EXPLORING INNOVATIVE REUSE OF DREDGED MATERIAL FROM BALTIMORE HARBOR

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ABSTRACT
A modern approach to dredged material management has been adopted at the Port of Baltimore. This practice is termed “innovative reuse,” and is intended to convert dredged material into a usable resource instead of being relocated in landfills. In Maryland, innovative reuse is defined as recycling of dredged material so that it can be substituted for other raw materials—or in combination with them—for manufacturing, construction, and reclamation projects (MPA 2010). Examples of innovative reuse include: capping a landfill or Brownfield, incorporating dredged material into lightweight aggregates, reclaiming lands impaired by sand, gravel, and coal mining, manufacturing bricks and blocks, enhancing degraded farm land, producing manufactured topsoil, and creating fill for construction projects (Francingues and Thompson 2005).

In 2001, the state’s Dredged Material Management Act named innovative reuse as one of the top priorities for the future management of contaminated dredged material. The Maryland Port Administration (MPA) published a 2007 report titled “Innovative Reuse of Dredged Material” (IRC 2007). The report discusses several hurdles that must be cleared before innovative reuse can succeed in Maryland. These are sediment quality, regulatory issues, public acceptance, and cost.

The primary purpose of this paper will be to describe how MPA is overcoming these challenges through the funding of demonstration projects to explore how well a variety of vendors can launch and manage innovative reuse projects at a reasonable cost. This paper will specifically describe the status of the ongoing IR program for processing dredged material into innovative intermediate use products, the demonstrations, and present the results of a marketing assessment for Lightweight Aggregate (LWA) produced from Baltimore Harbor dredged material.

Keywords: Innovative reuse, beneficial use, dredging, dredged material disposal, contaminated sediment.

INTRODUCTION
Maintaining safe passage to and from the Port of Baltimore requires dredging an average of 3.5 million cubic meters (m³) 4.7 [million cubic yards (MCY)] of sediment annually from the Baltimore Harbor and its approach channels. For over twenty years, all of the dredged material deemed contaminated by state law was hauled and placed in the Hart Miller Island (HMI) Dredged Material Containment Facility (DMCF). On December 31, 2009, by law the HMI DMCF ceased to be an operational placement site and has been undergoing conditioning and restoration as a wildlife habitat as part of the Maryland Department of Natural Resources Hart Miller Island Park System.

Unfortunately, the closure of Hart Miller has left a 382,277 m³ [500,000 cubic yard (cy)] shortfall of placement site capacity for the annual dredging need of Baltimore Harbor. Nearly 1.15 million m³ [1.5 MCY] of legally defined contaminated sediments, 764,554 million m³ [1.0 MCY] of which is maintenance, is dredged annually from Baltimore Harbor and must be placed in DMCFs or hauled to upland disposal sites. MPA currently operates only two placement sites, Cox Creek and Masonville, which combined can accept only 764,554 million m³ [1.0 MCY] of the entire annual dredging volume without premature filling. Although MPA is seeking to identify and permit additional DMCFs, it will take considerable time to bring this much needed additional capacity online. Therefore, innovative reuse may become not only a long-term but also a short-term strategy as part of the MPA’s dredged material management plan.
INNOVATIVE REUSE PROGRAM STATUS

The Maryland Port Administration (MPA) and its partners are exploring methods of innovative reuse that may increasingly transform dredged material from a problem into a resource (MPA 2010). MPA has been exploring innovative reuse as an alternative means of offsetting the 382,277 m$^3$ [500,000 cy] shortfall in disposal site capacity in nearshore DMCFs and island containment sites. In 2006, MPA formed a committee to explore innovative reuse options. The Innovative Reuse Committee (IRC) released a 2007 report titled Innovative Reuse of Dredged Material (IRC 2007). The IRC made three recommendations:

1. The MPA and its DMMP partners should consider implementing at least one pilot or demonstration project.
2. The MPA and its DMMP partners should develop an implementation strategy for the innovative reuse of dredged material.
3. The State of Maryland should conduct a broad review of its policies and regulations affecting dredging.

The report recommends examining which if any of the applications are viable in Maryland. It also asserts that innovative reuse could address at least 382,277 m$^3$ [500,000 cy] of dredged material each year. The potential exists to increase that amount substantially notwithstanding considerable obstacles.

Challenges for Innovative Reuse

The IRC identified several hurdles that must be cleared before innovative reuse can succeed in Maryland.

