# The Use of Sediment Decontamination Technologies for the Management of Contaminated Navigational Dredged Materials

W. Scott Douglas and Eric A. Stern

**Abstract**

The management of dredged materials in the Port of New York and New Jersey (USA) has posed considerable challenges due to extensive historical and ongoing pollution from point and non-point sources. Excessive contamination of sediments by PCBs, dioxins/furans and chlorinated pesticides has resulted in severely restricting the ocean disposal of dredged materials, threatening the Corps navigational dredging program and, with it, the $29 billion economic engine of the PANYNJ. Costs of dredging and disposal have increased dramatically. As part of an overall alternative management planning program, the USEPA, USACE, USDOE (Brookhaven National Laboratory), and the State of New Jersey have designed and implemented a program to evaluate the efficacy of sediment decontamination technologies to manage navigational dredged materials. Technologies in the program include thermal destruction (plasma arc vitrification, and rotary kiln), sediment washing, chemical oxidation, enhanced mineralization and various combinations thereof. All proposed techniques include the manufacture of a value-added or "beneficial use" product such as topsoil, lightweight aggregate, construction-grade cement, or architectural glass tile. This "environmental manufacturing" has the potential to defray the costs of the decontamination process and provide much needed construction materials for regional development. Environmental manufacturing in this manner has the added benefit of continually renewing capacity for the management of dredged materials. Success criteria for pilot and full-scale demonstration projects are a combination of material handling, decontamination efficiency, sediment throughput, beneficial use, and economics. Bench scale results indicate that thermal destruction and sediment washing are the most likely to be successful on a large scale. Pilot scale results of all technologies will be discussed as well as a detailed plan of one or more full-scale demonstration projects.

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## Background

The Port of New York and New Jersey is situated in the metropolitan center of the Hudson-Raritan Estuary complex (Figure 1). The NY/NJ Harbor complex is naturally shallow, with an average depth of 19 feet at low tide. The Port of NY and NJ is the largest on the East coast, and the third largest in North America, providing the region with $30 billion in annual direct and indirect benefits. It is also the largest petroleum distribution point in the United States. Due to the Port's strategic position in regional and international trade, the U.S. Army Corps of Engineers (USACE) has provided some 250 miles of engineered waterways at depths ranging from 20 to 45 feet. Plans are underway to deepen the main channels to 50 to 55 feet in this decade. Maintenance of these waterways, so crucial to safe navigation, requires dredging of 4-6 million cubic yards of sediment, or "dredged material" annually. Unfortunately, the proximity to heavily industrialized urban land use, coupled with historical and ongoing discharges, has resulted in a legacy of contaminated sediments.

