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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

United States
Environmental Protection Agency
Region 2

United States
Army Corps of Engineers
New York District

DEPARTMENT OF ENERGY UNITED STATES OF AMERICA

United States
Department of Energy
Brookhaven National Laboratory

Fast Track Dredged Material Decontamination Demonstration for the Port of New York and New Jersey

Report to Congress on the Water Resources and Development Acts of 1990 (Section 412), 1992 (Section 405C), and 1996 (Section 226).

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Submitted by:

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Executive Summary

This Interim Report sets forth the major accomplishments of the Fast Track Dredged Material Decontamination Demonstration for the Port of New York and New Jersey authorized by Congress under the Water Resources Development Acts of 1990 (Section 412), 1992 (Section 405c), and 1996 (Section 226). The final goal of the demonstration is to develop environmentally and economically-acceptable methods for the processing of contaminated dredged material from the Port on a scale of 500,000 cubic yards per year (cy/y).

An average of 3-5,000,000 cy/y of dredged material is produced as a result of the dredging required for maintenance of navigation channels essential for the safe and efficient operation of the Port. Approximately 70 - 80% of this total is currently unsuitable for ocean disposal at the Historic Area Remediation Site (HARS), due to toxicity and/or bioaccumulation. As an alternative to ocean disposal, one approach to placement on land is to carry out a decontamination procedure to produce an environmentally-acceptable material suitable for beneficial use that can be used as part of an overall self-sustaining commercial operation.

The demonstration has gone through a number of discrete steps. These are:

Planning: literature survey/evaluation of existing technologies. (Section 412)

Bench-scale test: evaluation of a number of technologies on the laboratory scale. (Section 405c)

Pilot-scale: evaluation of effectiveness of several technologies found to be most effective from the results of the bench-scale tests. (Section 405c)

Planning for full-scale demonstrations: conceptual designs for treatment facilities. (Section 226)

Large-scale treatment demonstrations: construction of facilities is now in progress. (Section 226)

Scale-up to full-scale operations: conceptual designs for commercial-scale treatment facilities. (Section 226)

Operational demonstrations for decontamination of dredged material in quantities of 10,000 cy or more are being carried out for two technologies during 1999. An increase to larger facilities will follow.

This report summarizes the work performed for the phases listed above. In summary, it is shown that dredged material can be successfully decontaminated using several different technologies at the bench- and pilot-scale levels. Several potentially-viable beneficial use applications have been demonstrated. They include production of construction grade cement, glass tiles and fiber products, and manufactured topsoil. Finally, plans for the work necessary to develop the demonstration during 1999 are discussed. Possible governmental actions to assist in the development of a commercial operation are also proposed.

1. Introduction

Environmentally-responsible management of sediments and soils containing potentially toxic organic and inorganic compounds is a problem of national importance. There is an urgent need to provide affordable methods to remove the contaminants and beneficially use the decontaminated material.

The New York (NY)/New Jersey (NJ) Harbor is a specific example of this broad national problem. The Harbor, which is an immense natural resource in the center of a densely populated urban area, is a critical habitat for estuarine and marine life and a stopping place on the Atlantic flyway for migratory birds. It is used for recreational activities by millions and generates important business opportunities based on these recreational uses. The Harbor is also the location of the Port of New York/New Jersey which is the largest port on the eastern seaboard and contributes to the economics of New York, New Jersey, and other nearby states.

However, the Harbor is naturally shallow (approximately 19 feet) and must be routinely dredged to maintain navigation channels and private berthing facilities that are crucially important for the operation of shipping activities. Sediments found in the Harbor are contaminated with varying levels of organic and inorganic compounds. Some of these contaminants may adversely impact the health of the aquatic environment and thus, in many cases, the sediments are currently found unacceptable for unrestricted placement in an aquatic environment.

Therefore, there is an urgent need for developing other options to dispose each year of the several million cubic yards of dredged material produced in the dredging of federal navigation channels or remediation of specific sediment "hot spots" in the Harbor. *The application of sediment decontamination technologies is one component of a potential approach for the management of dredged material in the Port of NY/NJ.*

The great challenge is to find practical, environmental and economically sound solutions for the management of the dredged material that meet the environmental, commercial, and recreational needs of the Harbor users. This interim report details progress on a Congressionally-authorized program designed to render contaminated dredged material suitable for beneficial uses. The results of this program will be applicable to other harbors and port regions in the United States.

2. Charge From Congress

Work performed on this project has been authorized by Congress under the Water Resources Development Acts (WRDA) of 1990, 1992, and 1996. The program set forth by Congress defines a series of progressive steps that lead to a full-scale demonstration of one or more decontamination technologies with a processing capacity of at least 500,000 cy/y. These goals abstracted from the legislation are listed below. The complete text of the relevant sections of the WRDA legislation is given in Appendix 1.

Phase 1. Study of Alternative Methods for Disposal of Dredged Material (WRDA 1990)

Implement a demonstration project for disposing on an annual basis up to 10 per cent of the material dredged from the NY/NJ Harbor region in an environmentally sound manner other than by ocean disposal. Environmentally sound alternatives may include, among others, capping of borrow pits, construction of a containment island, application for landfill cover, habitat restoration, and use of *decontamination* technologies.

Phase 2. Bench- and Pilot-Scale Demonstrations (WRDA 1992)

The term decontamination as defined under WRDA 1992 includes local or remote prototype or production and laboratory decontamination technologies, sediment pre-treatment and post-treatment processes, siting, economic, or other measures necessary to develop a matrix for selection of interim prototypes of long-term processes. Decontamination techniques need not be preproven in terms of likely success.

Select removal, pre-treatment, post-treatment, and decontamination technologies for contaminated marine sediments for a decontamination project in the New York/New Jersey Harbor and recommend a program of selected technologies to assess their effectiveness in rendering sediments acceptable for unrestricted ocean disposal or beneficial use, or both.

Phase 3. Full-Scale Dredged-Material Decontamination Demonstration (WRDA 1996)

Select removal, pre-treatment, post-treatment, and decontamination technologies for contaminated estuarine sediments for a decontamination project in the New York/New Jersey Harbor from results of Phase 2 or equivalent testing.

Provide for the development of one or more sediment decontamination technologies on a full-scale pilot scale demonstrating a processing capacity of at least 500,000 cy/y.

3. WRDA Decontamination Program Overview

3.1 Program Objectives and Challenges Addressed

The WRDA Decontamination Program has been carefully designed to meet the overall goals specified by Congress. To that end, the program, which emphasizes the rapid development of environmentally- and cost-effective methods for decontamination of dredged material in NY/NJ Harbor, is a matter of pressing importance. Hence, emphasis has been placed on demonstrations of technologies that can be put into commercial operation as rapidly as possible.

The WRDA Decontamination Program draws upon many disciplines. They range from basic science and engineering fields that technically support the technology development to matters of marketing and commercialization related to beneficial use of the decontaminated materials. Together they define a complete treatment train for removing, processing, and disposition of the treated material through beneficial use. The final objective of the program is to promote dredged material decontamination on a commercial scale as a component of the overall dredged material management plan for the Port of NY/NJ.

The topics that enter into the overall WRDA Decontamination Program are as follows:

- Bench-, pilot-, and full-scale technology testing and evaluation
- Design of an integrated treatment train
- Commercial-scale design engineering
- Commercialization of decontamination technologies
- Public Outreach Program/Citizens' Advisory Committee (CAC)

3.2 Organizational Structure of the WRDA Program

Meeting the need for decontamination technologies is a challenging task not only from the standpoint of solving formidable scientific and engineering problems, but also, and more importantly, from the need to implement complex collaborations among the many different parties concerned with the problem.

The WRDA Decontamination Program is the direct responsibility of the U.S. Environmental Protection Agency (EPA)-Region 2 working in collaboration with the U.S. Army Corps of Engineers (USACE) New York District. They have involved the U.S. Department of Energy's Brookhaven National Laboratory (BNL) as the technical project manager for the work. An organization chart for the project is shown in Figure 3-1.

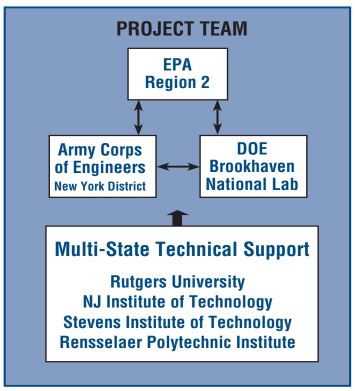


Figure 3-1. WRDA Program Technical Team

The team concept is the foundation for the WRDA group organizational structure. It includes federal, state, and local government, and university groups on the public side, and technology/engineering development firms, harbor shipping interests, and citizen groups on the private side.

An enhanced reservoir of technical expertise for the project was created through the organization of the Multi-State Alliance (MSA) to bring in participation of regional NY and NJ academic institutions including Rensselaer Polytechnic Institute, New Jersey Institute of Technology, Stevens Institute of Technology, and Rutgers University. This MSA expertise assisted the project in its early phase by providing proposal review, specialized technical expertise, and public outreach activities. As the WRDA Decontamination Program moves toward commercialization, there has been reduced funding for MSA because of a decrease in programmatic needs. However, the MSA structure was successful in providing "seed" funding that resulted in an expansion of the regional basic science and engineering capabilities relevant to the dredged material problem.

The WRDA Decontamination Program has also used the recognized resources of the USACE Waterways Experiment Station (WES) on many portions of the project. WES is an international authority on dredged material research and management and serves both the USACE districts and EPA regions.

3.3 Relation to the U.S. Army Corps of Engineers-New York District Dredged Material Management Plan

The USACE-New York District is responsible for developing a comprehensive Dredged Material Management Plan (DMMP) for the Port of NY and NJ. A DMMP report, issued in the Fall, 1999, provides a menu of options from which federal, state, and local decision makers, along with the harbor and estuary stakeholders, can select or modify for inclusion into the final DMMP. The DMMP will undergo detailed investigations necessary to implement the alternatives in an environmentally protective manner based on short-, mid-, and long-term needs and economics of the Port.

Some of the options that are presently proposed include deposition of dredged material into containment facilities. These may include upland confined disposal facilities (CDFs), contained aquatic disposal facilities, sub-channel sites, nearshore containment facilities, and island CDFs (containment islands). Decontamination of dredged material with beneficial use is one component of an overall dredged material strategy. Pollution prevention, and contaminant and sediment reduction into the waterways are paramount to the DMMP. A final plan will include a set of options that will comprise a major thrust in cost-effective disposal and beneficial use.

4. The New York/New Jersey Harbor

4.1 Description of the Harbor

The NY/NJ Harbor complex comprises the Hudson River, East River, Long Island Sound, Hackensack River, Passaic River, Newark Bay, Jamaica Bay, Arthur Kill, and the Kill van Kull. The waters of the Harbor drain into the Atlantic Ocean through the Narrows which lies between Brooklyn and Staten Island, NY. A map of this complex marine and estuarine system is shown in Figure 4-1. Note that estuaries are water bodies where freshwater empties into and mixes with saltwater. Estuaries are different from oceans and rivers – chemically, biologically, and hydraulically – and are highly productive from an ecological and economic standpoint. They are regions where there is a complex interplay of the river currents with tidal effects that causes dynamic changes in salinity and layering of the saline and fresh water involved. The sediments in the system are moved back and forth in the Harbor as a result of the changing water velocities. These movements transport contaminants through the Harbor system. By way of visualizing this system, the Harbor performs as a sediment trap because the decreased water velocity gives the contaminated sediment particles more time to settle to the bottom. The estuarine salinity in the Harbor promotes agglomeration of the particles thereby also leading to their enhanced settling.

The origin of contaminants in sediments is due to industrial and other anthropogenic activities. The contamination is the result of decades of point source and nonpoint source pollution into the estuary. Point sources include industrial outfalls, sewage treatment plants, and combined sewer overflows. Nonpoint sources include urban runoff, leachate from adjacent landfills, and atmospheric deposition. It can be visualized that as the erosion of the land mass occurs, soil particles enter a water body where they can be transported until conditions develop further to settle or deposit them on the bottom. During this transport process, when these particles interact with contaminants in the water column, the contaminants can adhere to these particles. Depending on the local conditions, some of these particles may settle directly in navigational channels, thereby creating the need to dredge, or the contaminated particles may settle in non-navigational, but quiescent areas such as mud flats. These areas may in turn re-distribute contaminants to navigational channels.

The sediments are composed of materials from various geological strata. The composition of the sediment around the harbor is of great importance for beneficial use. Figure 4-2 shows the composition of materials taken at eight locations in the Upper Bay and along the western shore of Manhattan. Measurements of the composition of ten core samples at various points along the Harbor show that there is not a wide range of variability in the major elements present. In particular, silica content is of importance for several beneficial uses and is found to be relatively high in all the latter cores. The composition of these cores is summarized in Table 4-1.

The sediments found in the Harbor are generally very fine-grained silts and clays (80-95%) with a small fraction of larger grain sizes and large-size debris.

Figure 4-1.
NY/NJ Harbor Estuary

Contaminants mostly associate with these fine-grained sediments. The size distribution of the sediment particles is shown in Figure 4-3 for sediments from Newark Bay. Most of the particles are very small with many of them being less than one tenth the diameter of a human hair. While the fine-grained nature of the sediments can be a major complication in the development of some treatment trains, their presence may be a non-issue for some beneficial use applications.

As-dredged material has the consistency of a black mayonnaise or gel with a solids content at 30% to 40% when obtained using a conventional clam-shell bucket dredge. The total organic carbon (TOC) of typical NY/NJ Harbor dredged material ranges from 2-10%; the higher the TOC, the greater the affinity for organics to bind to a sediment particle. Generally, upon dredging, the material is chemically stable and is found to pass the EPA Toxicity Characteristic Leaching Procedure (TCLP) at least as a short-term assessment. TCLP measures the leachability of forty contaminants. TCLP is used by the EPA and the states of NY and NJ as one of the several regulatory “tools” to determine if

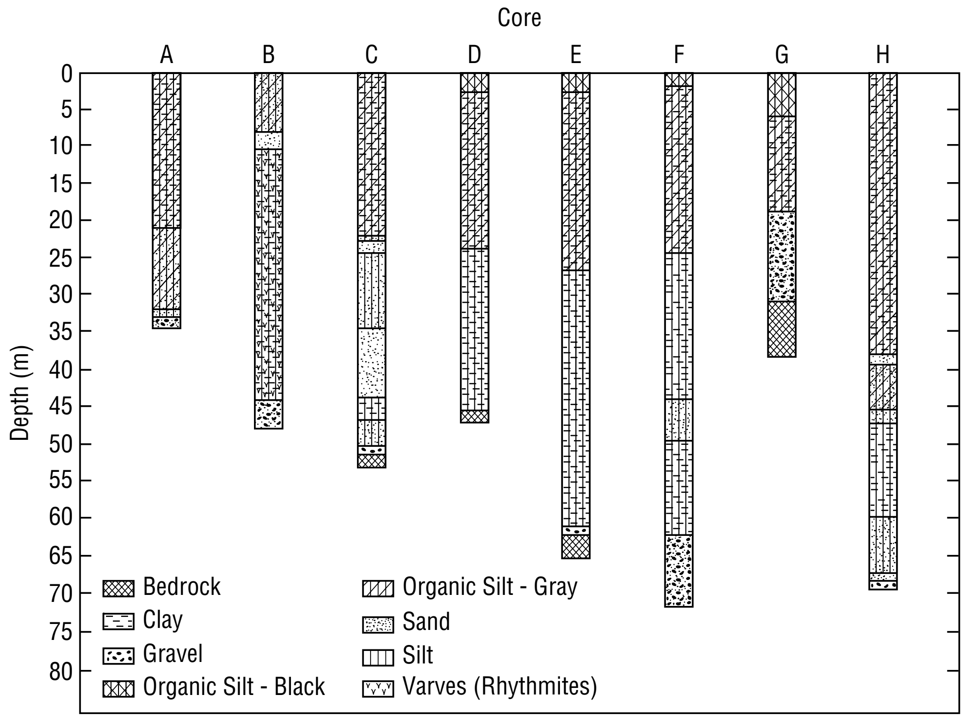


Figure 4-2. Variation of sediment core compositions as a function of depth below the surface for eight locations in the NY/NJ Harbor. (Source: "Environmental Geology and Geological Development of the Lower Hudson Estuary and New York Harbor" by Nicholas K. Coch and Dennis Weiss in Geology and Engineering Geology of the New York Metropolitan Area, Field Trip Guidebook T361, 28th International Geological Congress, American Geophysical Union, Washington, DC, 1989.)