Sediment Quality

Baltimore Harbor has long been home to heavy industry, ship-building, and manufacturing. It is also a transportation hub, a depot, and the collecting basin for major sewage, stormwater, and urban stream outfalls. All of these activities have left pollutants buried in the sediment. However, sediment from some areas of the harbor is relatively clean. This is the combined result of regular dredging, less industrial activity, and stricter environmental regulations. Unfortunately, the public views all dredged material within the harbor as contaminated.

Regulatory Issues

Most if not all innovative reuse of dredged material would require approval from the Maryland Department of the Environment (MDE). Approval would be issued based on the potential impact of the projects. While MDE has not identified any major concerns in the array of applications suggested by the innovative reuse committee, navigating the permit process could still be a challenge for anyone interested in launching an innovative reuse project. Demonstration projects are underway to test, among other things, the ability of dredged material to meet state requirements in various innovative applications.

Public Acceptance

The general public mistakenly views dredged material as nothing more than contaminated waste. Citizens and even scientists sometimes fail to distinguish between the variations in sediment quality, viewing all dredged material as contaminated waste. They are therefore reluctant to use harbor sediment in upland locations. Finding communities that will allow the use of dredged material near their towns or cities may require a significant outreach effort.

Cost

Some ports have had success with innovative reuse, but the economics are challenging. Drying, transporting, and blending dredged material with amendments can add significant costs to the final product. In Germany, for example, a facility produced bricks from dredged material, but the customers couldn’t afford to buy them. Maryland is examining ways to make innovative reuse affordable. Vigilance in containing costs and maximizing the benefits will be essential for any innovative reuse plan. Cost is a big factor in the demonstration projects currently underway.

IRC Activities

The IRC identified six broad categories of innovative reuse: landfill (daily cover), landscaping (topsoil), agricultural (amendment to farmland), reclamation (mines, Brownfields), engineered fill (roads, embankments), and building materials (bricks, blocks, LWA, cement, flowable fill). In response to the recommendations of the IRC to demonstrate innovative reuse the MPA has done the following:

- A request for proposals (RFP) was advertised in August 2007 that invited participation by all parties and processes. The RFP remains open and terminates at MPA’s discretion.
The first demonstration contract was approved December 17, 2008 for Schnabel Engineering from Baltimore to manufacture general or bulk embankment and structural fills using dredged material and slag fines.

The second pilot demonstration contract was awarded to HarborRock LLC, on March 18, 2009, to test dredged material from Cox Creek for potential to manufacture commercial Light Weight Aggregate (LWA). The project consisted of laboratory and pilot testing, economic, and market analysis of Lightweight Aggregate (LWA) production.

The third demonstration project was initiated in December 2009, after a right of entry was signed with Weanack Land, LLLP (Weanack) and Sevenson Environmental Services, Inc. Dredged material was removed from Cox Creek and transported by truck to perform pilot-scale demonstration project to render the material suitable for larger scale upland placement and agricultural use.

DEMONSTRATIONS

The three demonstration projects identified above are currently ongoing and scheduled for completion in 2011. Two projects are exploring the use of dredged material for construction products and the other is evaluating the requirements for conditioning dredged material for reclamation of historical sand and gravel mines. These demonstrations will hopefully answer many questions regarding the challenges that lie ahead.

Shirley Plantation at Port Weanack

Shirley Plantation is Virginia’s oldest operating plantation and oldest family business dating from 1638. Port Weanack is the James River port located at Shirley Plantation. Historically, a number of projects have been dredged and material hauled by truck and barge to Shirley Plantation for site reclamation (Table 1). These projects include:

- Woodrow Wilson Bridge completed 2004 – 382,277 m³ [500,000 cy]
- Earle Naval Weapons Station completed 2007 – 229 366 m³ (300,000 cy)
- Cheatham project – completed July 2010 – 53,520 [70,000 cy]
- James River (various) projects 1960s – 2008
- Cox Creek Dredged Material – 181 metric tons [200 tons] excavated & hauled by trucks to Shirley Plantation in December 2009

Table 1. Shirley Plantation Site Features

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<th>Feature</th>
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<tr>
<td>40+ years of sand &amp; gravel mining</td>
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<td>Natural layers of sand, gravel and mined down to layer of clay underlying the sites acting to protect the groundwater</td>
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<tr>
<td>Mining yielded low productivity agricultural soils</td>
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<tr>
<td>Reclamation of mined areas using dredged material</td>
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<td>Goal is to restore agricultural soils to higher productivity</td>
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Dredged material from the Cox Creek DMCF was hauled to Shirley Plantation on the James River in Virginia for testing and evaluation as potential media to restore agricultural land at mined-out sand and gravel pits. This project is a no-cost (to MPA) demonstration using 181 Metric Tons [200 U.S. Tons] of dredged material from Cox Creek. The goal of the demonstration is to indicate how well dredged material performs as a soil amendment to improve land for agriculture.

