
A new shredder/screening device was tested for dredged material size reduction and placement in the cells (Figure 15). North Shore Environmental Construction, Inc., Germantown, WI, developed a shredder mounted on a backhoe arm with the ability to screen and shred a variety of materials to 3.8-cm- (1.5-in.-) diameter and place the materials directly in the cells. Material was placed in the shredder/screen device by backhoe. The backhoe arm would swing over the cell, shredding and screening the material directly into the cells, and then swing back with the oversized rock and debris to be placed in a stockpile or dump truck. The device worked effectively for this special use. It may have wider application in areas where conventional land-based sorting and reduction equipment is limited by space or weight concerns.

Example 6 – Demolition Equipment Demonstration. This technology case study came from a construction demolition project. The equipment tested in this demonstration should be effective in reducing the size of concrete, wood, and other materials in dredged material. The equipment demonstration took place at Fort Campbell, KY, where landfill space was not available and 920,000 cu m (1.2 million cubic yards) of construction debris was projected from the demolition of 400 World War II era structures, over a hundred Korean War era structures, and 1,000 Family

Housing Units. The WW II and Korean War structures were heavily steel reinforced concrete. Other debris included concertina wire, 55-gal drums, tires, and normal current era construction debris.

a. Shredder/screen

b. Placing material into treatment cells



c. Dump truck for debris

Figure 15. Shredder/screen demonstration at the Jones Island CDF (photos courtesy of North Shore Environmental Construction)

Two pieces of equipment were demonstrated: a low-speed, high-torque, pressure-regulated shredder and a mobile wood processing unit. The shredder head had chamber dimensions of 1.1 by 1.9 m (45 by 75 in.), 101-mm (4-in.) teeth, hydraulic-driven twin shafts, and a shaft speed of 17 rpm. The unit also had an infeed hopper ram, twin-cylinder hydraulic ram, and a discharge conveyor with magnetic head pulley. The unit was driven by diesel generators, electric motor, and hydraulic pumps. The shredder had a production rate of 37,000 kg (41 tons) per hour, shredding 7,000 cu m (250,000 cu ft) of heavily reinforced concrete in 2 weeks and recovering 744 kg (0.82 ton) per hour of steel rebar for recycling (Figure 16). Volume reduction was approximately 80 percent, shredding 1,715 cu m (2,243 cu yd) to a final volume of 359 cu m (469 cu yd) while creating relatively little dust. There was a high demand for the coarse aggregate on post for road base, erosion control, tank trails, and forest fire breaks.

The second piece of equipment tested was a mobile wood processing unit (The Tank™ by Bouldin and Lawson), which had a horizontal cutting wheel, quick-change teeth, and sizing grates (Figure 17). It was used for volume reduction of wood and like materials (not mixed debris). The integrated mobile system is housed on a semi trailer that was 15 m (48.5 ft) long and 2.6 m (102 in.) wide, and had a low profile. The system was made up of an infeed hopper with a 2.6-m (8.5-ft) by 3.7-m (12-ft) opening, a rotating tank, horizontal flywheel cutting mechanism with quick-change teeth, a folding variable speed discharge conveyor, a 6.7-m (22-ft) boom that telescopes to 8 m (27 ft), with a lift capacity of 2,300 kg (5,000 lb) at 8 m (27 ft). The unit was hydraulically powered by a 525-hp Cummins diesel engine. The weight with loader was approximately 36,000 kg (78,800 lb).

The shredder technology appears to be appropriate for use in reducing the size of large debris (concrete, wood wharfs, etc.) found in dredged material. A mobile unit has been developed. However, the equipment is extremely heavy and may not be suitable for many CDF sites without established roadways or other trafficable surfaces. Also, there would have to be significant mixed wastes at a single site to make this equipment economically feasible. The Wood Processor is mobile,

a. Low-speed, high-torque shredder

b. Preprocessed concrete debris

c. Postprocessed concrete

Figure 16. Demolition equipment (photos courtesy of Corps of Engineers)

a. Mobile wood processor

b. Wood processor shredding wheel

Figure 17. Mobile wood processing unit (photos courtesy of WasteAway, Bouldin and Lawson)

easily set up, and should be applicable for wood waste reduction at CDFs if there is a significant need.

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SUMMARY: The useful life of a CDF can be extended by removing dredged material for application to beneficial uses. The composition of dredged sediments in CDFs reflects several factors, including the watershed in which dredging takes place, local land use activities, and method of disposal with mechanical or hydraulic dredges. Mechanical dredges pick up relatively undisturbed loads of sediment that can include debris, while trash may be present in both mechanically and hydraulically dredged sediments.

CDF material processing plants usually consist of a series of units. A grizzly unit is commonly used at the beginning of the processing train to separate large debris and trash, although a rake in a scow could be used for this purpose. The use of other types of equipment in the processing train such as trommels, vibrating screens, or shredders depends on the composition of the dredged material, the chosen end use, and the presence of contaminants that may require remediation.

Examples are presented illustrating debris and trash removal during sand and gravel reclamation, topsoil production, and construction fill development. A variety of equipment and methods are available for reclamation of CDFs having dredged materials with diverse physical and chemical characteristics and different end uses.

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