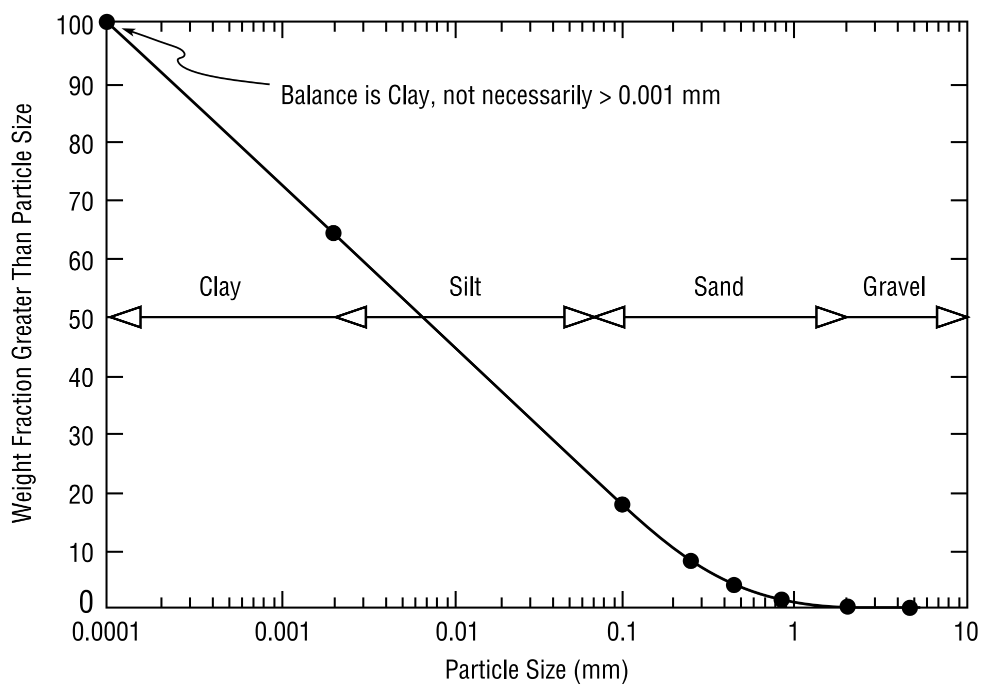


Figure 4-3. Typical particle size distribution found for sediments in the NY/NJ Harbor. Note that most of the particles are less than 0.1 mm in size.

Table 4-1. Major Oxide Composition for Sediments from NY/NJ Harbor

Compound	Claremont I	Claremont II	Claremont III	Lower Hudson River	Upper Hudson River	Arthur Kill B/A Sed	Arthur Kill C/CB Sed	Bay Ridge A/Red Hook	Bay Ridge Gowanus	Composite
Fe_2O_3	7.14	4.87	5.20	5.41	5.85	5.59	4.68	6.08	6.72	4.86
CaO	2.64	2.38	4.57	5.82	2.37	2.10	1.70	2.96	1.93	2.50
MgO	2.99	1.64	1.80	1.70	1.87	1.71	1.04	2.34	2.13	1.57
TiO_2	.89	.74	.72	.83	.85	.75	.54	.80	.93	.66
K_2O	3.08	2.42	2.51	2.27	2.66	2.34	1.71	2.73	2.66	2.19
SiO_2	65.72	74.05	70.70	69.07	71.40	73.53	79.48	69.05	69.61	75.23
Al_2O_3	14.17	11.13	11.73	12.18	12.12	11.02	7.69	12.57	12.79	10.25
Na_2O	2.74	2.30	2.30	2.24	2.38	2.36	2.68	2.89	2.54	2.30
ZrO_2	.058	.062	.044	.063	.058	.049	.038	.045	.053	.044
P_2O_5	.41	.27	.29	.26	.28	.39	.34	.38	.43	.28
MnO	.093	.070	.080	.078	.097	.064	.038	.096	.081	.061
NaCl Calculated	4.04	2.44	2.80	2.31	2.54	2.21	1.32	3.86	2.97	2.31

Values are given in pecent.

dredged material could be subjected to the Resource Conservation and Recovery Act (RCRA). In all but a very small number of cases, RCRA has not been applied in practice to proposed discharges of dredged material.

4.2 Dredged Material Issues in the Harbor

The dredging and disposal options are of paramount importance to the Port of NY/NJ, since ships require depths in excess of 40 feet, while the average natural depth of the Harbor is 19 feet without any dredging. Authorized by Congress, the USACE built and maintains a system of 240 miles of federal navigation channels designed to provide the required depths. The average annual volume of sediments that need to be dredged to keep these federal navigation channels and private berthing areas operational in the Port of NY/NJ is approximately 5 million cy/y. In addition, another 2 million cy are dredged by private applicants annually. A summary of yearly dredging for the past 20 years is given in Figure 4-4 and Table 4-2. It can be seen from this figure that the average yearly dredging volume is about 5,800,000 cy/y. Future dredg-

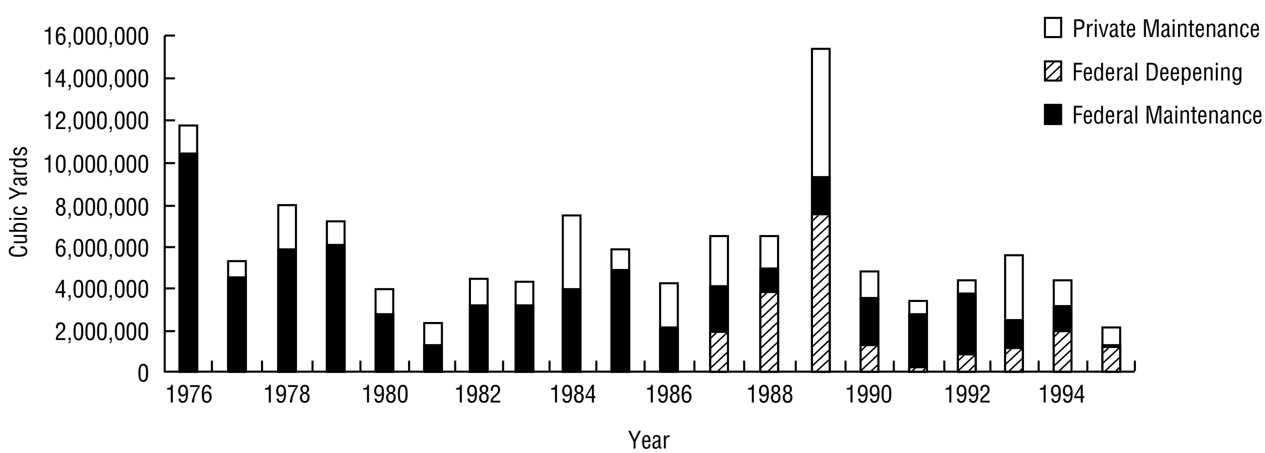


Figure 4-4. Summary of yearly dredging in the Port of NY/NJ from 1976-1995.

Table 4-2. Yearly Dredging Volumes for the Port of NY/NJ

Year	Federal Maintenance (cubic yards)	Federal Deepening (cubic yards)	Private Maintenance (cubic yards)	Total (cubic yards)
1976	10.358.895	0	1.253.083	11.611.978
1977	4.516.349	0	776.969	5.293.318
1978	5.736.442	0	2.214.045	7.950.487
1979	6.058.124	0	1.146.400	7.204.524
1980	2.551.702	0	1.337.460	3.889.162
1981	1.095.109	0	1.236.000	2.331.109
1982	2.959.622	0	1.405.410	4.365.032
1983	2.951.500	0	1.211.342	4.162.842
1984	3.851.022	0	3.540.100	7.391.122
1985	4.605.709	0	997.500	5.603.209
1986	1.964.647	0	2.135.071	4.099.718
1987	2.056.199	1.834.880	2.464.251	6.355.330
1988	1.094.769	3.638.555	1.544.263	6.277.587
1989	1.715.082	7.393.961	6.092.163	15.201.206
1990	2.110.246	1.220.900	1.282.971	4.614.117
1991	2.293.700	207.650	653.858	3.155.208
1992	2.769.739	719.700	677.012	4.166.451
1993	1.510.829	688.200	3.133.015	5.332.044
1994	1.116.650	1.725.250	1.388.340	4.230.240
1995	73.507	1.001.970	874.411	1.949.888
Total	61.389.842	18.431.066	35.363.664	115.184.572
Av/yr	3.069.000 (53%)	922.000 (16%)	1.768.000 (31%)	5.759.000 (100%)

ing needs will also be high because of the need to deepen the channels up to 55 feet to handle the next generation of super-container (Post Panamax) ships. In fact, USACE estimates for the Port a long-term average of approximately 4 million cubic yards of dredged material generated every year. This volume includes federal and non-federal dredging projects. Approximately 75% of that total volume, or 2.9 million cubic yards, is estimated to be unsuitable for use at the Historic Area Remediation Site (HARS) and therefore requires other management options.

4.3 Importance of the Harbor of NY/NJ

Based on tonnage of freight handled, the Port is the largest on the eastern coast of the United States and third largest in the entire country. It plays a key role in the economy of the region, and its continued efficient operation is important to a substantial population. In 1995, 2.3 million 20-foot equivalent container units (TEUs) were handled in the Port of NY/NJ. According to the Port Authority of NY and NJ, the Port generates more than $29 billion in revenue annually and is responsible for more than 193,000 jobs. Thus, any prolonged interruption in dredging would adversely affect the regional economy. The Port is currently faced with an operational crisis brought about by stricter regulations that reduce the amount of dredged material that is considered suitable for ocean placement in the coastal Atlantic Ocean thereby restricting the ability to maintain — let alone deepen — port navigation channels and private berthing areas where access to these channels is needed.

5. Contaminants in Harbor Dredged Material

5.1 Types of Contaminants

There are many sources for the contaminants found in the Harbor sediments. They include inputs from industrial activities over the past 100 years or more, effluents from sewage treatment plants, storm water run-off, and airborne particulates from local and distant sources. It is not surprising then that there is a long list of contaminating compounds of anthropogenic origin found in the sediments and waters of the Harbor. They fall into a few major categories:

Polynuclear aromatic hydrocarbons (PAHs):
PAHs are organic compounds that may be naturally occurring, in association with petroleum materials, but are also the product of incomplete combustion of a variety of fuel stuffs, e.g., coal. PAHs have been associated with cancer both in aquatic and terrestrial systems. They (or their metabolic intermediates) act by binding to biologically-important molecules, especially nucleic acids, causing mutations and metabolic errors that can result in the development of tumors which may be cancerous.

Chlorinated organic compounds - pesticides, herbicides, and polychlorinated biphenyls (PCBs):
These are organic compounds that derive from specific targeted uses, e.g., pesticides to control nuisance agents. PCBs were developed as insulating chemicals for transformers and capacitor usage, but were used in other industrial processes, as well. The major concern about these compounds is that they tend to degrade very slowly and thereby bioaccumulate and bioconcentrate in food chain dynamics. They exert a wide range of effects that are dependent upon the ability to concentrate to actionable levels in organisms where they are found mostly in fatty tissue and oils.

Dioxins and furans:
Organic compounds formed as a by-product of chemical production, principally of Agent Orange (2,4D and 2,4,5T), a defoliant, or in combustion of materials, e.g., coal, solid wastes, as a gaseous emission. These compounds act at very low doses because they bind to specific biological receptors of both aquatic and terrestrial organisms. They are considered carcinogens and have been found to inhibit intercellular communication and stimulate cell proliferation in carcinogenesis.

Metals:
Metals may be naturally occurring in the region due to erosion of upland geological deposits, or may originate from industrial or other anthropogenic activities, e.g., metal finishing, painting, and in liquids, gases, or solid residuals. The dose determines whether a metal is toxic since many metals are essential to most species at some level. Non-essential metals, e.g. mercury, cadmium, and lead may affect organisms by inducing deficiencies of the essential metals through competition at active sites in biologically-important molecules as well as by exerting toxicity above certain levels.

The contaminants found at several key locations in the Harbor are shown in Table 5-1. The locations are Newark Bay, Arthur Kill, and Newtown Creek which are of major importance for shipping in the first two cases and for direct impact on the environment and nearby population in the latter case. Most of the material dredged from federal navigation channels and private berthing areas contains a wide range of organic and inorganic contaminants at relatively low concentrations. However, there are sediment “hot spots” that exist in areas outside navigational channels with significantly higher contaminant levels. These “hot spots” are legitimate candidates for application of decontamination procedures in their own right since their elimination would contribute to contaminant source reduction in other Harbor areas.

With respect to generalities related to contaminant levels, the following points should be noted:

- The USACE estimates, that 70-80% of all dredged material from the Port would fail the effects-based testing criteria for use as remediation material at the HARS (i.e., non-HARS material). Effects-based testing means select benthic animals (e.g., amphipods, sandworms, clams, and shrimp species) are exposed to the test material and measured for mortality and bioaccumulation.
- Typically, contaminants present in dredged material are adsorbed to the clay and organic fractions. Thus, when the material is brought upland, contaminants are largely immobilized, which limits their bioavailability. However, long-term effects of upland placement may promote oxidation, which could increase leachability of metals and other contaminants.
- It should not be construed that non-HARS material is consequently unsafe for upland or nearshore placement. Different testing protocols are used to

Table 5-1. Summary of Contaminants in Select New York/New Jersey Harbor Sediments (Chen 1994)[1]

Contaminant	Newark Bay	Arthur Kill	Newtown Creek	NJ Non-Resid.[2]	NJ Resid.[3]	NY Resid.[4]
2,3,7,8 TCDD (ppt)	130	39	9.9	---	---	---
OCDD (ppt)	5494	3016	15369	---	---	---
TCDD/TCDF TEQ (ppt)	197	61	224	---	---	---
Total PCBs (ppm)	.92	1.16	2.86			
Anthracene (ppb)	1400	880	5820	2	0.49	1
Benzo(a)anthracene (ppb)	3070	1460	6190			
Chrysene (ppb)	3100	1630	6050	10,000	10,000	50,000
Total PAHs (ppb)	32550	19120	59380	4000	900	224
Total Herbicides and DDT (ppb)	145	1219	420	40,000	9000	400
Arsenic (ppm)	9-17	17-25	5-33	---	n/a[5]	396,500
Cadmium (ppm)	1-2	1.5-3	1-20			
Chromium (ppm)	175	161	305	20	20	7.5
Copper (ppm)	105-131	178-304	61-770	100	1	1
Lead (ppm)	109-136	111-261	68-554	---	---	10
Mercury (ppm) total	2-3	2-4	1-3	600	600	25
Nickel (ppm)	33-40	20-60	12-140	600	400	SB[6]
Silver (ppm)	2-4	2-5	2-3	270	14	0.1
Zinc (ppm)	188-244	230-403	104-1260	1500	1500	20

[1]Chen, A. S. C. 1994. *Letter Report: Analytical Results of NY/NJ Harbor Sediments*. Base-Catalyzed Dechlorination Demonstration Project, Battelle, Columbus, OH. Correspondence to A. Massa, US EPA, Region 2, New York, NY.

[2]NJ Department of Environmental Protection. Non-residential soil, direct contact. J.J.A.C. 7:26D, revised 7/11/96.

[3]NJ Department of Environmental Protection. Residential soil, direct contact. J.J.A.C. 7:26D, revised 7/11/96.

[4]NY Department of Environmental Conservation. Recommended soil cleanup objectives. HWR-94-046 (Revised). January 24, 1994.

[5]n/a = not available.

[6]SB = Site background.

determine dredged material acceptability at different types of placement sites. Thus, non-HARS material may be suitable for placement or beneficial use at upland or nearshore sites. An important example of beneficial use upland is land remediation, an umbrella term that includes landfill capping, brownfield remediation, and mine reclamation. Dredged material for this use may only require minimal treatment, such as solidification/stabilization and manufactured-soil production (see below).

- For the non-HARS material, the concentrations of these compounds are low compared to action levels under RCRA hazardous-waste regulations and Toxic Substance Control Act (TSCA) toxic-waste regulations. The contaminant levels in navigation dredged material under current management practices do not pose a significant threat to public health. Newtown Creek sediment passed TCLP testing, with all but one of the 40 regulated contaminants (under toxicity characteristic) found below method detection limit (MDL). The one exceedance, chromium, was slightly above MDL and two orders of magnitude less than the action level.
- If environmental dredging is conducted in the future, some sediment "hot spots" in the Harbor may have much higher contaminant levels than those found in navigational dredged materials. For these more-contaminated materials, more stringent management and engineering controls will be taken to ensure their safe handling and disposition and compliance with all applicable environmental regulations.

5.2. Managing Contaminated Dredged Material in the Harbor

The WRDA Decontamination Program focuses on one option for managing dredged material, namely decontamination. The improvements of testing and evaluation procedures for the Remediation Material at the HARS have created the need for finding new methods for placement of that portion of the material unsuitable for HARS placement. Several other management options exist and are being evaluated under the USACE Dredged Material Management Plan for the Port.