The following excerpt was taken from a presentation by Dr. Lee Daniels (2011) at the 2011 Battelle Sediment Remediation Conference in New Orleans, LA.

“Maryland Ports Authority (MPA) sediments arrived in November 2009 with a potential acidity by hydrogen peroxide (H₂O₂) oxidation equal to 10 tons Cation Exchange Capacity (CCE)/1000 tons and potential acidity by acid-base-accounting equal to +30 tons CCE/1000 tons. The initial pH was 7.8 and the CCE was equal to 7.1%. MPA materials placed in into three test cells in April 2010 with either 12.5 Mg CCE/1000 Mg of bulk-mixed lime, layered lime or no lime added. In May the pH dropped to 4.0 and the CCE to 3.0%; obviously, something reacted. Grasses
germinated, but quickly died out as summer progressed. The surface was heavily mulched and acid/salt tolerant species were used. Similar results occurred with a fall seeding. Significant oxidation and acidification of Baltimore Harbor dredged materials can occur in situ during covered storage over a period of several months. Initially, saline origin materials will generate very high pore water and leachate salinity (EC) values due to entrained chlorides, but over time these will be replaced by sulfates and the salinity in sulfidic materials will remain high for much longer than expected. Monitoring is ongoing to determine how long and what measures will be needed to produce a soil that will support target vegetation.”

Shirley Plantation offers significant potential placement site capacities for reclamation of the sand and gravel mines. Currently, permits issued by the Virginia Department of Environmental Quality (VADEQ) are in place and the diked capacity at Shirley Plantation is 764,554 million m³ [1.0 MCY]. That capacity could be doubled within a year by raising the existing dikes. There is also the potential for up to 30.6 million m³ [40 MCY] in additional capacity at other sites within the James River Basin in the vicinity of Shirley Plantation. Unfortunately, the transportation distance is about 740 kilometers [460 miles] round trip from Baltimore Harbor dredging sites to Port Weanack, making Shirley Plantation a potential higher cost option than current placement options (Cox Creek and Masonville). Actual costs to reclaim sites at Shirley Plantation for up to 382,277 m³ [500,000 cy] are currently under investigation.

Construction Fill at Cox Creek DMCF

Schnabel Engineering (Baltimore, MD) is conducting a project at the Cox Creek DMCF to demonstrate the feasibility of blending dredged material with steel slag fines to produce a fill material for road construction. Schnabel Engineering was awarded a three phase project to develop and test DM-steel slag fines (SSF) blends for local fill construction uses including:

1. Phase I - Preliminary Activities
2. Phase II - DM-SSF Blend Laboratory Study
3. Phase III - Field Demonstration Project

Material Sources and Characteristics of Test Piles

Cox Creek dredged material samples were collected from the “Volvo Area” in the North Cell. Laboratory samples were taken in February 2009 mostly from the south end of the Volvo Area. Field samples were collected in July 2010 from the northern end of the “Volvo Area” in the North Cell. The bulk of the DM was collected in the vicinity of the outfall area. The SSF were collected from Sparrows Point Steel Mill Complex and 8,468 Metric Tons [9,335 U.S. tons] of 10 mm [3/8-inch] minus SSF trucked to Cox Creek for subsequent construction of the demonstration test embankments. Five test embankments 3.7 m x 3.7 m x 15.2 m [12 ft x 12 ft x 50 ft] top deck with 2:1 slopes) were constructed using 20.3 cm [8-inch] loose lifts that were compacted in place.