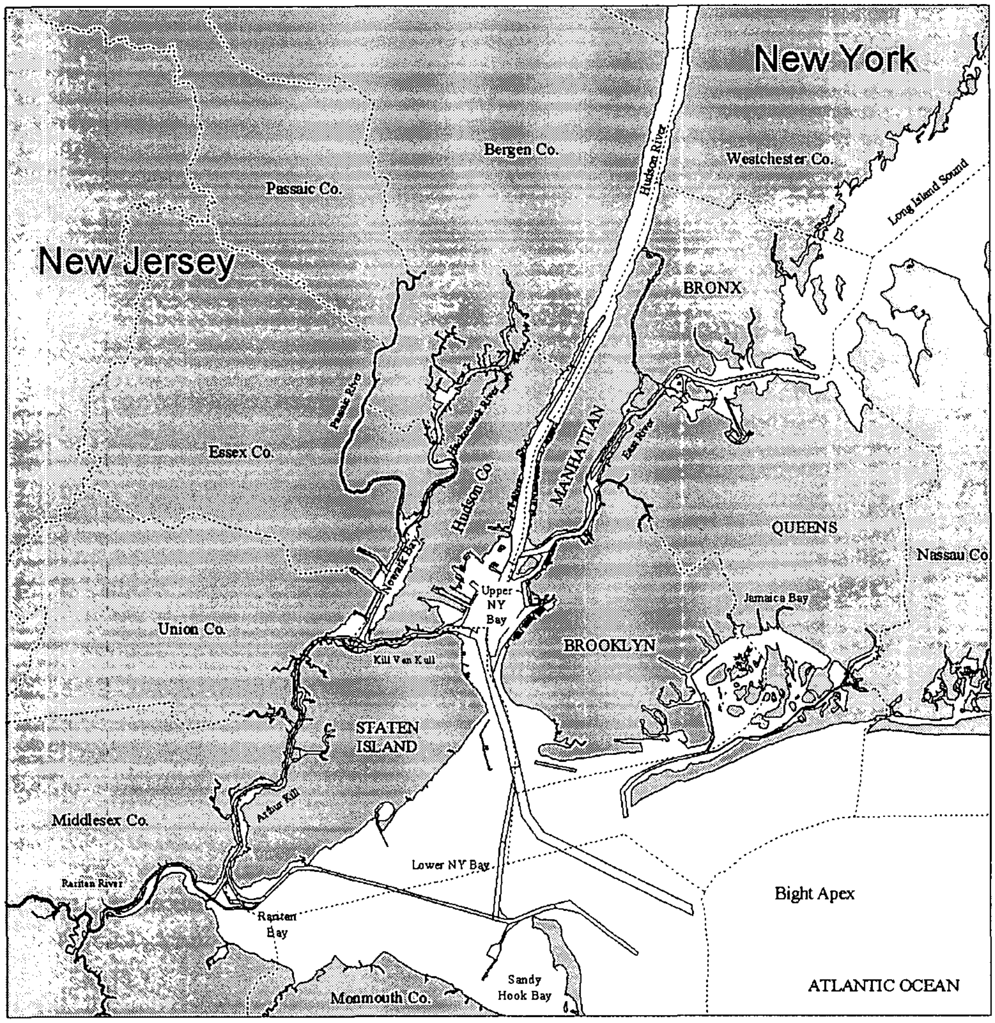


**Figure 1**. New York/New Jersey Harbor Estuary, USA

Historically, dredged materials from the channels and berths in the Port were dumped in the ocean. Following the London Convention, the USEPA directed materials suitable for ocean disposal to be placed at a 2 nautical square mile area off Sandy Hook, New Jersey, in the coastal Atlantic Ocean. This site has been known locally as the "Mud Dump". While these disposal events were closely monitored, the vast majority of sediments proposed for disposal were deemed suitable. Modifications to the ocean disposal testing requirements in 1991 resulted in more stringent testing requirements for materials proposed for disposal at the site (USEPA/USACE, 1991 and USEPA/USACE, 1992). Despite the increased scrutiny given to material, the United States Environmental Protection Agency (USEPA) closed the Mud Dump to dredged materials in 1997. The area within and surrounding the Mud Dump was immediately re-designated the Historic Area Remediation Site (HARS) (USEPA, 1997). Only dredged materials meeting the strict criteria of "remediation material" are permitted for placement at the site. The result of this action was not only a significant decrease in the volume of dredged material being disposed of in the ocean, but also an inability to cost-effectively manage over 75% of the regions dredged materials. What was once a business cost of $5 - $10 per yard skyrocketed to over $100 per yard overnight. The region's maritime industry reeled and dredging all but ceased.

Given the practical necessity and economic importance of the Port, there was no option but to find immediate solutions to the crisis. Both the State of NJ and the federal government mobilized dollars to evaluate potential alternatives to ocean disposal. In the meantime, material was shipped long distances to be disposed in secure landfills at a cost of over $118 per cubic yard. The Port Authority of New York and New Jersey (PANYNJ) and the State of New Jersey began engineering a 1.5 million cubic yard (mcy) confined aquatic disposal facility in Newark Bay, NJ (the Newark Bay CDF). The State of New Jersey, under the direction of the NJ Department of Environmental Protection (NJDEP) and the newly formed NJ Maritime Resources, marshaled in a program to utilize amended dredged materials to remediate brownfields and landfills. Over the last five years, these programs and initiatives have resulted in stabilizing the price of dredged materials management, and provided assurances that dredged materials would have a home. Still, prices are approximately 5 to 10 times higher than before and the disposal capacity is still short term. There are a finite number of disposal options available, regardless of how environmentally appropriate the use.

In order to provide long-term stability for the Port community, a way is needed to change the view of dredged material as a waste to a new view of dredged materials as a valuable resource. One of the most intriguing suggestions to resolve this problem is to utilize sediment decontamination technologies. Technology for cleaning soils and sediments has, in fact, been used successfully in USEPA's Superfund program, but the costs have been quite high, in some cases as high as $1000 per cubic yard. The reasons for these costs are many, but certainly the temporary nature of remedial projects plays an important role. The facilities for these projects are temporary by nature, assume a highly technical professional labor force, are usually small volume projects, and have no beneficial use component. If sediment decontamination technology can be coupled with the production of a value-added product and the nearly unlimited availability of a high-quality feedstock (navigational dredged material), perhaps the costs of the decontamination processes can be reduced to those affordable to the dredging community. We term this concept, "environmental manufacturing". The purpose of this paper is to introduce the reader to the concept of environmental manufacturing, the technologies being fostered in the Port, and the results of the evaluation program to date.