In 1977, the EPA and the USACE developed the "Green Book" to provide a methodology for testing and evaluating dredged material to determine its suitability for ocean disposal. Since the manual was national in scope, local dredged material concerns were addressed and implemented by Regional Guidance Manuals. The 1977 "Green Book" was revised and replaced in 1991. Improved testing and evaluation procedures increased the analytical sensitivity of chemical detection limits, the number of chemicals of concern for testing, and added other biological testing assays. These changes in the testing protocols significantly reduced the volume of dredged material that could be disposed of at the New York Bight Dredged Material Disposal Site (Mud Dump Site (MDS)). The MDS is a 2.53-square mile area located 6.1 miles east of Sandy Hook, NJ, and 11.05 miles south of Rockaway Beach, Long Island, NY.

In a final rule that became effective on September 29, 1997, EPA de-designated and terminated the Mud Dump Site and simultaneously designated it as part of the Historic Area Remediation Site (HARS). The HARS is designated to receive only dredged material suitable for use as Material for Remediation. This material is defined as uncontaminated dredged material (i.e. dredged material that meets current Category I standards and will not cause significant undesirable effects including through bioaccumulation).

The placement of the dredged material is the subject of intense interest to many different groups in the NY/NJ region since the requirement for the Remediation Material reduced the volume of sediments found suitable for placement in the ocean. Proposed solutions for the disposal problem include the use of sub-aqueous disposal facilities, containment islands, upland disposal sites, reclamation of abandoned mines, and sediment decontamination.

Most of the sediments in the Harbor are currently unsuitable for placement at the HARS as Remediation Material. Currently, USACE estimates that only 20% to 30% of the sediments are suitable for remediation material.

This means that other acceptable means for managing this dredged material must be found for approximately 70-80% of the dredged material handled yearly. The USACE estimates this volume of non-HARS material to be 2.9 million cy/y. This estimate covers public and private dredging.

Public acceptance of options for untreated dredged material and even dredged material that has been treated, but still contains contaminants, is often affected by concern for the long-term fate of the contaminants and the possible associated environmental and human-health effects.

Decontamination, a component of other management alternatives, is the only option that reduces or eliminates the toxic organic and inorganic compounds that may cause harmful effects, thereby directly addressing the Public's concerns.

6. Distribution of Contaminants in the Harbor

6.1 Visualizations of Contaminant Distributions

Surprisingly, up to this effort there were no readily accessible maps or comparable visual representations of the distribution of contaminated sediments in the NY/NJ Harbor region. Several large-scale temporal and spatial studies have been conducted to date, but compiling this information into a comprehensive database that can map sediment characteristics and its attributes such as, sediment concentrations, sediment toxicity, and bioaccumulation over the entire Harbor has yet to be accomplished. This lack of a Harbor atlas of sediment contamination means that it is difficult to determine the location of "hot spots" related to point sources of contamination. Furthermore, knowledge of "hot spots" defines the regions that may be causing environmental impacts and may thus be primary candidates for application of the decontamination technologies.

Overlying these maps with site facility and outfall data may help pinpoint contributions from active sources that are reflected in increases of surficial sediment concentrations. A general view of the extent of Harbor contamination is also necessary to make predictive evaluations with sediment toxicity data in defining the total volume of material that is not suitable for ocean placement and could be in need of decontamination.

Sediment visualization of NY/NJ Harbor sediments serves several different functions as it relates to sediment decontamination. By delineating problem areas, three-dimensional spatial distributions of contaminants can be helpful. This is important as it helps to define the appropriate type of decontamination technology to be used and the volume of material that must be treated. Visualizing with depth gives more precise information on how deep down to remove sediment, while making sure that we are not exposing more contaminated material that historically we find with depth. This information is critical in deriving the cost economics of sediment decontamination as well as in defining areas that need further investigation.

There is need for visualization of sediments not only for federal navigational channels, but also for "mudflat" areas outside these channels. These are areas that are not dredged and have accumulated sediments over time. Since the sediments may be exposed at low tides, the contaminants may be bioavailable for organisms, birds, etc. that feed in the areas. These areas can contribute to the growing volumes of navigational material designated unsuitable for HARS remediation.

The WRDA Decontamination Program has addressed these needs by developing a preliminary Harbor Atlas of Sediment Contamination. The data were taken from recent measurements, including data from the EPA Regional Environmental Monitoring Assessment Program (R-EMAP), that give large-scale coverage of sediment contaminants in the Passaic River, NJ, and in each major water body in the Harbor. The Atlas shows the degree and extent of the Harbor contamination which is the target of the decontamination treatment train that has been developed. A web site for display of the maps and other Harbor data is being developed and can be found at http://www.wrdadcon.bnl.gov

6.2 Contaminant Maps for:

6.21 Passaic River, NJ

The Passaic River is acclaimed as one of the most polluted in the United States. Intensive manufacturing has taken place along its banks for over a century. The crowning insult to its environmental condition was the fire and destruction of a production facility manufacturing Agent Orange, causing major contamination from dioxins (a by-product from Agent Orange synthesis) at a location close to the center of Newark, NJ. The upland location is classified as a Superfund site, with six miles of the Passaic River designated a study area of the upland Superfund site. A detailed sampling of contaminants along a six-mile stretch of the river was carried out in 1995 in an attempt to delineate the problem. A total of 78 core samples were taken at 1200-foot (up/downstream) intervals with three cores obtained on the left and right banks and midstream of the channel. The cores were analyzed for contaminant concentrations in one-foot sections to a depth of 15 feet.

The results of the investigation can be displayed in different ways. Figure 6-1 shows the distribution as a function of depth for 2,3,7,8-TCDD, the most toxic form of the dioxins. The "hot spot" of dioxins is clearly visible. The data can be viewed in several different ways. A vertical section through the "hot spot" is given in Figure 6-2. A total of some three hundred similar sections have been produced over the entire length of the study section. A stereo view of the "hot spot" is shown in Figure 6-3. This approach gives the environmental managers the ability to study the spatial distribution in a very elegant and interpretive way.

Management decisions can be based on precision remediation methods as opposed to requiring the treatment of excess amounts of material to ensure that the contaminated portion of the waterway can be processed in its entirety. This translates into determining the cost and economics based on volume of what needs to be removed (or kept in place), and what depth to dredge to ensure complete removal of the contaminants. Displays of multiple contaminants can also determine which type of decontamination technology should be used.

6.22 Newark Bay, NJ

Newark Bay (home to Port Newark and Elizabeth Channels), is the focus of shipping efforts in the Harbor. It is fed by water and sediments from the Passaic and Hackensack Rivers and is extensively contaminated as a result. In this case, as for the data for the Hudson and East Rivers and Jamaica Bay, surficial data only are available. The calculated surface distributions for PAHs, PCBs, lead, and 2,3,7, 8 TCDD are shown in Figure 6-4a. Indications of "hot spots" can be seen at several locations. The number of data points are limited so that care needs to be taken in drawing conclusions from these displays. However, they do show in the best possible way where there is maximum reason for concern and where further, more detailed sampling is needed.

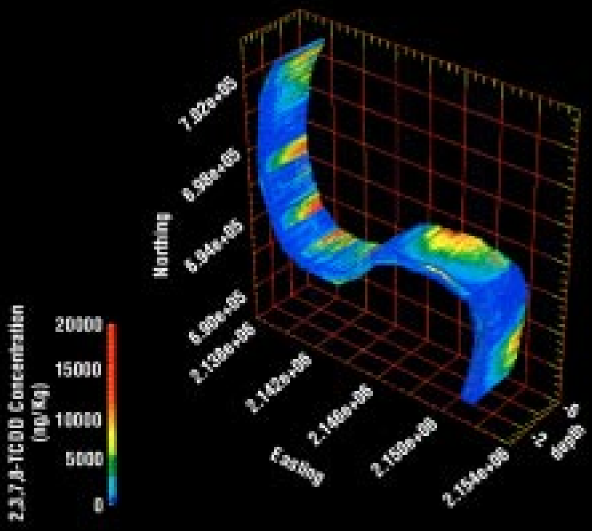


Figure 6-1. Three-dimensional visualization of the distribution of 2, 3, 7, 8-TCDD in the Passaic River. The depth below the surface is shown in feet.

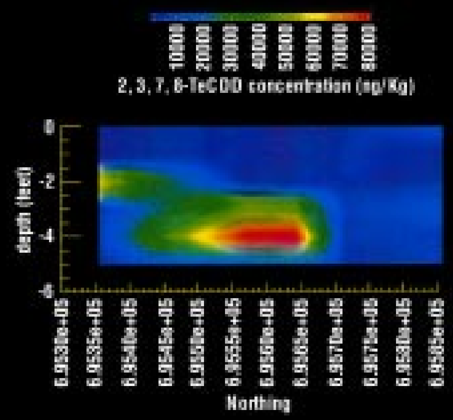


Figure 6-2. North-south section of the Passaic River at Easting 2148263 showing the localization of 2, 3, 7, 8-TCDD as a function of the depth in feet below the sediment surface. The "hot spot" below the surface is clearly seen.

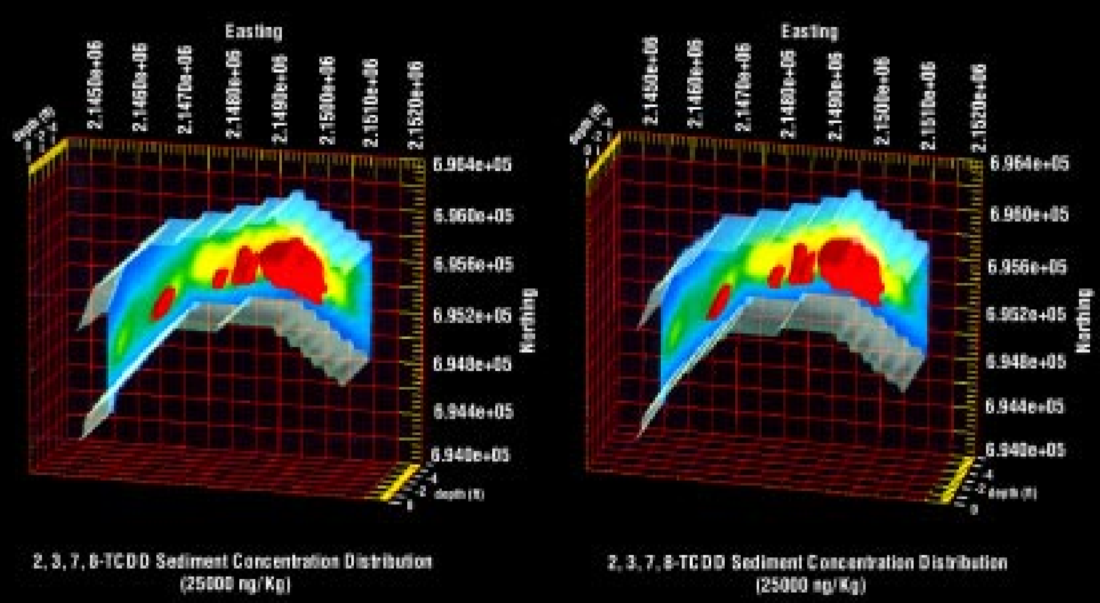


Figure 6-3. Stereo pair showing the concentration of 2,3,7,8-TCDD in the Passaic River, NJ as a function of depth in feet. Even though they are not printed in three dimensions, you may be able to see the two 2-D images in 3-D if you bring the page near your eyes, unfocus your gaze while staring at the background, slowly pull the page away, and let the two images become one.

6.23 Hudson and East Rivers, NY

Data for the Hudson and East Rivers are of interest for environmental and commercial reasons. Figure 6-4b shows the distributions of PAHs, PCBs, and lead. Recent investigations consider contributions to Harbor contamination from sources in the Harbor region and from transport down the Hudson River into the Harbor. The results show that there are substantial effects from riverine transport for some compounds and that, for others, the inputs are from Harbor sources. Thus, the Harbor cannot be considered as an isolated system and solutions to contamination of sediments extend over substantial regions of New Jersey and New York.

6.24 Jamaica Bay, NY

Jamaica Bay stands apart from the other locations. It is a major environmental preserve for aquatic life and for migratory birds. While it is not the location for major shipping activities, nor a location where major industrial activity has taken place, nevertheless, a federal navigation channel is maintained for access to landfills and petroleum terminals.

The major potential point sources for contamination in the Bay are John F. Kennedy International Airport, two Brooklyn landfills located on the shore line, and contributions from sewer outfalls and direct discharges. The distribution of PAHs, PCBs, and lead is shown in Figure 6-4c. Contaminant levels are lower than for other areas of the Harbor, but the regions of concern are very obvious. These results, supplemented by other data, can be used in planning methods for contaminant reduction in the Bay.

7. Technology Summary

7.1 Phase 1: Study of Alternative Methods for Disposal of Dredged Material (WRDA 1990).

Methods for the handling and disposal of dredged material have been studied and developed for many years. An extensive literature evaluation of these methods was conducted so that an informed selection of the best existing methods for forming a complete treatment train could be made. The evaluation covered a number of different technological processes that are summarized below. Overall, the information gathered in this initial study provided a summary of the existing state-of-the-art that gave an excellent starting point for planning the later phases of the WRDA Decontamination Program.

7.11 Evaluation of Innovative Technologies

Information on more than 500 treatment technologies was obtained through inquiries to government agencies and through literature and database surveys. A review of these technologies was performed, and six vendor-specific technologies and eight conceptual technologies were chosen for consideration for further evaluation, testing, and/or development.

7.12 Evaluation of Potential Fast-Track Demonstration Technologies

A second evaluation of technologies was done to search for technologies which had potential for use in a fast-track demonstration at the pilot-scale size. Possible technologies were found from discussions with representatives of government agencies and research institutions, whereby, more than 400 technologies were found for consideration. After review, 60 technologies were considered to have potential for a fast-track demonstration. More detailed consideration was given in two further reviews using the following criteria: effectiveness, implementability, cost, full-scale suitability, and potential for beneficial use of the residuals. After completion of the three-step selection process, seven technologies were finally selected as the best candidates for further evaluation and testing after completion of the three-step selection process. The seven types of selected technologies are as follows:

PAHs

PCBs

Figure 6-4c.
Jamaica Bay

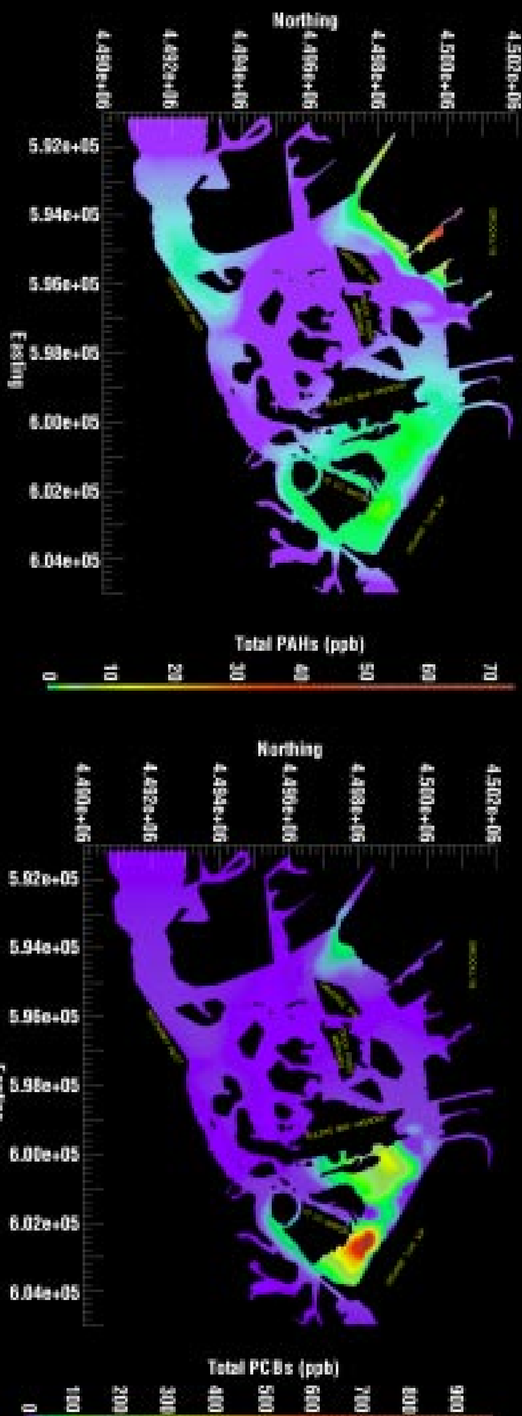


Figure 6-4b.
New York Harbor

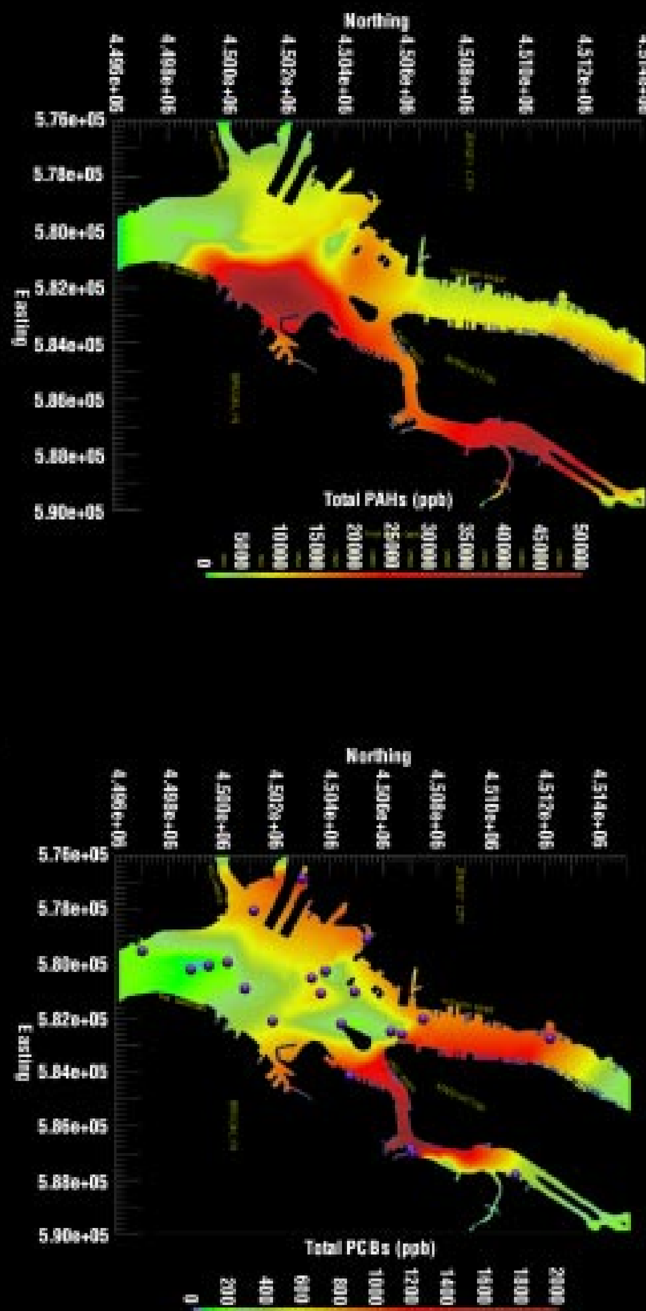
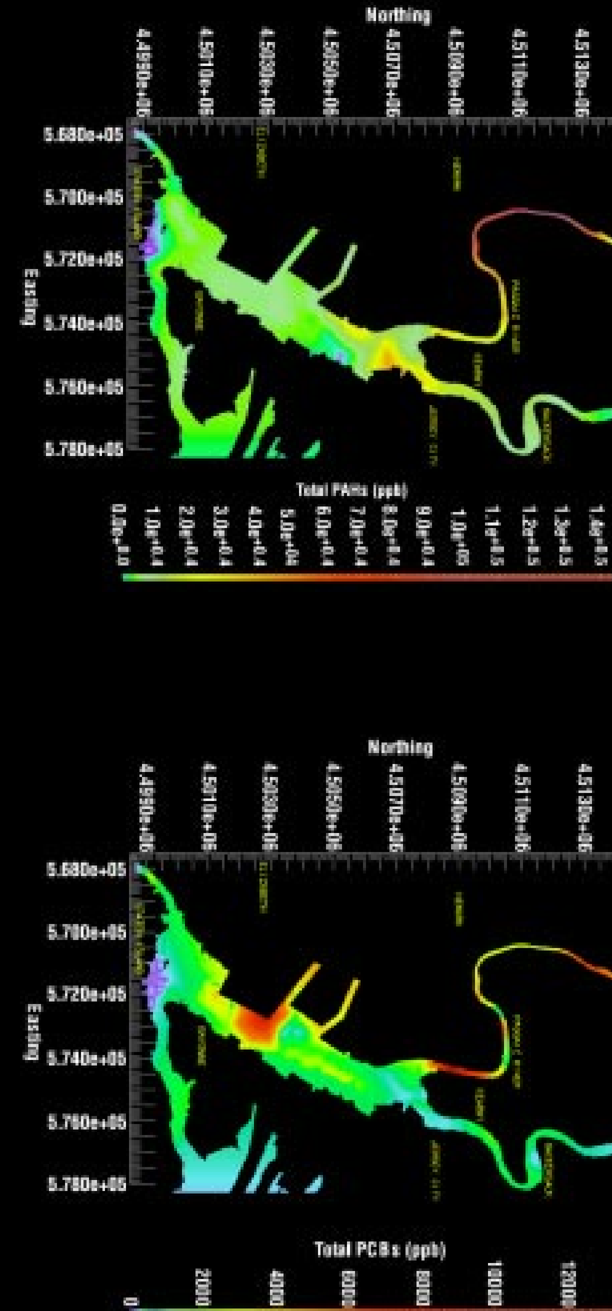
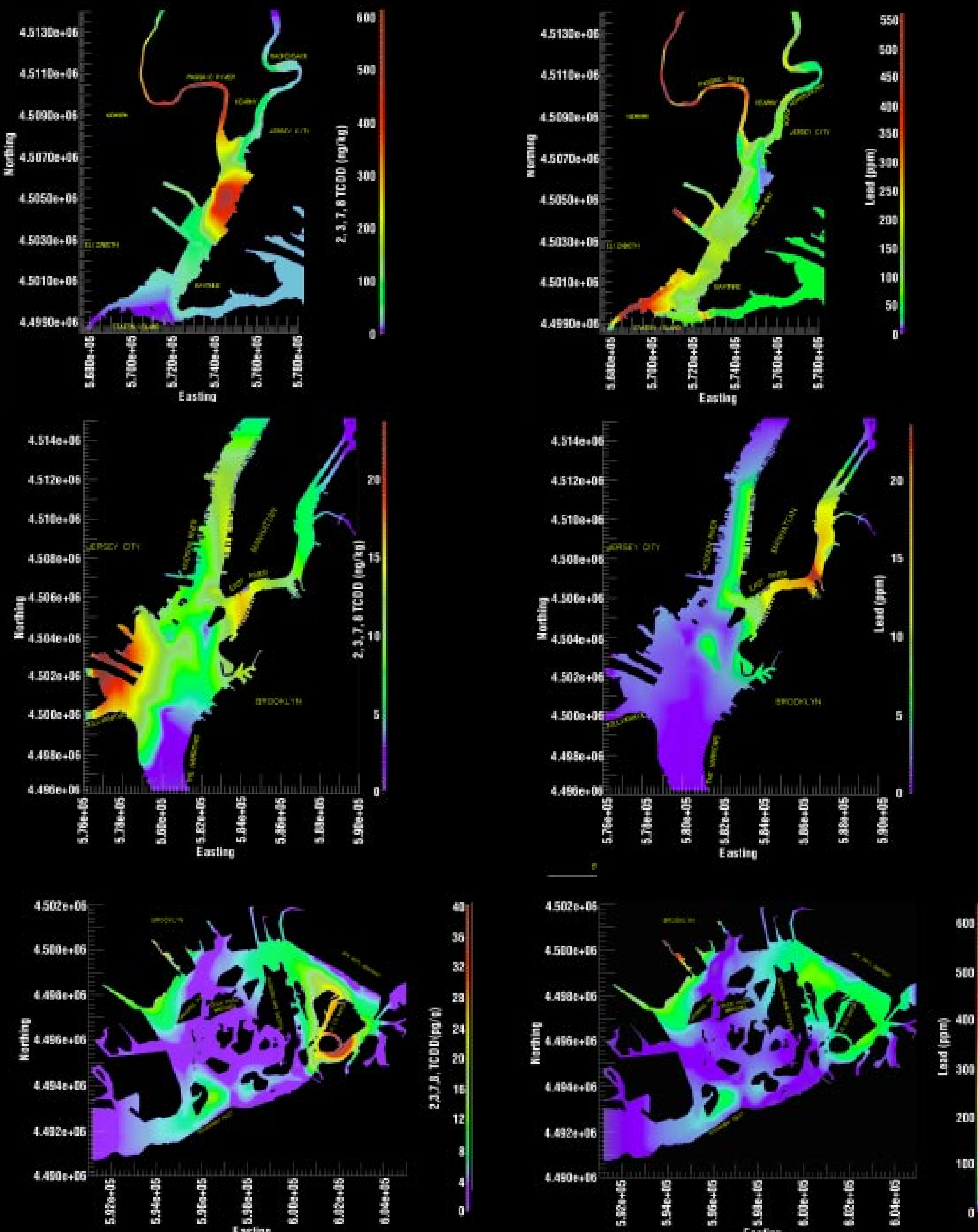


Figure 6-4a.
Newark Bay




Northing
Easting
2, 3, 7, 8 TCDD (ng/kg)
Lead (ppm)
2,3,7,8, TCDD(pg/g)
JERSEY CITY
MANHATTAN
BROOKLYN
BAYONNE
EAST RIVER
HUDSON RIVER

TCDD **Lead**

- Low energy extraction process
- Soil and sediment washing
- Critical fluid solvent extraction
- Thermal desorption
- Dehalogenation/stabilization/solidification
- Solidification/stabilization with silicate compounds
- Anaerobic thermal processing.

7.13 Demonstration Project Site Screening

Ideally, a successful decontamination treatment train must be able to handle dredged material volumes on the order of 500,000 cy/y. The scale of the operation is such that an appropriate site will need to have an area of 10 to 20 acres, good access to barge, rail, and truck transportation, and crucially, be acceptable to the community in which it is to be located. A list of 27 potential locations in New York and New Jersey was developed. However, many of those sites were found to have serious drawbacks and were eliminated from further consideration during following phases of the decontamination demonstration. In the later phases of this project, it has been found most effective to make the site acquisition the major responsibility of the private sector. The federal agencies contribute by verifying technologies and treatment effectiveness to the state agencies responsible for permitting and to the site owners.

7.2 Phase 2. Bench- and Pilot-scale Demonstrations (WRDA 1992).

The application of decontamination technologies to the sediments found in the Port of NY/NJ, on a scale large enough to contribute significantly to solution of dredged material management, is a task that has not been attempted previously in the United States. A phased approach is required to validate the performance of the technologies and to acquire data needed to engineer operational facilities. These needs were met by the WRDA Program by setting up a series of steps running from an initial “proof-of-concept” demonstration at the bench scale (five to twenty gallons) and pilot scale (2-20 cy) on through to construction of a commercial-scale facility. The Phase 2 work was devoted to the bench- and pilot-scale testing steps. Sediment taken from Newtown Creek, NY, one of the most polluted waterways in the Harbor region, was used for these tests.

7.21 Development of a Treatment Train

Sediment decontamination ties together a series of operations starting with removing sediment from the Harbor and finishing with production of a material that is suitable for beneficial use options. In this case, the complete system defines a treatment train. A conceptual plan for a treatment train is shown in Figure 7-1. The objective of the testing of decontamination technologies is to provide viable methods for incorporation into the decontamination and beneficial use portions of the treatment train.

The choice of technologies utilized results from the initial survey carried out under Phase 1 and also incorporated findings from the EPA Assessment and Remediation of Contaminated Sediments (ARCS) and Superfund Innovative Technology Evaluation (SITE) programs. However, the characteristics of the estuarine sediments found in the Harbor may differ from those of the fresh water sediments and soils used in the ARCS and SITE tests, and results of the earlier tests needed to be revalidated for the Harbor environment. It was also felt that a series of tests at different volume scales were necessary for actually assembling a viable treatment train.

The guiding principles in selection of technologies for the demonstration testing were:

- selection of a range of approaches for flexibility in treating different sediment types and different levels of contamination
- selection of existing commercially-relevant technologies that could be extended rapidly to full-scale operation

An innovative procurement procedure was developed for meeting these criteria within the framework of the Department of Energy Federal Acquisition Regulations (FARs). The project was organized into a series of four phases that took the work from the bench-scale through optional work at the pilot-scale and ultimately to demonstrations at 100,000 and 500,000 cy/y. This procedure eliminated the need to carry out individual procurements at the larger scales and reduced the overall contracting time by 9 to 12 months for each step. Another advantage of this procurement process is its ability to re-visit technologies that may have performed “under par” and since then improved their process efficiencies.

A list of potential technology vendors was assembled from several sources. This list was supplemented by announcing the issuance of the request for proposals (RFP) in the *Commerce Business Daily* (September 26, 1994). A potential bidder list of 150 technology vendors resulted, all of whom requested copies of the RFP, which resulted in a total of 24 formal proposals being received. These were evaluated with the assistance of several federal and university technical experts. Seven companies were selected for the initial bench-scale testing.

The bench-scale testing selections actually defined a matrix of technologies that fit into the treatment train concept. They included low-, medium- and high- temperature methods that could be used to treat dredged material with different contamination levels and which yielded different products for beneficial use. A block diagram showing how they can be combined into a treatment train or matrix is shown in Figure 7-2. Note that this treatment train adds parallel tracks into the decontamination procedures so that the path followed by a treatment train can be optimized to fit the needs of the Harbor.

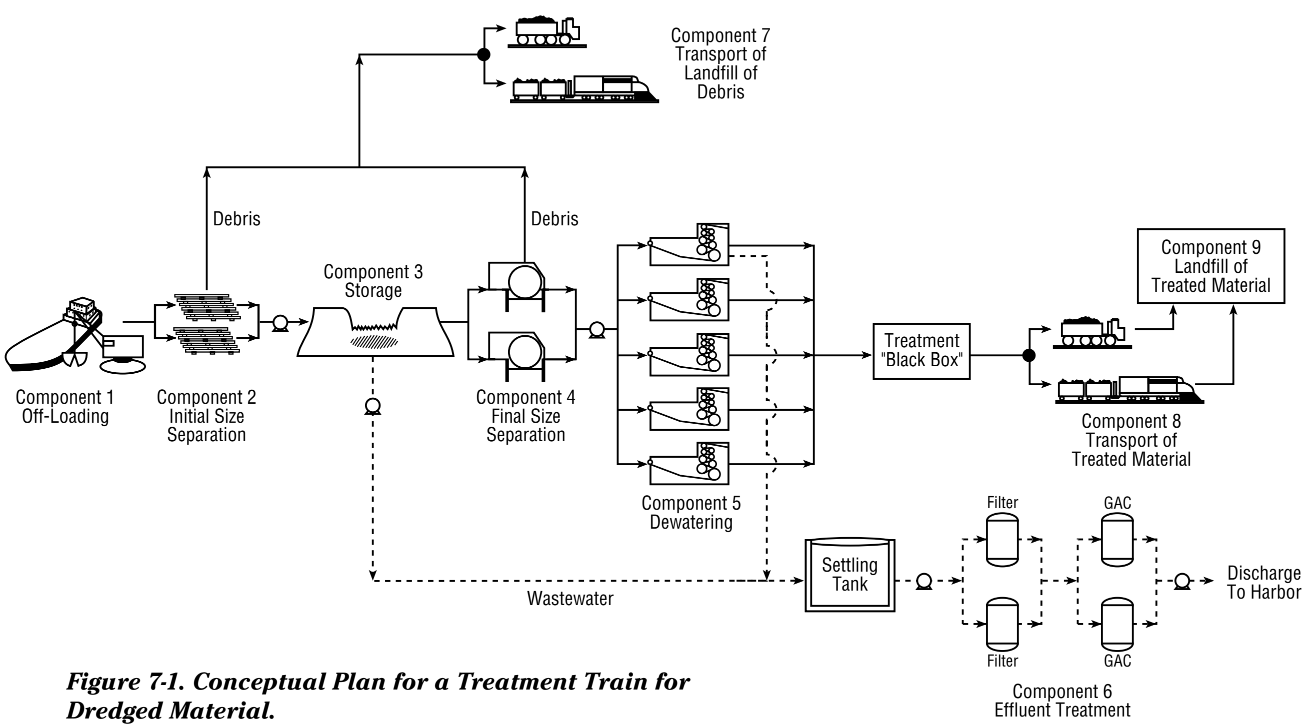


Figure 7-1. Conceptual Plan for a Treatment Train for Dredged Material.