Key findings

Malasavage, et al (2011), reported the following:

“The granular nature (3/8-inch minus), mineralogy, reactivity and residual lime contents of the SSF media make it well suited for blending with DM (OH soil), so that geotechnical and environmental soil improvement occur simultaneously with one material (SSF; SW soil). The source materials (100% DM, 100% SSF) were evaluated along with the 80/20, 60/40, 50/50, 40/60 and 20/80 DM-SSF blends (dry weight basis), where the DM content is reported first. The 100% DM had a $\phi'_{CI}$ (triaxial shear) of 27.3° which increased to a peak $\phi'_{CI}$ value of 45° for the 50/50 DM-SSF blend. The hydraulic conductivity (k) of the 100% DM (10-8 cm/s) remained relatively constant but finally increased to 10^{-5} cm/s when the SSF content reached 80%. The field demonstration project confirmed that the DM-SSF blends could be easily blended to within ±5% of their target DM content.

Trial highway embankments were constructed with the 100% DM, 100% SSF and the 80/20, 50/50 and 20/80 DM-SSF blends to modified Proctor compaction goals ranging from 85 to 95% relative compaction on the maximum dry unit weight, depending on the blend. The average CPT tip resistance for 100% DM and 100% SSF media were approximately 57.3 MPa (megapascal)
and 1.3 MPa, respectively. The compacted 20/80, 50/50, and 80/20 DMSSF blend embankments were generally characterized by average CPT tip resistances on the order of 2.9, 6.2 and 11.6 MPa, respectively."

In another paper on aging effects of dredged material and SSF blends, Grubb et al (2011) reported:

"Compacted DM-SSF blends cured up to 360 days were tested for their unconfined compressive strengths (UCS; ASTM D1633), pH, totals arsenic (As) concentrations and As leaching by the toxicity characteristic leaching procedure (TCLP) and synthetic precipitation leaching procedure (SPLP). DM-SSF blends containing greater than 50% SSF media had UCS values greater than 20 lb/in². The DM-SSF blends were characterized by initial pH values between 9 and 12.5 that were gradually reduced to 7<pH<11.5 by 360 days. Neither the 100% DM nor any of the DM-SSF blends were associated with detectable TCLP-As (<0.111 mg/L) or SPLP-As (<0.056 mg/L) concentrations at any time, despite the 100% DM containing approximately 45 mg/kg As."

Field monitoring of environmental quality is being conducted by the Maryland Environmental Service (MES). Table 2 presents the major components of the environmental monitoring plan for the test embankments. Results of the physical testing and environmental quality monitoring will be reported separately at the end of the project in December 2011.

**Status of the Schnabel Demonstration Project:**

- Five embankments were successfully constructed at Cox Creek
- Based on initial field testing, DM-SSF blends are comparable or superior to conventional soils used for embankment construction
- Monitoring is under way and will be completed by September 2011
- Project completion and final report are scheduled December 31, 2011
- An independent market analysis will be conducted in 2012
Lightweight Aggregate (LWA)

The other demonstration of construction products manufactured from dredged material is being conducted by HarborRock®, Inc. The HarborRock® technology incorporates the processing of dredged material in a high temperature kiln to produce light weight aggregate (LWA). The HarborRock® pilot test program was designed to: (1) demonstrate the feasibility of producing a high-quality lightweight aggregate from dredged material collected from the Cox Creek DMCF; (2) produce sufficient product to support standard ASTM tests; (3) collect process and emission data required to design a commercial LWA production facility in a severe non-attainment zone and; (4) to evaluate commercialization of the process in terms of equipment selection, Capital Expense (CAPEX) and Operating Expense (OPEX).

Test program objectives were:

- Develop mass and energy balances
- Quantify air emissions, and
- Assess the quality of the LWA produced with respect to market requirements

The pilot tests completed in 2010 produced a high quality LWA that met ASTM 330 requirements (Standard Specification for Lightweight Aggregates for Structural Concrete) and ASTM 331 requirements (Standard Specification for Lightweight Aggregates for Masonry Units). The emissions results were positive indicating severe non-attainment goals can be met; and, a significant database was generated to support equipment selection, full-scale design and preparation of CAPEX and OPEX estimates.

Based on the promising results, MPA decided in late 2010, to request additional evaluations in a Phase II by HarborRock® to answer three questions:

1. Would the HarborRock® LWA produced from the Cox Creek CDF dredged material make marketable lightweight concrete blocks?
2. How would the HarborRock® dredged material excavation activities from Cox Creek North and South Cells coincide with the operation of the Cox Creek CDF? And
3. Could HarborRock® make smaller extrusions of dredged material to potentially create smaller LWA minimizing post-processing crushing and sizing requirements?