**WRDA Sediment Decontamination Program**

The United States Environmental Protection Agency (USEPA) Region 2 and the United States Army Corps of Engineers (USACE) New York District, under authorization from the Federal Water Resources Development Act (WRDA) of 1992, began to examine the feasibility for decontaminating sediment in the Port of NY/NJ as early as 1992. In order to assist in relieving the navigational dredging crisis, these technologies would need to demonstrate sediment decontamination at an environmentally and economically acceptable level. The charge of the congressional authorization was to evaluate those technologies that would both have the greatest potential for commercial scale-up applications at the level of 500,000 cubic yards per year (cy/yr) and would have a marketable end-product (beneficial use). The United States Department of Energy (USDOE)- Brookhaven National Laboratory was contracted by the USEPA to solicit proposals from the private sector and adminster the program. Proposals were solicited in 1994. Under this program, a successful bidder could move forward with built-in contract options, based on performance standards, from bench through pilot-scale testing all the way up to commercial scale applications. Firms needed to demonstrate treatment efficiencies based on a contaminant matrix of inorganics and organics typically found in navigational harbor dredging. Out of a potential bidder list of 150 technologies, 24 formal proposals were received. Seven companies were selected for the initial bench-scale testing. Five companies moved on to pilot-scale testing. These pilot projects were required to demonstrate a "treatment train" approach that covered all aspects of sediment management from materials handling, decontamination, and beneficial use of the post-treated product. The WRDA Program in 2002 has progressed to the stage where full and commercial-scale demonstrations are underway. To date, approximately $20 million has been appropriated to this program.

**New Jersey Sediment Decontamination Program**

With incremental progress being made under the WRDA Program, the State of New Jersey also became interested in sediment decontamination as a potential solution to the dredged materials management crisis. Recognizing the effectiveness of the WRDA program, New Jersey agreed to integrate its program with the Federal program to test viable technologies at the field demonstration and commercial level. To determine the level of interest and commercial viability of technologies, the New Jersey Department of Transportation Office of Maritime Resources (then under the Department of Commerce) solicited proposals from the private sector for a two-stage program. Stage one would be a small-scale pilot of at least 200 gallons, followed by a stage two large-scale demonstration of between 30,000 and 150,000 cubic yards.

Given the potential for a large number of proposals, a formal selection process was required. Proposals were to be reviewed by a multi-agency technical panel of experts, selected by the Office of Maritime Resources (OMR) and then approved by the Dredging Project Facilitation Task Force (DPFTF). The DPFTF is a group of regional stakeholders appointed by then New Jersey Governor Christine Todd Whitman to approve projects to be funded by the 1996 Harbor Revitalization and Dredging Bond Act. The Office of Maritime Resources (OMR) would administer the program and the funds. Proponents of decontamination technologies needed to show that their environmental manufacturing model had the potential to provide meaningful relief to the navigational dredging program by demonstrating the following abilities:

1) be economically viable at a cost of $35/cyd or less;
2) be able to handle 5,000 cyd/day and process a minimum of 500,000 cyd per year; and
3) be able to produce a product that has a demonstrated market in the region.

Proposals that met these criteria were evaluated by the technical review committee for the potential to meet these goals and then ranked by the amount of data available to demonstrate technical viability. Care was taken to select as many technologies for testing as possible, given qualified proposals. In order to be successful, proposals needed to, at a minimum:

1) demonstrate the potential to produce a product that met appropriate product-specific environmental criteria;
2) show competitive viability by an economic analysis of projected costs; and
3) have a location and the facility to perform the project.

A total of 14 proposals were received, nine were considered responsive, and five were selected for pilot projects (Table 1). Five technology vendors were selected, representing thermal destruction (2), sediment washing, chemical oxidation and enhanced mineralization/attenuation. Beneficial use products proposed were lightweight aggregate, construction-grade cement, and manufactured soil for uses from topsoil to nonstructural fill. Twenty million dollars was approved by the DPFTF for the sediment decontamination demonstration program and appropriated from the Bond Act.

Material for the stage one pilot program was obtained from a waterfront petroleum facility in northern Newark Bay at the mouth of the Passaic River. This is a location well known to have sediments that fail ocean disposal criteria, but where geochemical conditions were typical of navigational dredged materials throughout the Harbor (see Table 2). Additional material for stage two demonstration projects will come from nearby facilities, or may be proposed by the technology vendor themselves.