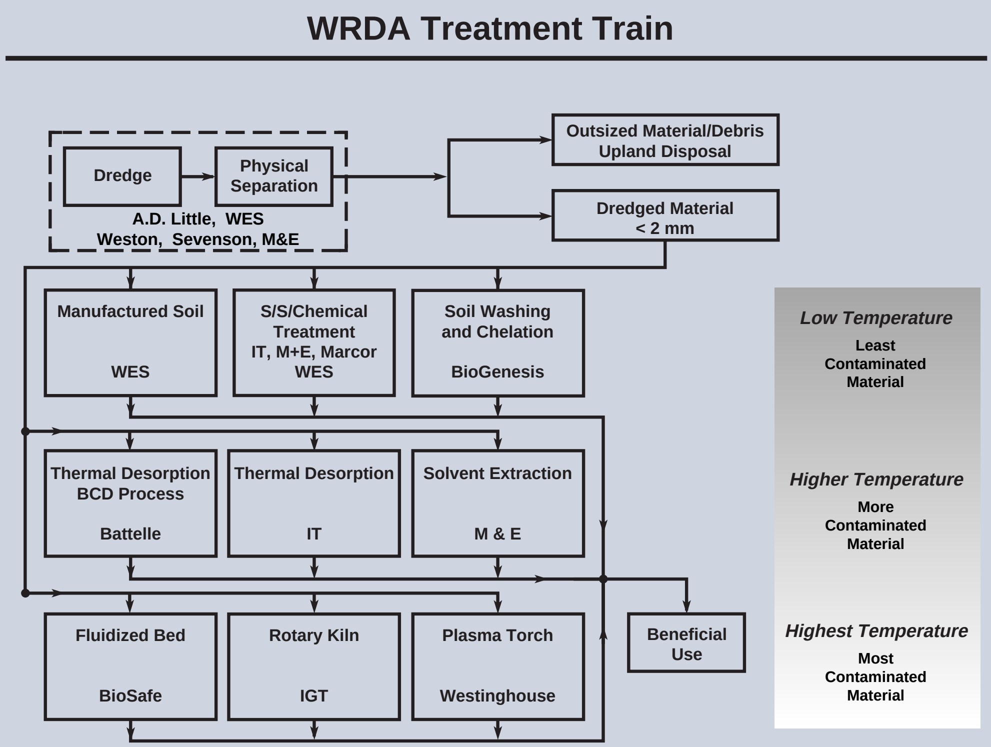


Figure 7-2. WRDA Treatment Train. The different technologies tested in the program are displayed according to the temperature used in the processing.

7.22 Bench- and Pilot-Scale Technology Testing

The specific approaches tested were (listed in order of increasing temperature used in the process):

Manufactured Soil: US Army Corps of Engineers, Waterways Experiments Station (WES)

The manufactured soil is created by blending cellulose waste solids (yard waste compost, sawdust, wood chips) and biosolids (cow manure, sewage sludge) with the as-dredged sediment.

Manufactured soil production has been developed by the USACE WES and applied in test projects. Its inherent simplicity makes it an attractive approach. Initially, contaminant concentration reductions are accomplished through dilution coming from the addition of materials needed for soil formation. Over time, however, it is possible that organic contaminants may be reduced, e.g., through bioremediation (including phytoremediation and other natural methods), although specific data are lacking.

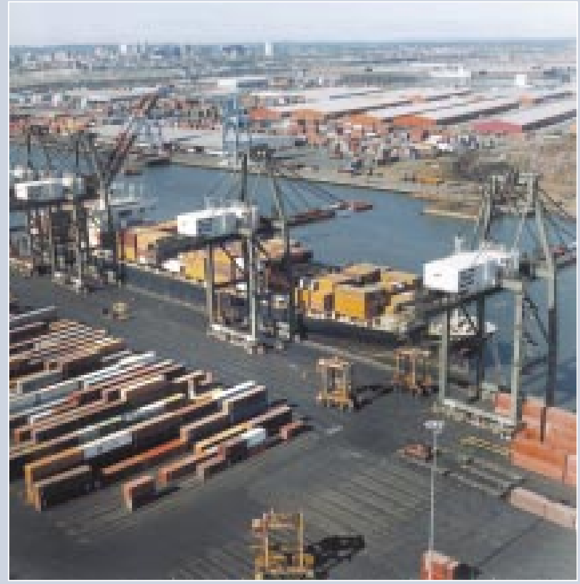
Sites for placement of the manufactured soil will be determined by criteria formulated by the states of NY and NJ. For example, comparison with NJ residential and nonresidential soil cleanup standards show that the contaminants in the manufactured soil will exceed standards in several instances. There probably will be sediments that are less contaminated and where this approach could meet these clean-up criteria.

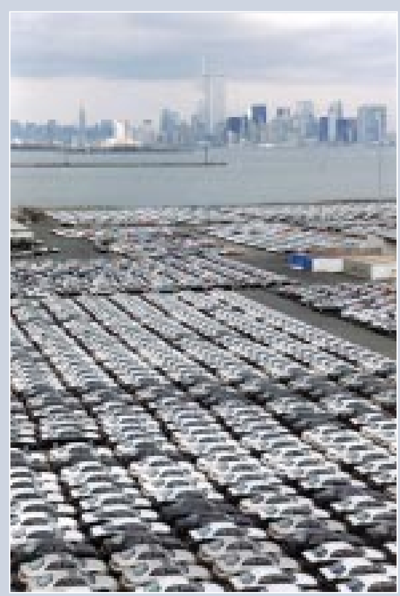
Bench-scale testing was performed in a green house to determine whether the estuarine sediments could be formed into a viable soil. The results were positive and showed values for the relative amounts of the manufactured soil

Harbor Views

Harbor Overview

Port Activities





components that formed the most fertile soil. The suitability of the soil for growth of different plant species was tested for tomato, marigold, rye grass, and vinca. The results of analytical testing are shown in Table 7-1. The reduction in contaminant concentrations results from the dilution by the materials added to create the soil.

The results of the initial testing showed that a viable soil was formed. The approach gave promise of being able to serve as a management option for placement of large volumes of dredged material at a potentially low cost. As a variation in this approach, the use of dredged material that had been treated to reduce contaminant levels could eliminate possible questions about placing large volumes of dredged material in the environment with a possible deleterious effect on environmental and human health. It was therefore considered useful to proceed to carry out a pilot-scale test under actual weather conditions to be found in the Harbor area.

The work was undertaken at a site in the Port Newark Marine Terminal. A number of test cells were constructed so that the soil composition could be varied and growth of several different plant species could be evaluated. The test period covered two growing seasons. A photograph of two test cells with grass produced during the second growing season is shown in Figure 7-3. The

Table 7-1. Summary of Results for U.S. Army Corps of Engineers Waterways Experiment Station Bench-scale Manufactured Soil Demonstration: 30% Dredged Material, 50% Sawdust, 10% Cow Manure

Containment	As Dredged	Man. Soil 30% As Dredged	Percent Reduction	NJ Non-Resid.[1]	NJ Resid.[2]	NY Resid.[3]
2, 3, 7, 8 TCDD (ppt)	41.5	15.2	63.4	—	—	—
OCDD (ppt)	17463	5290	69.7	—	—	—
TCDD/TCDF TEQ (ppt)	518	182	64.9	—	—	—
Total PCBs (ppm)	1.22	0.782	68.0	2	0.49	1
Anthracene (ppb)	3700	1590	57.0	10,000	10,000	50,000
Benzo(a)anthracene (ppb)	4480	3130	30.1	4	900	224
Chrysene (ppb)	4560	3720	18.4	40	9000	400
Total PAHs (ppb)	57,900	35,800	38.2	—	n/a[4]	396,500
Arsenic (ppm)	33.5	12.5	62.7	20	20	7.5
Cadmium (ppm)	3.0	7.9	78.6	100	1	1
Chromium (ppm)	377	140	62.9	—	—	10
Copper (ppm)	1172	393	66.5	600	600	25
Lead (ppm)	617	331	46.4	600	400	SB[5]
Mercury (ppm) total	1.29	—	—	270	14	0.1
Zinc (ppm)	1725	514	70.2	1500	1500	20

[1] NJ Department of Environmental Protection. Non-residential soil, direct contact. J.J.A.C. 7:26D, revised 7/11/96.
[2] NJ Department of Environmental Protection. Residential soil, direct contact. J.J.A.C. 7:26D, revised 7/11/96.
[3] NY Department of Environmental Convervation. Recommended soil cleanup objectives. HWR-94-046 (Revised). January 24, 1994.
[4] NJ Department of Environmental Protection. Non-residential soil, direct contact. J.J.A.C. 7:26D, revised 7/11/96.
[5] SB = Site background.

Figure 7-3. Grass growing in test cells used during the pilot-scale testing of manufactured soil created by the US Army Corps of Engineers Waterways Experiment Station.

Table 7-2. Metal Concentrations In Plant Tissue (mg/kg) from Port of Newark Demonstration Site in May 1997.

Metals	Control	PI Treatment	PII Treatment	PIII Treatment
Antimony	0.00	0.00	0.19 (0.31)	0.00
Cadmium	0.07 (0.01)	0.56 (0.50)	0.30 (0.03)	0.06 (0.02)
Chromium	0.40 (0.15)	0.70 (0.27)	0.51 (0.16)	0.57 (0.15)
Copper	5.65 (0.22)	20.57 (2.46)	12.53 (5.78)	15.30 (2.67)
Lead	1.53 (0.29)	1.92 (0.58)	1.91 (0.23)	1.32 (0.21)
Mercury	0.11 (0.10)	0.42 (0.07)	0.04 (0.06)	0.07 (0.12)
Nickel	0.87 (1.51)	6.94 (1.532)	5.46 (1.58)	5.92 (2.15)
Thallium	0.13 (0.05)	0.03 (0.00)	0.03 (0.05)	0.05 (0.05)
Zinc	38.50 (5.38)	167.67 (44.41)	115.17 (43.78)	123.33 (15.37)

Standard deviations are listed in parenthesis.

overall results from the pilot testing corroborated and extended results from the bench-scale tests. Uptake of metals observed in the pilot-scale testing are shown in Table 7-2. Transfer of metals and organic contaminants was demonstrated during the testing and must, therefore, be considered carefully when planning actual uses for the soil created from untreated sediments.

The overall results showed that a viable topsoil was formed and that, under carefully controlled conditions, use of manufactured soil could be considered for use on a larger-scale project. The advantages of this method include relatively low cost and easy implementation with no need for complex capital equipment or dewatering of the material. The disadvantage is that the degradation of the organic compounds and fate of the heavy metals proceed with unknown rate and pathways so that food chain transfer issues could restrict use as a topsoil. Since the removal and transport of these contaminants is an *in-situ* process that proceeds slowly and unpredictably, long-term monitoring will be required.

It was also concluded that a large-scale demonstration of the use of manufactured soil, if performed under the WRDA Decontamination Program, should be done in conjunction with an actual decontamination technology to ensure manufacturing an end product that would pass public scrutiny, i.e., placement for brownfields, ornamentals, etc.

Solidification/Stabilization: WES/International Technology (IT)/Marcor/ Metcalf & Eddy Inc. (M&E)

Solidification/stabilization (S/S) is a treatment that creates solid aggregates from dredged material by addition, of Portland cement, fly ash, lime and/or proprietary chemicals.

Solidification/stabilization (S/S) is a treatment technology that mixes in binding agents to reduce the water content, improve structural/geotechnical properties, and better immobilize the contaminants within the material. Binders include Portland cement, fly ash, lime, and cement kiln dust. Proprietary additives may also be used. After blending, the material is allowed to "set" into a hardened, granular soil-like condition, with a lower water content and improved structural/geotechnical properties (e.g., shear strength, compactability). Contaminants typically become more tightly bound to the sediment matrix by chemical and mechanical means. This enhanced immobilization prevents significant levels of contaminants from leaching into aquifers and water bodies or otherwise becoming biologically available. The high alkalinity found in commonly-used binders further aids in reducing the leaching potential of most toxic metals. Material that has undergone S/S is sometimes referred to as "stabilized" material.

The right types and proportions of admixtures are tailored to meet the engineering specifications and standards for a generally-accepted and similarly-manufactured product. Beneficial uses for a soil-like product include structural or nonstructural fill, grading material, daily/intermediate landfill cover, brownfield re-development projects, and final landfill cover. In the NY/NJ region, earthen material used for such purposes typically sells for $5-12/ton as delivered. In addition, quality control and quality acceptance requirements need to be established to ensure acceptable uniform quality.

There are several ways in which the S/S technique can be applied. It can be used with untreated sediments, or can be combined with treatment technologies that remove or destroy certain types of contaminants (such as those that remove or destroy organics but leave metal levels unchanged).

S/S has been applied in Japan to bottom sediments containing toxic substances and in the United States to industrial wastes as well as to dredged material from New York/New Jersey and Boston Harbors. Laboratory studies have been performed on dredged material from Indiana Harbor, Indiana; Everett Bay, Washington; and Buffalo River, New York.

Tests were performed by WES on untreated sediments from Newtown Creek, NY. They measured the physical properties of the solidified and stabilized sediments for a number of different cement/fly ash/lime mixtures. It was shown that the physical properties were adequate to meet standards for several beneficial uses in the construction industry. M&E produced cleaned

Figure 7-4. Solidification/ stabilization processing of dredged material from NY/NJ Harbor. Portland Cement and fly ash are being added through the chute at the left. The column at the right is the drive shaft for a mixer used to homogenize the mixture. The processing is done in the barge used to transport the material for placement at an upland site.

sediment using a solvent extraction technique (see below) which was then treated by S/S. The results of these tests showed that S/S procedures formed materials from the dredged material that had satisfactory physical and chemical properties and defined the optimum proportions of additives for use with the dredged material found in the New York/New Jersey Harbor region. These data, when combined with results from other projects in progress in the region, will help in setting performance standards for the practical application of the S/S technologies. A photograph of commercial dredged material solidification/stabilization processing is shown in Figure 7-4. Portland cement and other materials are being added in the foreground of the picture. A mixing paddle (background) is used to blend them with the bulk sediment.

A summary of the results obtained by M&E for several S/S formulations are shown in Table 7-3.

Table 7-3. Physical Characterization Data for Stabilized/Solidified Sediments

Sample, Cement/ Sediment Ratio	Unconfined Compressive Strength (pounds/square inch)	Particle Specific Gravity	Permeability cm/sec	Bulk Dry Density, lbs/cu ft
0.1 Cement Fixation Only	26	2.54	8.05E-06	37.7
0.2 Cement Fixation Only	123	2.61	7.05E-06	48.9
0.4 Cement Fixation Only	501	2.63	2.81E-07	58.8
0.15 Cement Solvent Extraction/Fixation	234	2.70	1.61E-06	51.4
0.3 Cement Solvent Extraction/Fixation	658	2.69	5.62E-07	64.7

Sediment Washing: BioGenesis

Sediment washing uses a proprietary blend of surfactants (detergents), chelating and oxidizing agents, and high pressure water jets (collisions) to remove both organic and inorganic contaminants from the dredged material.

The BioGenesis treatment technology has blended a mechanical scouring of the dredged material particles by a high-pressure jet of water with application of (1)surfactants (2) chelating agents, and (3) oxidizing chemicals to clean the particle surfaces. Chelating chemicals are used to render metals soluble so that they are transferred from the solid to the surrounding liquid. The contaminants that are removed from the dredged material are treated by producing bubbles that create a local region of high temperature that destroys the organic compounds in the water (cavitation-oxidation). Floatable organic material is separated by surface skimming in a flotation tank and metals are precipitated in the form of a sludge which is disposed of at a landfill. A diagram outlining the treatment process is shown in Figure 7-5.

The results obtained during the bench-scale testing showed reductions of the organic compounds by about 90% and of inorganic compounds by about 70%. The specific reduction efficiency varied with the particular contaminant compound or element considered. The BioGenesis technology is simple in concept and in the type of equipment used, but it is also one that rests on a knowledge of sediment chemistry and particle/contaminant interactions in the liquid and solid phases. For this reason, the sediment washing approach has potential for improvement as the process is gradually optimized for the conditions found in the Harbor. The process produces an end material which can be combined with humates, lime, and other organic materials to form a manufactured soil. Any contaminants left in the sediments are diluted by these additions. The overall reduction for organic compounds then becomes about 97% and for inorganic compounds about 90%. This magnitude of decontamination makes it possible to produce manufactured soil which meets the standards for residential soil. Revenue from the sale of this topsoil can be used to reduce the tipping fee charged for dredging and decontamination of the dredged material.

The BioGenesis approach has been extended to a large-scale pilot demonstration. The details of the work are discussed in Section 7.32.

Solvent Extraction: Metcalf & Eddy, Inc. (M&E)

Solvent extraction is similar in concept to sediment washing. It employs solvents (alcohols) at an elevated temperature to remove contaminants from the dredged material.