Phase II evaluations were completed in early 2011. HarborRock® subcontracted with the National Concrete Masonry Association (NCMA) to manufacture concrete blocks using LWA produced from Cox Creek dredged material. NCMA also sought input from a large regional block manufacturer. The initial results from this effort indicate that LWA produced from the Cox Creek CDF will make an excellent lightweight block and meet all requirements for ASTM C 90 requirements (Standard Specification for Loadbearing Concrete Masonry Units). HarborRock also consulted with a portable hydraulic dredge manufacturer located in Baltimore, MD and confirmed that a hydraulic dredge could be operated in the DMCF concurrently with ongoing filling operations. This would require close coordination with the Cox Creek operators and may potentially make the HarborRock® dredged material excavation process more efficient. Lastly, the bench testing performed on smaller extrusions proved that LWA of suitable strength and weight characteristics could be made which also warranted the more detailed evaluation as a potential post-processing cost savings measure.

A Phase III effort is currently underway to refine the dewatering process to be used on the hydraulically dredged slurry from rehandling of the dredged material from the DMCF. A detailed evaluation is being done to ensure that the dewatered sediment slurry will meet HarborRock® process requirements to the maximum extent possible using mechanical filtration, preferably without the addition of polymers. The goal is to produce a drier material that will require less thermal energy to achieve the ultimate desired moisture content for extrusion of the material.

In summary, the HarborRock® LWA demonstration project has:

- Determined mass balances and energy requirements
- Obtained air emissions data for design of air pollution control systems
- Obtained chemical concentrations in LWA samples
- Confirmed the construction quality of the LWA meets all applicable ASTM standards
- Identified a dredging technique for removal of the dredged material directly from the DMCF cells
- Completed manufactured block testing by the National Concrete Masonry Association (NCMA)
Developed a method for the extrusion of smaller pellets resulting in smaller diameter LWA

Marketing Analysis for LWA

The goal of the LWA demonstration project has been to process fine-grained dredged material from Cox Creek to produce a marketable product. The LWA produced by HarborRock® from Cox Creek dredged material samples appears to be highly marketable based upon an independent market analysis that was conducted by McCormick Taylor, Inc. (2010) for the MPA to determine:

- Average costs for lightweight aggregate and other competitive products
- Estimated quantities of lightweight aggregate supply and demand
- Existing competitors in the marketplace
- Potential constraints such as permitting, specification requirements, etc.
- Strongest market potential for anticipated end-use of lightweight aggregates
- Adaptability of existing market and/or potential to absorb a new product line

The methodology used by McCormick Taylor, Inc. for the marketing analysis is shown in Table 3.

Table 3. Marketing Analysis Methodology

<table>
<thead>
<tr>
<th>Interview Local Industry Representatives</th>
<th>Compare Responses</th>
<th>Develop Recommendations</th>
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</thead>
<tbody>
<tr>
<td>Concrete Block Manufacturers</td>
<td>Identify Competition</td>
<td>Testing &amp; Approvals</td>
</tr>
<tr>
<td>Lightweight Concrete Manufacturers</td>
<td>Quantities and Costs</td>
<td>Targeted Markets</td>
</tr>
<tr>
<td>Cement Manufacturers</td>
<td>Typical Uses</td>
<td>Targeted Price Range</td>
</tr>
<tr>
<td>Concrete and Cement Precasters</td>
<td>Desired Characteristics</td>
<td>Targeted Quantities</td>
</tr>
<tr>
<td>Construction Agencies</td>
<td>Most Promising Markets</td>
<td></td>
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<tr>
<td>Construction Contractors</td>
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<td></td>
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<tr>
<td>Designers and Engineers</td>
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*Focus on Central Maryland*

Figure 1 presents the average weight of LWA per ft³ determined from the market survey. Note that HarborRock® LWA at 1.2 metric tons / m³ [37 tons/ft³] is the lightest of the potentially available LWAs. In addition, the HarborRock® LWA, estimated at $57/ton in Figure 2, falls below the median cost per ton of $67.50.

Market Summary - Quantity Estimates for Central Maryland Users

- Total quantity range from all respondents equals 287 to 380 metric tons [318,165 to 420,005 tons] annually.
- Over half of the local consumption is in concrete block.
- Additional users exist in Central Maryland marketplace, and not all respondents shared their quantity and cost information.
- Additional markets may include Eastern Shore, Western Maryland, DC, Northern Virginia, Delaware, and Southeastern Pennsylvania.
- All respondents noted that Central Maryland had a strong market for LWA, and there are no local producers. The product would be competitive within a 161 kilometer [100 mile] radius of the manufacturing site - if it meets all the required industry standards.
- Many respondents also noted that the potential for Leadership in Energy and Environmental Design (LEED) certification points was highly desirable.