**Table 1.** Summary of responsive proposals received for demonstration program. Costs are as presented in bid (prior to contract negotiation) with demonstration at 150,000 cyd.

| Technology Vendor | Technology | Beneficial Use | Bid (thousands) Pilot / Demonstration |
|---|---|---|---|
| Applied Remediation Technologies | Sediment Washing | Manufactured Soil | 318 / 5,443 |
| BEM Systems, Inc[1] | Georemediation | Manufactured Soil | 298 / 7,807 |
| Web Consortium (BioGenesis)[1] | Sediment Washing | Manufactured Soil | 158 / 19,308 |
| ENDESCO/Clean Harbors[1] | Thermal Destruction | Blended Cement | 540 / 16,977 |
| Upcycle Associates, LLC[1] | Thermal Destruction | Lightweight Aggregate | 428 / 7,380 |
| NUI Environmental Group, Inc.[1] | Chemical Oxidation | Manufactured Soil | 107 / 5,801 |
| Obrien & Gere Technical Services | Bioremediation | Manufactured Soil | 393 / 11,007 |
| Plasmarc, LLC | Vitrification | Blended Cement | 303 / 4,615 |
| Soil Technology, Inc. | Various treatment trains | Various | 96 / 4,867 |

[1] Selected vendors

**Table 2**. Summary of bulk sediment chemistry for pilot dredged material from Newark Bay, NJ as compared to typical dredged material from recent navigation projects throughout the NY/NJ Harbor and New Jersey Cleanup Criteria.

| Constituent (dry wt) | Newark Bay | NY/NJ Range | New Jersey Cleanup Criteria Res. | Non-Res. |
|---|---|---|---|---|
| Arsenic (mg/kg) | 13.6 | 11-33.6 | 20 | 20 |
| Mercury (mg/kg) | 4.9 | 1.28-6.04 | 14 | 270 |
| Cadmium (mg/kg) | 9.3 | 1.26-4.85 | 1 | 100 |
| Copper (mg/kg) | 148 | 73.4-365 | 600 | 600 |
| Lead (mg/kg) | 144 | 67.6-292 | 100 | 600 |
| Chromium (mg/kg) | 148 | 62.1-159 | n/a | n/a |
| Nickel | 36.7 | 29.1-49.2 | 250 | 2400 |
| PAH 16 cmpds (ug/kg) | 16-310 | 15-5000 | varies by compound | |
| Total DDTs (ug/kg) | 3.8 | 11.1-773.4 | 2000 | 9000 |
| Total PCBs[1] (ug/kg) | 196.8 | 123-394 | 490 | 2000 |
| 2,3,7,8-TCDD (pg/g) | 188 | 5.21-82 | n/a | n/a |
| TEF Dioxin/Furan (pg/g) | 263.1 | 21.2-117.7 | n/a | n/a |

[1]Sum 22 Congeners X 2 method
n/a: no criteria, case by case basis
res: residential

## The Technologies

*Chemical Oxidation/Stabilization* - NUI Environmental Group, Inc. proposed to utilize a chemical oxidation procedure to reduce contamination in raw dredged materials, thereby increasing the volume of dredged material that would be acceptable for upland use once amended. The resulting decontaminated and stabilized sediments could then be used to produce a manufactured soil product suitable for construction projects or brownfield/landfill cap. While it may not seem at first to be a viable business strategy to produce a manufactured soil using decontamination technologies, the value of clean fill and capping material in the greater Metropolitan NY area is, in fact, greater than $10 per ton, when available.

*Georemediation™* - BEM Systems of Chatham, NJ proposed to reduce contamination in dredged materials utilizing the Georemediation technology developed by Jeffrey Newton, Aleph Group, Ithaca, NY. Georemediation™ utilizes a proprietary mixture of reagents and catalysts that enhance the natural attenuation processes of oxidation and sequestration. Cleaned sediments could then be used as fill materials for use in construction projects or brownfield/landfill capping.

*Thermal Destruction 1* - ENDESCO/Clean Harbors proposed to capitalize on their successful bench and pilot-scale work under the WRDA Program on the Cement-Lock technology. Based on technology developed at the Gas Technology

Institute, Des Plaines, Ill, sediments are passed through a submerged melter or rotary kiln and heated to temperatures in excess of 2000°F (1200°C). Exhaust gases are rigorously cleaned utilizing a state-of-the-science secondary combustion chamber, powdered lime injection followed by an activated carbon bed. Metals are incorporated into the molten matrix and be rendered unavailable. Volatile mercury vapor is captured in the carbon injection system baghouse. The resulting vitrified product (EcoMelt) is pulverized and utilized to produce a manufactured-grade cement product comparable to Portland cement suitable for commercial sale in ready-mix cement facilities. Pilot work indicates that environmental and geotechnical criteria are similar to currently available products. The current market for cement in any metropolitan area is virtually unlimited.