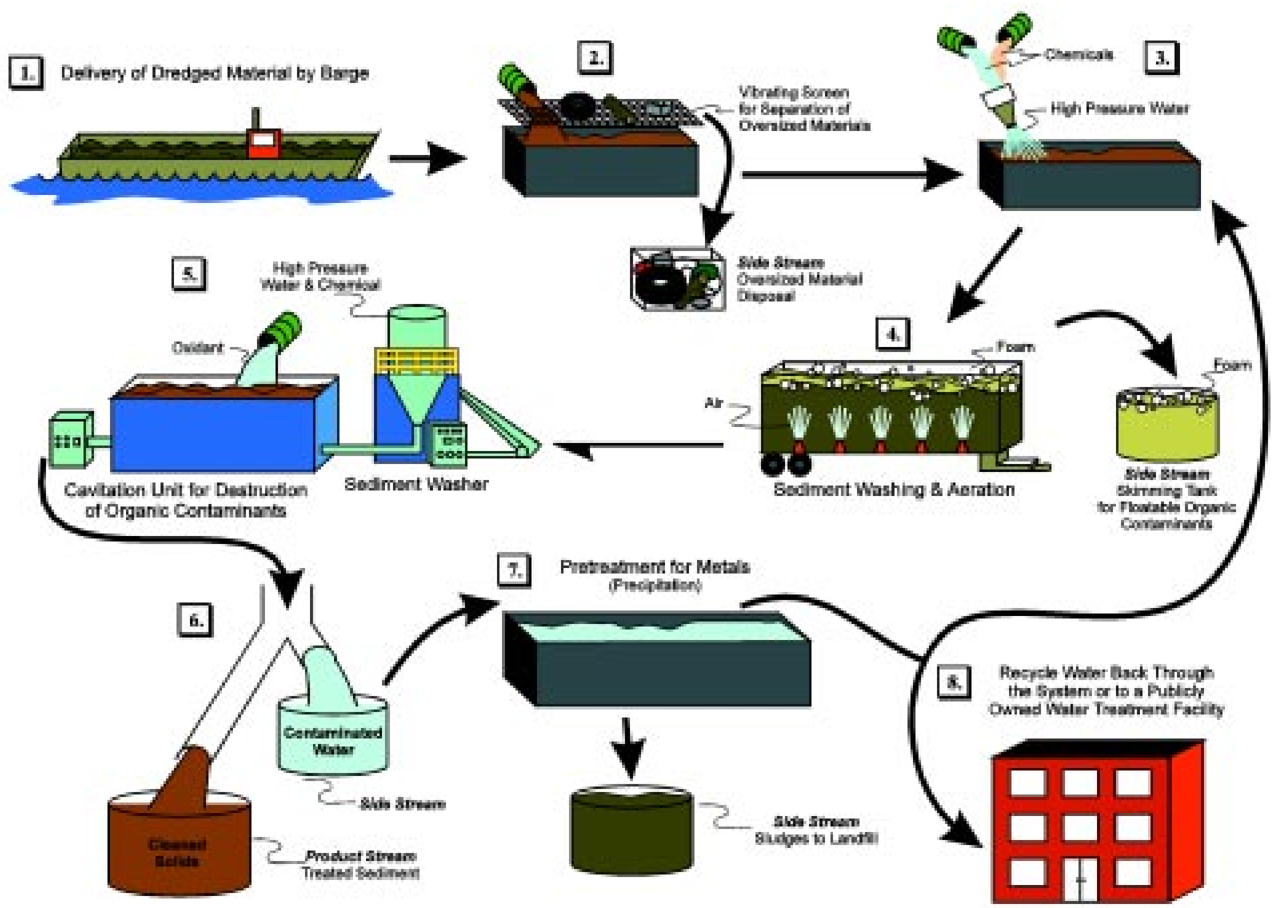


Figure 7-5. BioGenesis™ Sediment Washing Process

Solvent extraction procedures are similar to the sediment washing process of BioGenesis in the sense that a chemical solvent is used to remove the surface coatings of contaminated materials. Removal of contamination depends on the porosity of the material and the treatment time as well as on the details of the chemical interactions of the contaminants with the bulk sediment material. The extraction process operated at a temperature of 37.7-60.0°C and employed isopropyl alcohol and isopropyl acetate as the solvents. These conditions require more elaborate apparatus than the BioGenesis process and require more attention to operating conditions because of fire/explosion hazards.

Pilot-scale tests were carried out using multiple passes through the system and in a continuous operation mode. This demonstration did not use a chelator and the metal levels are not substantially reduced. The testing included production of stabilized materials from both untreated and treated dredged material by M&E and the USACE WES. Compressive strengths of over 100 lbs/in^2 were achieved. These values are comparable to values reported for a project carried out on dredged material from the Port of Boston.

Thermal Decomposition/ Desorption: Battelle Memorial Institute

The base-catalyzed decomposition (BCD) process is an enhanced thermal desorption technology which removes organic contaminants from the dredged material and then passes them through a second treatment stage that transforms them into harmless compounds.

The base-catalyzed decomposition (BCD) process was developed by EPA and other laboratories in work that began in 1978. The research effort that followed led to the design of a two-stage process. In the first stage of the process, materials containing halogenated contaminants (PCBs, dioxins, and furans) are mixed with sodium bicarbonate and heated to 340 °C to vaporize and partially decompose the contaminants. This is a modified thermal desorption process related to the simpler version tested by the International Technology Corporation. The vaporized contaminants in the resulting small volume of water and organic condensates then are dehalogenated using heat (340 °C), a hydrogen-donor oil, sodium hydroxide, and a catalyst (stage 2). The volatile and semi-volatile organic compounds present in the contaminated dredged material will also be removed by the heat treatment as will inorganic compounds with high vapor pressure or solubility. The main steps in the two-stage BCD process are shown in Figure 7-6. The removal/destruction efficiency achieved for this test of the application of BCD to estuarine dredged material is shown in Table 7-4. It can be seen that the process has excellent success in handling chlorinated compounds and is somewhat less successful in removing PAHs. It was found that the metals remaining in the treated sediment were not removed during standard leachability tests.

Because the BCD process operates at elevated temperature, the water, volatile and semi-volatile organic compounds, and potentially volatile metals will be evaporated and subsequently partitioned into various sidestreams (e.g. condensates and off-gas). Therefore, complex material handling and pollution control systems will be required to treat the various sidestreams to minimize environmental emissions.

Battelle estimated the cost of decontaminatiing dredged material at a BCD treatment facility treating 150,000 cy/y to be $108/cy. The work also shows that there are many unknowns in the process parameters that will require further examination before the design of a full-scale plant would be prudent. The relatively high cost of treatment, need for further research work, and a probable long time before a plant could be operational made the BCD technology not practical for further consideration at this time.

Thermal Desorption: International Technology Corporation (IT):

Thermal desorption uses heat to remove surface contaminants. The temperatures are not high enough to destroy the organic compounds.

IT used thermal desorption to remove organic compounds from the surface of the sediments. Their laboratory testing was carried out with a small-scale rotary kiln. This is merely a tube containing the sediment that is rotated to mix the sediment while the tube is raised to a high temperature. The variables in the process are the temperature and the time the sediment spends at the elevated temperature. The apparatus is diagrammed in Figure 7-7.

The results of the bench-scale testing showed that the intermediate treatment temperature was effective in reducing contaminant levels. However, as a consequence of the approach, a side stream of hazardous material was produced that would require disposal at a hazardous waste treatment facility.

Table 7-4. Removal/Destruction Efficiency of BCD

Parameter	Stage 1 Removal/ Destruction Efficiency (%)	Stage 2 Destruction Efficiency (%)
2, 3, 7, 8-TCDD	>76.53[a]	>99.19[a]
OCDD	99.68	>99.39
Total PCDDs	>99.53	>99.65
2, 3, 7, 8-TCDD	>98.00[a]	>99.19[a]
OCDD	>99.76[a]	>96.04[a]
Total PCDFs	>99.88	>99.97
Total 2, 3, 7, 8-TCDD Equivalent	>97.84	>99.74
Total PCBs	98.56	97.45 - 97.80[b]
Total PAHs	89.19	14.73
Total Chlorinated Pesticides	98.10	NA[c]
Silver	13.19	NA
Arsenic	12.08	NA
Cadmium	19.10	NA
Chromium	0.00	NA
Copper	4.94	NA
Mercury	95.50	NA
Nickel	0.71	NA
Lead	4.33	NA
Zinc	0.00	NA

(a) Parameter was below detection after treatment

(b) Not detected in oily residue but 2.2% detected in the organic rinsate from the condenser walls.

(c) Not analyzed.

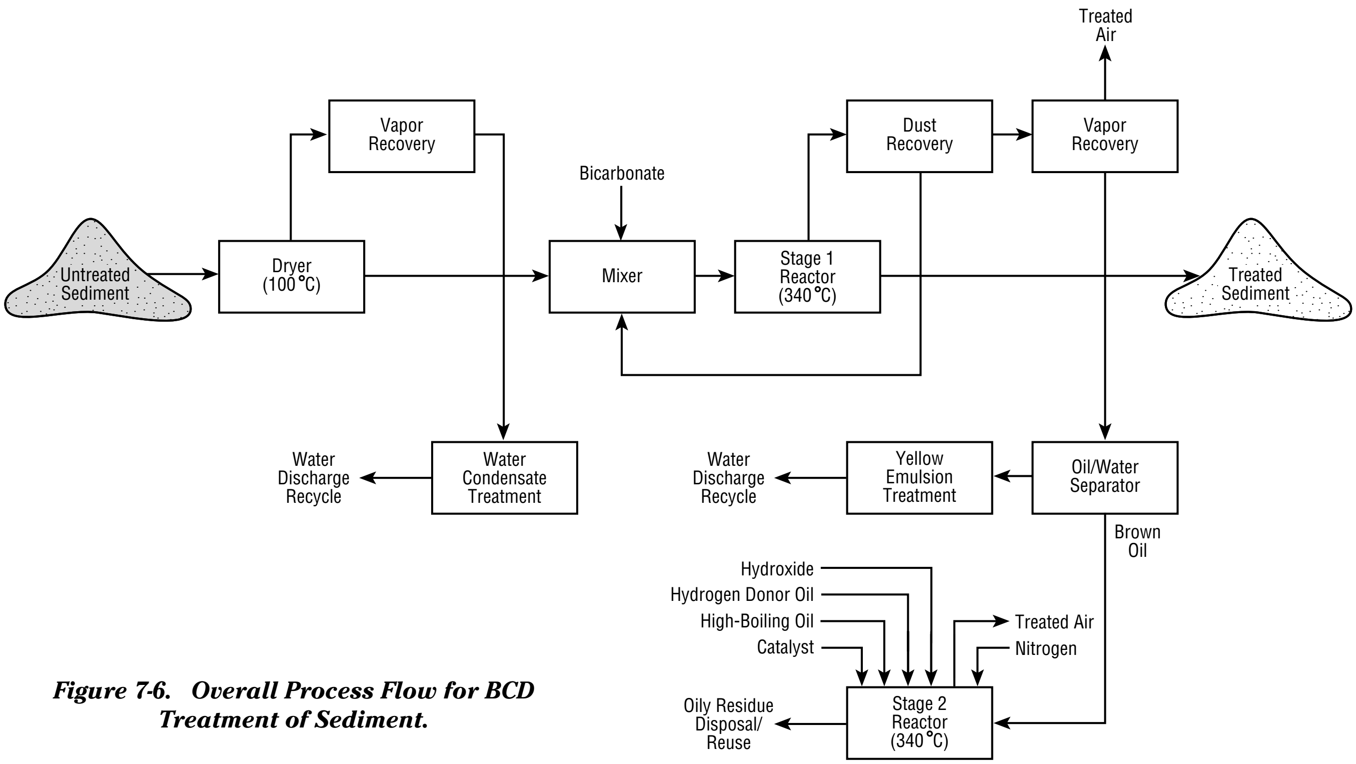


Figure 7-6. ***Overall Process Flow for BCD Treatment of Sediment.***

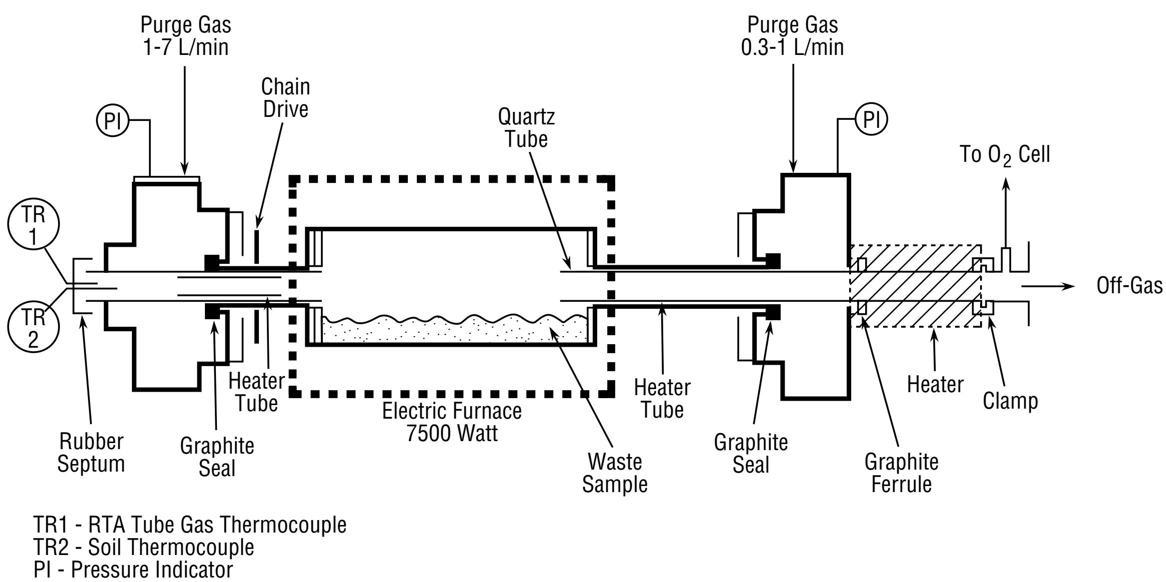


Figure 7-7. Schematic diagram of the equipment used in the bench-scale demonstration carried out by the International Technology Corporation.

Proposed beneficial uses for the end product were for applications such as construction fill and habitat restoration. Economic benefits from these applications would be low, and this fact combined with a relatively high capital cost made it seem unlikely that a self-sustaining business could be created based on this technology.

Therefore, it was concluded that moving to a pilot-scale test level was not justified.

Thermal Destruction: BioSafe

This is a high-temperature treatment that destroys any organic contaminants found in dredged material. The process is carried out using a fluidized-bed heating technology that is widely employed in the power industry.

BioSafe used a fluidized bed treatment (FBT) to destroy the organic compounds in the dredged material. Metal contaminants are either retained in the treated material or are volatilized and removed from the gaseous side stream.

The FBT process uses fluidized bed steam cracking to totally destroy any organic materials such as dioxins, PCB's, and petroleum products present in the dredged material. It is a robust process, based on the application of fluid-bed technologies that have been in practice for more than 50 years. The process is not incineration or oxidation. It converts all organic materials to carbon monoxide, hydrogen, and methane — a clean, fuel gas that is recycled in the process. The remaining solids are free of organic material, and, depending on the metal content, may be disposed of without restriction.

Key to the process is the use of fluidized beds as reaction vessels. While this particular application using dredged material as a feedstock is new, the concept of using fluid beds for thermal processes began in the 1930's. Fluidized bed operation depends on the fact that when the velocity of a gas flowing upward through a bed of small particles is increased sufficiently, the particles begin to float. At the threshold velocity for fluidization, the bed of material expands upward and behaves as if it were a viscous fluid. Further increasing the velocity of the gas causes the bed to expand by about 30 percent as bubbles form, and the bed begins to behave like a turbulent boiling fluid. Within this bubbling bed, the large gas bubbles that form move upward rapidly and in doing so displace bed material above it, and some circulates downward along the bubbles' upward path. This turbulence provides a significant agitation within the bed which provides a uniform distribution of hot material and temperature within the bed.

The most significant advantage of a fluid bed for thermal applications is the mixing of a large mass of material that is held at a constant temperature. Studies have shown that within fluid beds heat transfer coefficients are 5 to 25 times those for the combustion gas alone. This inherent efficiency is the basis of selection of the FBT process.

This demonstration was conducted in a pilot-scale unit with a size sufficient to realistically demonstrate the most critical aspects of the process. Data that were indicative of process operation at a size sufficient to measure the effectiveness of the technology for dredged material decontamination and to identify any potential barriers to scale-up to commercial operation were obtained.

The results of the testing procedures showed that:

- The FBT process can operate with a continuous feed of dredged material
- The FBT process can use the as-received dredged material (without dewatering)

- ♦ The FBT process produces an organic contaminant-free solid product. The destruction efficiency is >99.99% . Metals do not leach from the treated sediment.
- ♦ Beneficial use options for the treated dredged material include use as landfill cover material, concrete aggregate, or agricultural material.

The BioSafe FBT approach was very successful in treating the dredged material. It was deemed worthy of continuing the demonstration at the pilot-scale level. However, changes in the business directions of BioSafe after the conclusion of the bench-scale testing made it impossible to consider them as a candidate for a further demonstration.