The HarborRock® LWA product would be competitive in local markets if it meets all industry standards, remains cost competitive, has consistent quality and sufficient supply, and is accepted for LEED certification. Additionally, local LWA markets are strong, particularly with manufacturing of concrete blocks. Demand for lightweight concrete is inconsistent, but large enough to be a targeted market, and demand for use in landscape applications or architectural precasting is growing, but may be erratic. The product may help projects increase points towards LEED certification, which will make it more desirable and competitive.
The next step for MPA in assessing the potential for incorporating innovative reuse in their dredged material management strategy is to answer the question: Should the MPA provide an integrated dredged material processing facility that will pre-condition the dredged material to a suitable physical or chemical state for commercial vendors of innovative reuse technologies? The flow chart in Figure 3 illustrates the basic steps for processing of dredged material into a marketable product. Re-handling and pre-conditioning such as screening and dewatering are key steps in processing dredged material prior to any of the vendor technologies. As a result, it would probably prove more economical in the case of multiple technologies to develop a common, integrated facility including pre-processing of dredged material.
In anticipation that providing an integrated dredged material processing facility is determined to be the most cost effective approach, MPA developed a set of preliminary criteria for such a facility. The facility should be:

- Capable of receiving dredged materials of varying physical & chemical quality that can be further processed by one or more IR technologies
- Tailored to meet specific processing requirements and specific end products and their uses
- Sized for processing and stockpiling needs (20.2+ hectares [50+ acres], 382,277 m³ [500,000 cy] annually)
- Capable of receiving and processing dredged material directly from a DMCF
- Capable of processing (mixing and screening) of the conditioned dredged material requiring multiple unit operations
- Capable of obtaining necessary environmental quality and construction permits

A related question to be answered is: Would having a facility dedicated to processing dredged material for innovative reuse make it a more viable component of a long-range dredged material management strategy for Harbor material? The obvious answer to this question is that it would have to become part of a long-term strategy in order to make the implementation of a dedicated facility viable both economically and environmentally.

**CONCLUSIONS**

MPA continues to strive for a comprehensive dredged material management program, including both beneficial uses and innovative reuses of dredged materials. Presently, there is no demonstrated innovative reuse option available to replace existing methods of placement (nearshore confinement) of contaminated dredged material at a competitive cost. MPA has searched and continues to search for implementable innovative reuse solutions in an ever increasing global economy. Part of their search strategy has been the selection of three demonstration projects ranging from environmental restoration of sand and gravel mines, incorporation of dredged material with a steel manufacturing byproduct (slag fines) for construction fill, and production of a lightweight aggregate as an intermediary in various construction products. Together, these successful demonstrations should advance the effort to ensure that innovative reuse becomes an acceptable and affordable part of Maryland’s dredged material management program.

However, it is important that MPA addresses all components of the dredging process train to ensure that innovative reuse will become a viable part of their long-range dredged material management strategy. This is a very complex decision process and will require conquering many remaining hurdles before innovative reuse can be fully implemented. Several key issues remaining for IR implementation include:

- Characteristics of Harbor Dredged Material
Sediments inside the North Point to Rock Point line are legally defined as contaminated but not all of these sediments pose environmental risks.

- The physical nature is mostly fine-grained sediment which makes processing for IR more costly than traditional placement options.

**Long-term Commitment**
- Does a dedicated DM Processing Facility make sense for the Port? If so, there has to be a long-term commitment to infrastructure, procurement, and financial resources.

**Markets and Costs**
- Is there demand for products at an affordable cost?
- Is the cost competitive with current management costs?
- Can MPA provide a suitable size footprint for processing (20.2+ hectares [50+ acres], 382,277 m³ [500,000 cy] annually)

**Permits**
- Will the Maryland Department of Environment issue a general innovative reuse permit? Or, will permits be processed on case-by-case basis?

**Stakeholder and Citizen Support**
- Are citizens willing to support a DMCF permitted with an integrated innovative reuse technology processing capability?

**ACKNOWLEDGMENTS**

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**REFERENCES**


**CITATION**