*Thermal Destruction 2* – Upcycle Associates is a joint venture between Jay Cashman, Inc. of Boston, MA and Upcycle Aggregates of Albany, NY. The Upcycle process utilizes existing rotary kiln infrastructure technology, but with the manufacture of lightweight aggregate (LWA) rather than cement. LWA is a product that replaces stone in concrete applications that are weight sensitive, such as floors in high-rise buildings or bridges. The manufacturing process includes mixing in crushed shale and clay, extruding the mixture into pellets, then superheating the pellets in a rotary kiln at 1200°C. The organic matter in the pellets vaporizes and causes the pellet to "puff" or bloat. The expanded pellet is then cooled. This process results in a product that is much lower in density, but has strength equal to or greater than traditional aggregate. Currently there are markets for over 1 million tons of LWA annually in the NY metropolitan area alone.

*Sediment Washing* – BioGenesis Enterprises, BioGenesis of NJ, Roy F. Weston, and most recently Montgomery Watson/Harza, teamed up to evaluate the use of the BioGenesis sediment washing technology. The BioGenesis technology involves mixing the dredged materials with biodegradable surfactants and oxidizers as well as cavitation and rigorous mixing to isolate, remove and/or destroy chemical contamination. The resulting cleaned sediment is then mixed with composted organic materials (humus, yard waste etc.) to produce a soil product that can be used as potting soil, topsoil, landfill/brownfield growth medium, or non-structural fill, depending on residual contamination. Sediments are slurried and passed through a screen to remove debris. Surfactants are then mixed in and the slurry was then aerated to encourage loss of floatable organics. The slurry is then pumped into a "collision chamber" where the organic and mineral matrices of the sediment are separated. A strong oxidizer is then metered in at a rate proportional to the concentration of organic contaminants. The resulting mixture is centrifuged to remove the water. Organic materials such as yard waste or bark chips are then mixed into the sediment to produce soil.

**Stage 1 Projects**

*NUI Environmental Group* - Approximately 800 gallons of raw dredged material were tested in the pilot program. Superionized water and potassium permanganate were mixed with air-dried dredged materials and allowed to cure for several days to weeks in covered plastic trays. Several mixtures of oxidant and curing times were tested. Air monitoring was performed to evaluate the potential for mass transfer to air. No treatment for metals was performed. The geotechnical nature and suitability of the product for the proposed end use was not evaluated, but was assumed to be similar to traditional pozzolanic amendments to sediment already in widespread use in the Port.

*BEM Systems* - The 400-gallon pilot project was initated in the fall of 2000 at the Rutgers Center for Advanced Infrastructure and Transportation in New Brunswick, NJ. Georemediation reagent was mixed thoroughly with dredged materials and then allowed to cure for 4 to 6 weeks, or longer, depending on chemical concentration. Air quality was monitored to ensure that the process did not simply transfer pollutants from one media to another. The geotechnical nature of the product was evaluated as a raw product and when mixed with other pozzolanic agents to meet engineering criteria for the proposed use. Several hundred gallons of product were produced.

*ENDESCO/Clean Harbors* – In stage one of the project ENDESCO/Clean Harbors will treat of 300 cubic yards of de-watered sediments from northern Newark Bay. Material for the pilot was dewatered with a belt filter press methodology demonstrated by Upcycle Associates process (see below). ENDESCO intends to test fire an Anderson 2000 rotary kiln manufactured in Peachtree, Georgia. The kiln has a capacity of 30,000 cy/yr with the capability to ramp up to 100,000 cy/yr with enhancements such as oxygen injection. Sediment is currently being stored at the project site in Bayonne, NJ awaiting construction.

*Upcycle Associates* – In order to facilitate the transportation of the raw dredged material, Upcycle would first dewater the dredged materials. The sediment were to be slurried, mixed with polymer and then fed through a large Solomon belt-filter press. Water produced from the process was held in tanks for 24 hours for settling, then discharged under permit to Newark Bay. Upcycle originally proposed to utilize an existing rotary kiln in upstate NY currently used to produce LWA. Due to unforeseen and unrelated permit difficulties at the plant, the pilot project was moved to the Fuller Materials Research Center in Catasaqua, PA. Approximately 4 tons of dewatered material was first mixed with shale fines and extruded through a rotary hammermill. The pellets were then fed through a xx ton/hour rotary kiln. NEEDS DETAIL ON KILN The kiln was fitted with state-of-the-science computer controlled pollution abatement equipment. This provided an excellent opportunity to thoroughly evaluate the air quality impacts from this type of equipment and provide the type of data necessary to site a kiln. The product was tested at the New Jersey Department of Transportation (NJDOT) Materials Testing Laboratory and the PANYNJ Materials Testing Laboratory to determine if the product met ASTM standards for LWA.