Thermal Destruction: Institute of Gas Technology (IGT)/ENDESCO

This is a high-temperature treatment that destroys any organic contaminants found in dredged material. The process is carried out using a rotary kiln heating technology that is used for production of cement and aggregate.

The technology employed is in essence a manufacturing process, one that is commonly in use at existing cement plants. This is encouraging since it means that either existing or new manufacturing facilities could be devoted to processing of dredged material. There is essentially complete destruction of organic compounds. The metals are reduced by dilution and by loss to the gaseous side-stream. Moreover, the metal values in the processed material are in the range found for commercially-available cements. Strength tests have been carried out and show that the sediment-derived product meets compressive strength standards. The end product is a marketable construction grade cement product for use in the concrete and construction industries.

Bench-scale testing was performed to demonstrate that the organic contaminants could be destroyed by use of high temperatures and that a useable end product could be created. The particular aim of the demonstration was to show that it was possible to create a cement that could be sold on the open market. The results are shown in Table 7-5. These results verify that application of high temperatures can remove organic contamination. Construction grade cement was created by grinding the decontaminated material into a fine powder and adding Portland cement. Test results for the final product are shown in Table 7-6 where a comparison with ordinary Portland cement is made. A photograph of the as-dredged sediment is shown in Figure 7-8. Figure 7-9 shows examples of concrete blocks and paving material produced from the cement created from the as-dredged sediment.

Table 7-5

		Untreated Sediment		Blended Cement		DRE*	
Containment	Units	Bench-Scale	Pilot-Scale	Bench-Scale	Pilot-Scale	Bench-Scale	Pilot-Scale
PAHs (SVOCs)	µg/kg	116	370	0.3	0.22	99.24	99.93
PCBs	µg/kg	5,270	8,585	0.75	<D.L.**	>99.96	>99.99
2, 3, 7, 8-TCDD/TCDF	ng/kg	381	262	<D.L.	<D.L.	>99.99	>99.99
Total TCDD/F	ng/kg	2,260	2,871	<D.L.	<D.L.	>99.99	>99.99
Total TCDD/F	ng/kg	3,231	4,363	<D.L.	<D.L.	>99.99	>99.99
Total Hx/Hp/OCDD/F	ng/kg	38,945	34,252	18	<29	99.88	>99.90

* Destruction and Removal efficiency.
** Less than the detection limit of the analytical procedure used.

Table 7-6. Comparative Strength Data

Test Period	Cement-Lock Construction Grade Cement	ASTM Cement Requirements C-595 Construction Grade	ASTM Cement Requirements C-150 Portland
	psi		
3-day	1950	1800	1740
28-day	4620	3000-3500	4060

Comparative Trace Metal Concentrations

Element	Cement-Lock Construction Grade Cement	Portland Cement Range	
	mg/kg		
Mercury	<0.07*	<0.001	0.039
Selenium	<0.94	0.62	2.23
Cadmium	1.59	0.03	1.12
Lead	35.8	1	75
Silver	2.66	6.75	19.9
Arsenic	9.22	5	71
Barium	—	91	1402
Chromium	196	25	422
Nickel	133	15	129

*Less than the detection limit of the analytical procedure used.

The bench-scale testing showed effective decontamination of the dredged material. Creation of a high-value end product, construction grade cement, was verified. It was also shown that the physical properties of the cement were acceptable in comparison with industry standards. Hence, pilot-scale testing was justified as the next step towards creation of an operational facility.

The pilot-scale testing was carried out with a small rotary kiln. In addition to measuring destruction effectiveness under conditions more nearly equivalent to a full-scale facility, it was also possible to assess the types of compounds that should be emitted to the atmosphere following an exhaust gas scrubbing. The pilot-scale test generates data to serve as the foundation for design of larger facilities. The important results of the pilot testing were:

- Essentially all of the organic contaminants originally present in the sediments were completely destroyed (99.99% reduction efficiencies).
- The construction grade cement product readily passes TCLP test for priority metals.
- The construction grade cement product has a compressive strength that exceeds ASTM requirements for Portland cement.
- The flue gas was devoid of heavy metals, PCBs, chlorophenols, chlorobenzenes, and pesticides.

Figure 7-8. As-dredged Newtown Creek sediment prior to treatment in a rotary kiln by the Institute of Gas Technology.

Figure 7-9. Cement blocks and paving material produced following high temperature treatment in the pilot-scale demonstration performed by the Institute of Gas Technology.

- The concentration of dioxins/furans in the flue gas were below detection limits on a TEF basis.

Thermal Destruction: Westinghouse Science and Technology Center.

This is a high temperature treatment that destroys any organic contaminants found in dredged material. The process employs a plasma torch technology that has been used for treatment of several waste streams and in the coating industry.

The Westinghouse Science and Technology Center demonstrated the use of a plasma torch for destruction of organic contaminants and immobilization of metals in a glassy matrix. The plasma torch is an effective method for heating sediments to temperatures higher than can be achieved in a rotary kiln. Plasma, a high temperature (3,000 ^oC), ionized, conductive gas, is created within the plasma torch by the interaction of air with an electric arc. The sediment is melted in the plasma melter using fluxes to produce a target glass product. The molten glass can be quenched to produce a glass aggregate or directly fed to glass manufacturing equipment to produce a salable commercial product. In the plasma melter, all organics are dissociated into elemental species to form clean gasses (i.e., N_2, O_2, H_2O and CO_2). The metals are incorporated into a product glass.

Feeding of the dredged material into the plasma system is more complex since de-watering is necessary, and residence times in the high temperature regions are difficult to adjust. The end goal of the processing is not only to reduce contaminant concentrations, but also to produce a useful final product. Glass tiles and fiberglass materials were successfully produced during the pilot-scale test work. Glass production can, therefore, be considered as successful in reduction of contaminant levels and production of a valuable end product.

The bench-scale testing was carried out in an oven-heated crucible. The testing was designed to show that a useful glass product could be manufactured from the Harbor sediment by addition of chemicals to optimize the major element composition for glass production. The same approach is used by IGT where the composition is adjusted for the manufacture of cement.

The results of the bench-scale tests in terms of decontamination efficiency and beneficial use prospects were excellent. There was also a clear need for a technology of this type to use for highly contaminated sediments. Consideration of these factors led to a decision to proceed to a pilot-scale demonstration to test the operation of the plasma torch.

The pilot-scale testing was carried out an operational facility used for demonstrations of the plasma torch. A single torch was used which operated at a power of 2 megawatts. A photograph of the facility is shown in Figure 7-10. A stream of molten glass exiting the test apparatus is shown in Figure 7-11. A second test processed approximately 1000 gallons of sediments at rates up to 4 gallons per minute. The success of these runs showed that the sediment could be vitrified reliably over hours of operation to produce tons of glass product.

The glass produced in the bench- and pilot-scale tests showed destruction of the organic contaminants by 99.99%. Metals were incorporated and immobilized in the glass matrix and were not leached out during the TCLP tests. Fiberglass and raw glass for glass tile production were successfully produced showing that there was potential for manufacture of an end product with high resale value. The fiberglass and tiles produced are shown in Figure 7-12 and Figure 7-13, respectively. The economic benefit derived from sale of the product can offset the cost of the energy needed to produce the glass and thus make the overall process economically viable. This is also the case for the IGT cement production.

Figure 7- 10. Photograph of the Westinghouse Science and Technology Research Center 2 megawatt plasma torch facility.

Figure 7-11. Stream of molten glass prepared from dredged material emerging from the Westinghouse Science and Technology Research Center 2 megawatt plasma torch facility.

A summary of the main conclusions derived from the pilot-scale data is as follows:

- Demonstrated complete (99.9999%) destruction of organics in test sediment.
- Demonstrated metal incorporation into product glass. Leaching tests on glass product show that the glasses passes TCLP by several orders of magnitude.
- Confirmed pre-treatment system design and the filtrate water stream composition. Sediment was successfully dewatered to 58% solids; the filtrate water composition meets discharge criteria for publicly owned treatment works.
- Established off-gas compositions, providing the basis for a commercial off-gas treatment system design for SO_x, NO_x, particulate, organic, and metal compositions.
- 3,500 pounds of quenched glass products were produced. The glass product allowed an assessment of some glass product options.

Figure 7-12. Photograph of fiberglass fabricated from the glassy material produced with the Westinghouse plasma torch. This is a possible beneficial use for the treated dredged material.

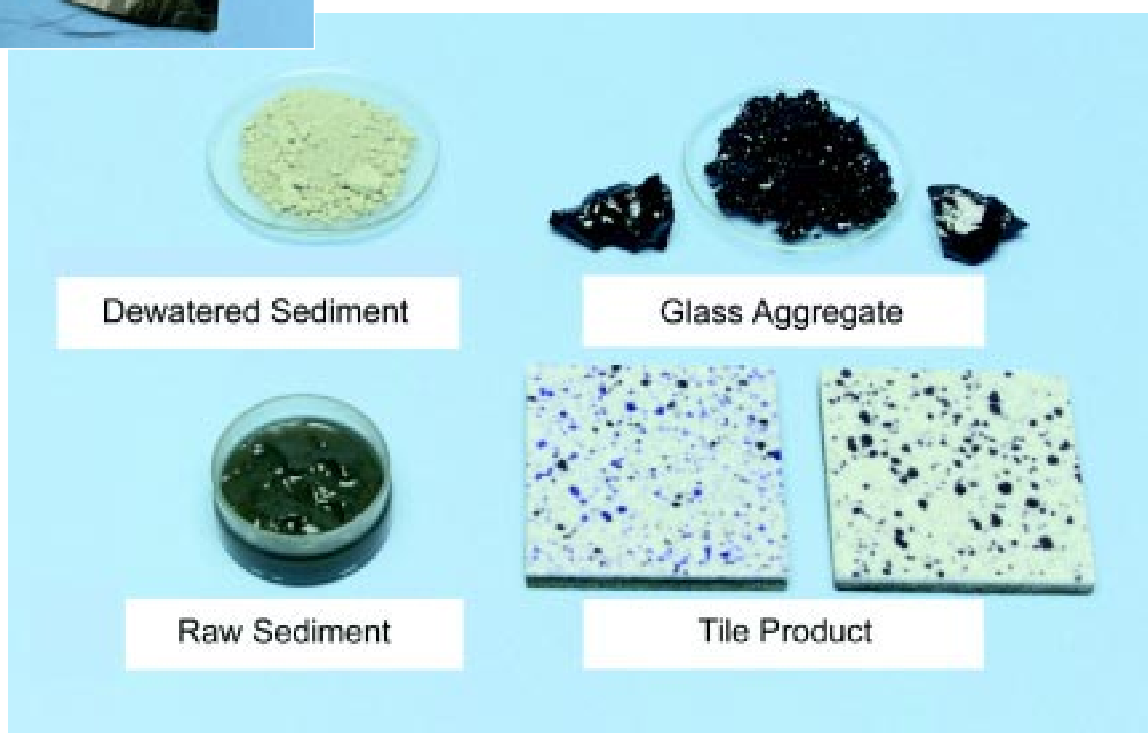


Figure 7-13. Photograph of raw and dewatered sediment, glass aggregate and glass tile manufactured from the glassy material produced with the Westinghouse plasma torch. This is a possible beneficial use for the treated dredged material.

7.23 Summary of Bench- and Pilot-scale Testing Results

High-temperature treatments were all successful in producing reductions in organic contaminant levels on the order of three or more orders of magnitude. Some reduction of metal concentrations occurred through emission into gaseous side streams and through dilution by additives used to produce cement or glass.

The main drawback of the high-temperature methods rests in the costs associated with the energy required for heating the dredged material to the temperatures above 1000 °C used for the treatment. The advantages are the destruction of organics and incorporation of the inorganics in a glassy or cementitious matrix so that they are not likely to leach from the product material. The manufacture of end products that have the potential for high-return beneficial use is essential to the economics of these high-temperature processes.

Per cent contaminant reductions obtained are summarized in Figure 7-14. The values are based on the contaminant concentrations found in the end product, including the effect of any addition of uncontaminated materials. The collection of samples, quality assurance, and quality control were supervised by the consortium of federal agencies and four university groups.

It can be seen that the high-temperature thermal technologies using temperatures higher than 750°C are extremely effective in destroying organic contami-

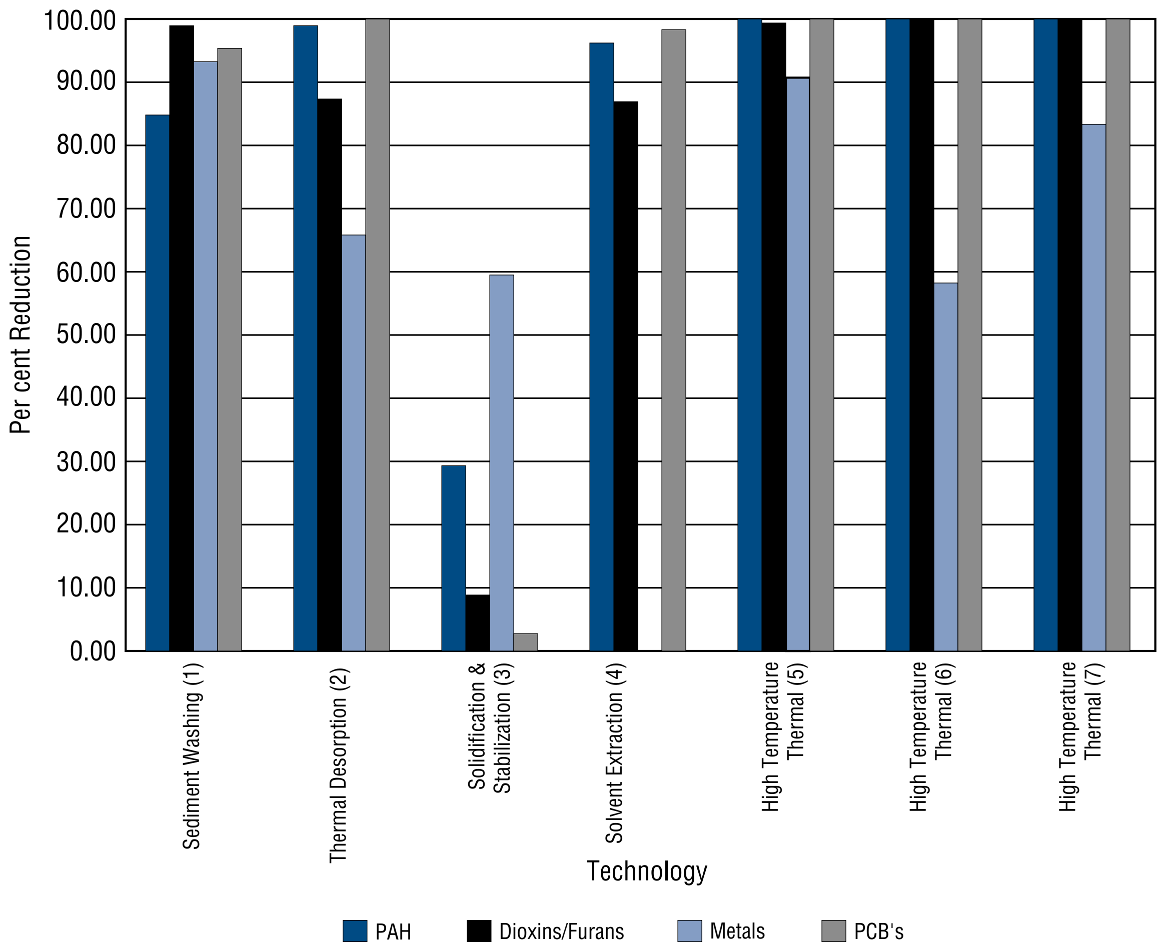


Figure 7-14. Summary of technology effectiveness in reduction of contaminants found in dredged material. The technologies were provided by: 1) BioGenesis, 2) IT, 3) Marcor, 4) Metcalf & Eddy, 5) BioSafe, 6)IGT, and 7) Westinghouse.

nation. The lower temperature thermal desorption process is also effective, but has the disadvantage of creating a sidestream of materials which must then be treated or disposed of in a separate step.

Solidification/stabilization and sediment washing were found to have less of an effect on the sediments. Analysis of the results suggests that the treatments may, in some cases, change the chemistry of the contaminants and render them more susceptible to leaching. This could affect the contaminant analyses. It also suggests the need for further experimentation with the specific chemicals used for the treatments to improve performance, and for consideration of the testing procedures themselves. The separations technologies used can also lead to recontamination of the material in the final stages of the process.

The overall conclusions of the work are that it is possible to assemble a complete treatment train that can be used to process dredged material with a wide range of contaminant concentrations.

7.3 Phase 3. Full-Scale Dredged-Material Decontamination Demonstration (WRDA 1996)

The tests carried out during Phase 2 of the demonstration were successful in defining the major elements of a sediment decontamination treatment train. The goal of the full-scale decontamination demonstration is the construction of one or more facilities capable of treating 500,000 cy/y of dredged material with end disposal through beneficial use. The facility itself is thus part of the overall treatment train.