*BioGenesis Enterprises* - The stage 1 project for the BioGenesis technology, conducted under the WRDA Program, was located at the Koppers Coke Seaboard Site. This site is an existing dredged material handling facility on the Hackensack River in Kearny, NJ. Approximately 800 cubic yards of dredged material was removed from the site in northern Newark Bay and transported by barge to Kearny. The material was screened to remove debris and then placed into steel circulating holding tanks. The process uses water so dewatering was not necessary. Trash pumps were used to agitate the sediment to produce a pumpable slurry. The dredged material was then fed into the pilot system in batches to allow for assessment of treatability and provide data for engineering of a full scale plant.

**Stage 1 Results**

*Upcycle Associates* – The Solomon technology proved successful at producing a stable product that was easily handled, transported, and stored. The results of the stage 1 project for Upcycle Associates showed that the rotary kiln technology was able to produce a quality, marketable LWA from dredged materials that meets or exceeds ASTM requirements. Raw dredged materials were pumped in an enclosed system and processed through a belt filter press to reduce free water to a point that made the material easy to handle, store and transport. The filter cake was further dried and homogenized with a heated air-swept Hammermill dryer/grinder system, mixed with 30% shale fines and extruded into a pellet suitable for firing in the rotary kiln. The feed pellets were fed into the rotary kiln without the need for an organic bloating agent. Analytical results for the product indicated that there were no detectable concentrations of organic compounds and metals were below TCLP limits (Table 3). Full-scale equipment is expected to provide emissions efficiency at or below current LWA plant emissions. Long term costs for dredged materials processing is expected to be within the competitive target range of $30-50/cyd for the NY/NJ Harbor. Demonstration level proposals are currently being prepared. The most difficult aspect of the demonstration phase for this vendor is likely to be the capitalization and siting of a full-scale rotary kiln. This might be overcome by the retrofitting of existing LWA kiln(s) to use dredged materials in place of shale.

*NUI Environmental Group, Inc.* – The stage 1 project for the NUIEG was conducted during the spring of 2001 at the NUI Elizabeth, NJ site. This site is being used to test a number of technologies, the one of interest to the program being the simple chemical oxidation methodology described above. Several different levels of oxidant and drying were tested, with reduction rates of 50-90% achieved for target compounds. Additional work on the use of stabilizers and the potential for this to reduce availability of metals was not performed. With additional testing, this technology appears to have the potential to increase the amount of dredged material suitable for placement on some sites in New Jersey.

*BEM Systems, Inc.* – The Stage 1 project for the Georemediation technology was conducted in the winter/spring of 2000/2001 at the Center for Advanced Infrastructure and Technology at the Rutgers New Brunswick, NJ campus. OMR is awaiting a report on the success of the project.

*BioGenesis Enterprises* – By far the most impressive pilot in scope, BioGenesis team successfully processed 800 cubic yards of dredged materials at their pilot facility in Kearny, NJ. Many different treatment scenarios were tested in order to provide information for engineers to scale-up the equipment to full scale. Decontamination to the target criteria (New Jersey non-residential soil cleanup criteria) was obtained for most compounds with a single pass through the system, further reduction will require treatment with additional passes through the oxidation step of the process. The resulting soil mixtures were found to be suitable for growth media and will be marketable as fill, final cover, or topsoil depending on residual contamination.

*ENDESCO/Clean Harbors* – As of the writing of this paper, ENDESCO/Clean Harbors has not yet conducted their stage 1 project. While dewatered dredged material is available for the proposed 300 ton pilot, site selection has proved difficult due to public perception of thermal technologies. The general public does not understand the difference between rotary kiln technology and low temperature incineration. Due to this problem, locating a suitable project site was a challenge, emphasizing the need for high-quality targeted public outreach. The project is finally being permitted at a chemical handling facility in Bayonne, NJ. Test firing of the Anderson 2000 rotary kiln will be completed in 2002. Should the pilot be successful, siting of the 100,000 cyd/yr plant (expandable to 500,000 cyd/yr) will need to be addressed through extensive public meetings and negotiations. It is hoped that the successful completion of the Upcycle Associates pilot (below) and the availability of actual data from a test firing, will assist the group in proving to host communities the safety of the rotary kiln technology.

**Stage 2 Projects**

On completion of each study, results are reviewed by a multi-agency technical review committee (TRC). The OMR then determines whether or not the technology is environmentally sound, capable of producing a marketable product, and economically viable for the navigational dredging program in the NY/NJ Harbor. Of the five stage 1 projects, four have been completed to date. Of these four, the first to receive approval to proceed to stage 2 was BioGenesis' sediment washing technology.

Construction of a full scale BioGenesis facility is planned to begin in the winter of 2001/02. For this project, BioGenesis Enterprises has teamed with the BASF Corporation, Mt. Olive, NJ and the engineering firm of Montgomery Watson, Harza, Salt Lake City UT. The commercial facility will be located in south Kearny, NJ at the site of a defunct BASF chemical manufacturing plant. The site is ideally located at the confluence of the Hackensack and Passaic Rivers. The proposed plant (Figure 1) will be able to process 250,000 cy/yr, expandable to 500,000 cy/yr by employing modular units. Storage for pre-mixing and surge is provided for 20,000 cy of material, expandable to 50,000 cy. Processing will occur in a fully enclosed plant, with outside holding areas for finished product. Also planned for the 27-acre campus is an interpretive trail and nature center, providing public access and educational outreach opportunities. The stage 2 project will include decontamination of approximately 20,000 cy from the berth at the site, followed by an additional 55,000 cy from the State-sponsored Port Jersey Channel deepening project in Jersey City, NJ. Funding for the project is a combination of State and Federal dollars, with the USEPA funding design and construction and the State of New Jersey funding the demonstration project at $90/cyd plus some fixed expenses (permitting, testing and interpretation).

Stage 2 projects for other technologies will be considered on a case-by-case basis as the Stage 1 reports are finalized. OMR will consider both the promise of commercialization and the need for further testing and analysis in the decision making process regarding which Stage 2 projects go forward.

**Discussion**

The WRDA/OMR Sediment Decontamination Demonstration program has been successful at determining those technologies suitable for commercial scale, fostering those technologies, and providing opportunities for large-scale demonstration projects. It is expected that at least two of the five vendors currently in the program will proceed to commercial scale, providing 1,000,000 cyd of annual capacity for the navigational dredged material program in the NY/NJ Harbor at a reasonable competitive cost. This will ensure a significant portion of the long-term dredged material management needs for the foreseeable future, but the region will still need to pursue alternative methods and techniques to manage all of the predicted needs. However, the region's recently published Dredged Material Management Plan predicts that pollution reduction programs currently underway in the harbor will reduce the amount of contaminated dredged material that requires non-ocean management. Long-range predictions indicate that by the year 2040, only about 1 million cy of contaminated material will need to be managed on a yearly basis (USACE, 1999). If this goal is met, the decontamination technologies currently being fostered by this program may be adequate to serve all of the region's dredged material management needs.

In addition to providing much needed dredged material management capacity, the presence in the Harbor of permanent facilities capable of handling contaminated sediments may prove useful in the restoration initiatives currently underway under the NY/NJ Harbor Estuary Program. Contaminated sediment "hot-spot mega-sites" have been identified in the Passaic, Hackensack and Hudson Rivers, and elsewhere in the harbor complex as being continual sources of contaminants of concern. While these sediments have previously been considered too expensive to remediate; high capacity, relatively low cost, decontamination facilities may allow the region to re-examine final removal remedies utilizing the environmental manufacturing paradigm. Plans are underway to examine the potential for decontamination technologies to assist in the remedy for the lower Passaic River Superfund site. It is hoped that decontamination technologies will provide an opportunity to not only restore urban corridors, but also provide economic engines for their revitalization.

In conclusion, the use of sediment decontamination in an environmental manufacturing context is one component of a comprehensive dredged material/contaminated sediment environmental restoration matrix. Successful implementation of this program requires not only innovative technologies, but also extensive interagency cooperation on federal, state and local levels. We believe that the future of sediment remediation lies in this type of cooperative, win/win approach to complex problems.

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**Table 3**. Summary of Results of Stage 1 Projects.

| Firm | Process | Product | Volume treated | Costs[1] Pilot[2] | Projected |
|---|---|---|---|---|---|
| BioGenesis Enterprises | Sediment Washing | Manufactured Soil | 800K cyd | 2.145 | $29/cyd |
| ENDESCO Clean Harbors | Thermal Destruction | Blended Cement | 300 cyd | 1.322 | not available |
| Upcycle Associates | Thermal Destruction | Lightweight Aggregate | 4 cyd | 1.423 | $47/cyd |
| NUI Environmental Group | Chemical Oxidation | Manufactured Soil | 800 gal | 0.485 | $30/cyd |
| BEM Systems | Mineralization | Manufactured Soil | 400 gal | 0.608 | |

[1]Costs do not include dredging or transportation to processing facility
[2]Milllions of U.S. Dollars

**Table 4.** Selected Final Product Chemistry For Stage 1 Products, Dry wt. Basis.

| Firm | Total PCB (ug/kg) | TEF Dioxin (pg/g) | Total DDT (ug/kg) | B(a)pyrene (ug/kg) | Hg (mg/kg) | Pb (mg/kg) | As (mg/kg) |
|---|---|---|---|---|---|---|---|
| BioGenesis Enterprises | 220 | 35.3 | 46.7 | 1663 | 0.3 | 67.9 | 7.8 |
| Upcycle Associates | | 1.02 | | | <0.15 | 9.0 | 9.3 |
| NUI Environmental Group | 142 | 85.0 | 12.4 | 242 | 1.4 | 84.8 | 4.9 |
| BEM Systems | | | | | | | |
| RDCSCC[1] | 490 | n/a | 2000 | 660 | 14 | 100 | 20 |
| NRDCSCC[2] | 2000 | n/a | 9000 | 660 | 270 | 600 | 20 |

[1]New Jersey Residential Direct Contact Soil Cleanup Criteria
[2]New Jersey Non-Residential Direct Contact Soil Cleanup Criteria

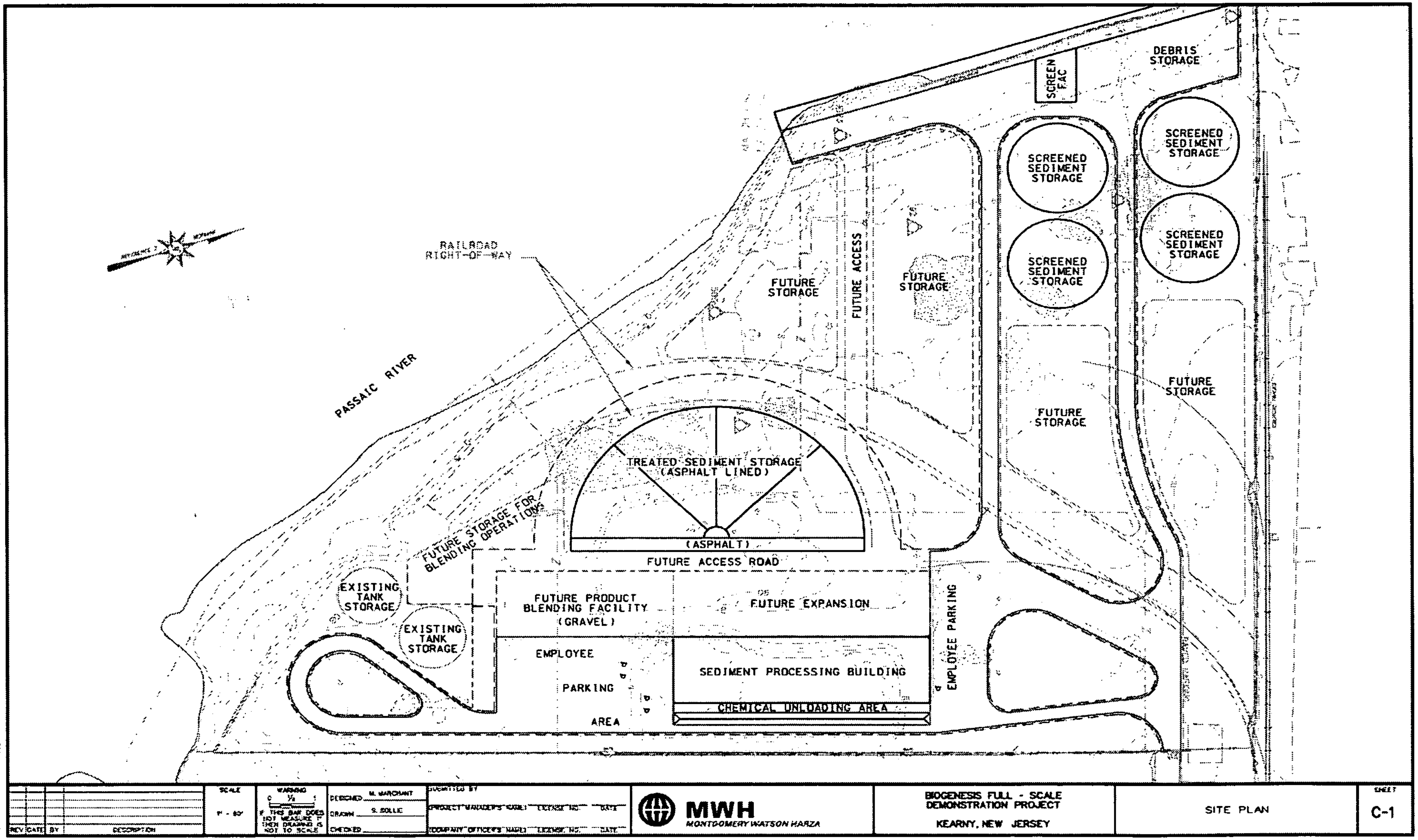


Figure 1. BioGenesis Dredged Material Processing Facility