7.31 Design of Treatment Train for Sediment Decontamination

Technologies tested during the bench- and pilot-scale phases of the WRDA Decontamination Program can be classified according to the temperature at which they operate:

- ambient or low temperatures (<200 °C),
- intermediate temperatures (~300 °C) that do not destroy the organic constituents, and
- high temperatures above the decomposition point of the organic compounds (>1200 °C).

The wide variety of contaminants and differing concentration levels make it plausible to search for technologies that can be applied to specific concentration levels. In addition, the low-temperature technologies may be more acceptable to the local and regulatory communities and may be easier to permit. The higher temperature technologies may be more applicable to the most contaminated sediments that are found outside of navigational channel and depositional areas. These areas may lend themselves to “hot spot” remediation. High temperature technologies will produce beneficial use products that have higher resale values. Examples of the previously tested technologies that fit each sediment contamination category are:

- **Low contamination.** Solidification/stabilization, manufactured soil, and phytoremediation. *USACE, Metcalf & Eddy, Inc., International Technology Corporation, Marcor*
- **Low to medium contamination.** Sediment washing and chemical extraction. *BioGenesis Enterprises Inc.*
- **Medium contamination.** Solvent extraction. *Metcalf & Eddy, Inc.*
- **High contamination.** High-temperature thermo-chemical / rotary kiln. *Institute of Gas Technology*
- **High contamination.** High-temperature plasma-arc torch. *Westinghouse Science & Technology Center*

Taken together, these technologies form the basis of an integrated treatment train for the management of contaminated dredged material from the Port of NY/NJ or other locations nationally (see Figures 7-1 and 7-2) that includes the BioGenesis low-temperature sediment washing method and the IGT/ENDESCO and Westinghouse high temperature methods.

7.32 Low Temperature Approach:

Sediment Washing of untreated sediment. A pilot-scale treatment train demonstration at a level of 700 cy was conducted starting in the fall of 1998 by a consortium of BioGenesis Enterprises, and Roy F. Weston, Inc. Under the guidance of EPA, BNL, WES, and RPI, BioGenesis conducted several treatability studies during 1997/8 demonstrating a "proof-of-concept" with encouraging results for continuation to the pilot-scale and full-scale/commercialization phases. They are now demonstrating an integrated treatment train that includes the following: physical separation of the sediments to remove oversize materials, sediment washing, liquid-solid separation, and beneficial use of the post-treated material. This pilot test is conducted first to determine design engineering parameters, mass balance, economic costing analysis, and beneficial use of making a manufactured topsoil prior to moving to a commercial-scale demonstration.

If the pilot test is successful, BioGenesis plans to scale up in 1999 to process a minimum of 30,000 cy of NY/NJ harbor dredged material. The sediment washing treatment process shall be capable of handling a high processing rate (250,000 cy/y system) of varying grain sizes at varying concentrations of a wide variety of chemical contaminants. The treatment process shall be performed in a cost-effective manner in attempts to identify public-private partnerships situations for funding of a commercial-scale treatment facility (250,000 cy/y) in order to fulfill the WRDA mandate.

7.33 High Temperature Approach:

7.331 IGT/ENDESCO

Rotary Kiln with cement-lock technology with beneficial use of post-treated sediment as blended cement. IGT/ENDESCO will carry out a final design study for a blended-cement manufacturing facility capable of processing 100,000 cy/y of dredged material. A 30,000 cy dredged material decontamination and construction grade cement manufacturing demonstration is planned for the winter of 1999. The intention is to operate the facility at a profit through revenues derived from a reasonable tipping fee and sale of the construction grade cement.

In 1997-1998 IGT/ENDESCO started work on designing for commercial scale-up operations. The following tasks were completed:

- preliminary design and cost estimation for a 100,000 cy/y plant
- piping and instrumentation drawings
- equipment lists and descriptions, quotes, and total equipment costs
- cost estimates for utilities and raw materials costs

The next step, the purchase and installation of equipment for a demonstration plant that will process in excess of 30,000 cy/y is now in progress. Purchase orders for a rotary kiln and ancillary equipment have been placed. Delivery and assembly of the plant by mid-year 1999 is anticipated. The exact location of the demonstration is now being negotiated with the expectation that a decision will be made during the first quarter of 1999. Initial discussions with the State of New Jersey on the necessary permits have been held, and permit applications are being prepared following the guidelines received from the state officials.

7.332 Westinghouse

Plasma-Arc Vitrification of untreated sediment. A design study for a vitrification facility capable of treating 100,000 cy/y has been carried out by the Westinghouse Science and Technology Center. The design basis for this facility includes the following:

- process flow diagrams for 100,000 cy/y plant
- piping and instrumentation drawings
- material and energy balance showing the detail for all major process streams
- stream flow rates and enthalpies
- flow rates of individual solid, liquid and gas compounds
- utility infrastructure
- sediment delivery systems, and
- environmental requirements (emission controls)

Westinghouse performed a demonstration of the manufacturability of glass tile from the glass produced from the dredged material. Approximately 4,000 pounds of glass produced from treatment of dredged material has been converted to high-value glass tile by Futuristic Tile in Allenton, Wisconsin. The production test was completed in February 1999.

7.34 Treatment Train Commercialization

The project was also organized so that it could serve as a general technical resource for the technology firms interested in commercialization of decontamination processes. Efforts have been made to provide assistance both to the firms funded through the project, and also to add firms so as to stimulate a wider technology base and to share knowledge gained with public agencies and the wider general public in the region. The WRDA Decontamination Program Team routinely collected large volumes of sediments not only for the firms working on the WRDA Decontamination Program but for other firms that requested samples to do their own treatability analyses at their own cost.

This has been very rewarding, since there have been several instances where contributions have been made to technical aspects of the tests and to the many questions involved in site selection and acquisition. In addition, efforts to expand the technology base by working with additional firms who could provide existing infrastructure have been successful.

At all times it has been recognized that economics is a major driving force in the effort to find solutions for sediment treatment. A technically-elegant solution is needed, but overall operational costs must be competitive. Funding for the work must be obtained from several sources. While federal and state funds will be available, they will not be sufficient for construction and operation of major facilities. Therefore, private investments must be applied in a major way in the commercialization process.

Public-Private Partnerships

At the inception of the project, the WRDA Decontamination Program Team introduced the concept of public-private partnerships for the decontamination program. It was evident from the beginning that this was a desirable approach because of the need to gain community support for siting of the decontamination facilities and because public funds were not intended by themselves to construct and operate a facility. This approach would interest private capital in providing funds for the creation of a new type of environmental business sector. The public sector's contribution would be "seeding" applied technology development combined with a corporate commitment for developing a long-term, sustainable, profitable enterprise.

We have explored this approach with a number of technology developers and site owners both within and outside the WRDA Decontamination Program. An illustration of how such an enterprise could be structured is given in Figure 7-15. The shaping of the partnership could be undertaken in ways that there is a commitment and level of contribution from all sectors involved.

Preliminary Estimates for Decontamination Costs

Technologies that are environmentally safe and that effectively decontaminate dredged material are not enough. They must also be economically viable.

A major mode of placement of dredged material is now stabilization with cement and fly ash. The beneficial use is construction material and brownfield cover at several locations in NJ. Currently, the total cost for dredging, treatment (solidification/stabilization), and disposal ranges from $45 to $50/cy.

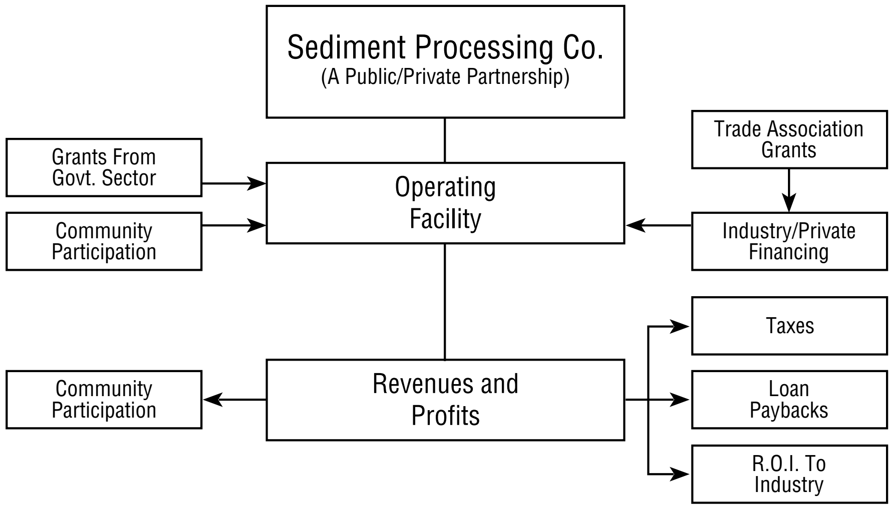
Another avenue is placement in an aquatic confined disposal facility in Newark Bay. The current total disposal costs in Newark Bay are approximately $32/cy including dredging.

We anticipate that the costs for sediment washing, cement production, and glass production will be competitive when commercial-scale (500,000 cy/y) operation is achieved and when the economic benefits of beneficial uses are considered. Preliminary estimates for the demonstration-scale level for processing costs range from $50 to $70/cy. Larger scale demonstrations planned in 1998/9 (minimum of 15,000 cy each) will provide economic information for scale-up volumes as well as information on potential return for beneficial use. The target range of costs for full-scale/commercial-scale operations is to be at or below $35/cy.

There is good reason to believe from the WRDA Decontamination Program that lower costs for decontamination can be achieved to help the Port of NY/NJ remain competitive. Competition from other East Coast ports also needs to be considered, in that environmental regulations from different states for handling of dredged material are not uniform and can be more or less stringent than the NY/NJ Harbor benchmark. If other ports attract deep water shipping away from the NY/NJ Harbor, then the entire transportation pattern in the region could change and completely alter the current needs for dredged material management in the Port. From an examination of two technologies undergoing the next phase of commercial scale-up potential, it is believed that preliminary decontamination costs may be low enough to meet the market cost as it is currently projected for other dregdged material placement options. The actual costs for decontamination in the future will be determined by cost-competitive responses to requests for proposals from the USACE, the Port Authority of NY/NJ, private dredging clients, and environmental restoration projects. In the final analysis, decontamination as with any dredged material management option will be evaluated for its costs with respect to its benefit to the environment and public health of the region.

Beneficial Use

To be used beneficially, decontaminated material must meet applicable state environmental and health and safety guidelines as well as engineering specifications for its proposed end-use. Since the states, and not the federal government, have jurisdiction of upland management of dredged material, the presiding state determines the end-use testing criteria and issues the acceptable/ beneficial-use determination for the end product of any treatment process. In October 1997, the New Jersey Department of Environmental Protection



Potential Owners of The Sediment Processing Company

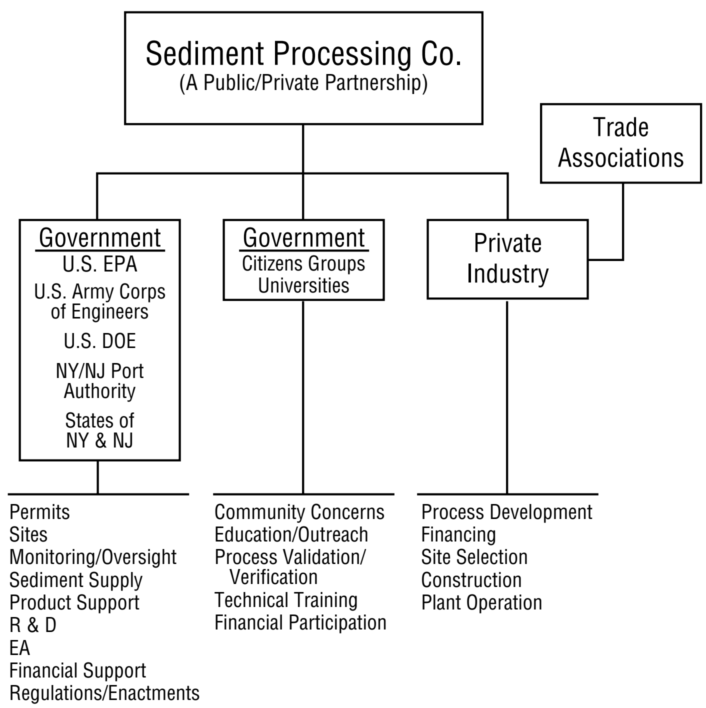


Figure 7-15. Conceptual plan for organization of a public-private consortium for operation of a dredged-material decontamination facility. Two schematic diagrams are given that show the consortium organization and the potential owners of the company.

(NJDEP) issued its guidance manual on dredging activities and dredged material. The New York State Department of Environmental Conservation (NYSDEC) is currently in the process of finalizing its guidance manual. The acceptability, and therefore the success, of decontaminated dredged material will be based on the ability of a given process to meet these standards at an affordable price. Discussions have been held with the NJDEP and NYSDEC on whether processed dredged material will qualify for an alternate use determination (AUD) in New Jersey or a beneficial use determination (BUD) in New York. Informal reactions in both states have been positive for production and use of topsoil, cement, and glass. Formal applications will be submitted in 1999, when both BioGenesis and IGT move to the commercial phase of the project.

8. Supporting Activities

This demonstration project has carried out a number of activities that are necessary to support the implementation of a dredged material decontamination facility in the Port of New York/New Jersey. The WRDA Decontamination Program Group has found it necessary to consider questions ranging from locating dredged material projects for processing to finding markets and private funding for starting private businesses devoted to dredged material decontamination.

8.1 Risk Assessment

Risk assessment must be considered from a number of different perspectives including: (1) risks to the environment from placement of the treated materials and from side/waste streams produced in the processing (residual management), (2) risks to human health including occupational exposures, and (3) risks from failures of components of the processing equipment. Evaluations of the first two risk categories indicate that it is feasible to define an overall approach which will be acceptable from the environmental and human health perspectives. Equipment-dependent risk will be considered during the large-scale facility design process so as to make sure problems are addressed during the design process.

As an example, a concern for local government and community groups is volatilization of PCBs from dredging, processing for disposal or shipment, and finally possible emissions if the materials are used for applications in brownfields or construction. This is an important issue that strongly impacts the decontamination project. For that reason, an effort has been made to evaluate the transport of PCBs from sediments to water or atmospheric interfaces and then to estimate the actual concentrations in air as a function of distance from the source. It is then possible to calculate the dose to workers and nearby residents and to assess the magnitude of any human health problems caused by this exposure. In addition to the theoretical calculations, an interchange of information has been made with other interested parties so that the calculations can be placed in the perspective of existing experimental measurements. This is a continuing effort, and it is expected that further efforts will be made to see if additional experimental work is needed and, very importantly, to convey an accurate evaluation of the magnitude of effects to the local communities.

8.2 Sediment Toxicity Evaluations

The placement of dredged material in the ocean is governed by tests that measure the sediment toxicity and bioaccumulation of contaminants in selected marine organisms. It is unlikely that decontaminated dredged material will be sent to the ocean or find beneficial use that requires this type of testing. One compelling justification for this statement is based on the economics. A remunerative beneficial use is generally needed to bring processing fees to an affordable level for the Port.

However, a limited amount of testing has been carried out at the U. S. Environmental Protection Agency Region 2 Biomonitoring Laboratory at Edison, NJ and by the IT group. It was found that materials subjected to a high-temperature process demonstrated less toxicity to testing organisms than those materials subjected to lower temperatures. Figure 8-1 shows the sediment toxicity results obtained for some of these materials.

Solid and liquid phase sediment toxicity testing were conducted on post-treated material from the bench-scale studies. These are some of the same tests that are used to regulate disposal of dredged material in the ocean. Percent survival of the amphipod *Ampelisca abdita* in the solid phase and the grass shrimp *Mysidopsis bahia* in the solid and liquid phases showed the highest survival in materials from two thermal processes. The physical characteristics of the final decontaminated product may have played a role in the survival of these testing organisms as it relates to a particular habitat that the organisms can live in. The Westinghouse sample was a crushed glass product; the organics were destroyed and the metals immobilized in a glassy matrix. It provided a substrate that the amphipods were well able to survive in. BioSafe's final product resembled dredged material and most closely provided sediment habitable substrate after processing. Even though other processes demonstrated high contaminant removal efficiencies such as IGT, their final product, which resembled a cementious product, had an alkaline pH which probably caused the high mortality to the testing organisms. In general the following conclusions can be made from this preliminary round of testing:

- Artifacts from chemical manipulations may render a sample more toxic than baseline.
- Solvents/added treatment chemicals to extract target contaminants may cause toxicity.
- Toxicity may be caused from changes in chemical oxidation states from drying or dewatering processes.

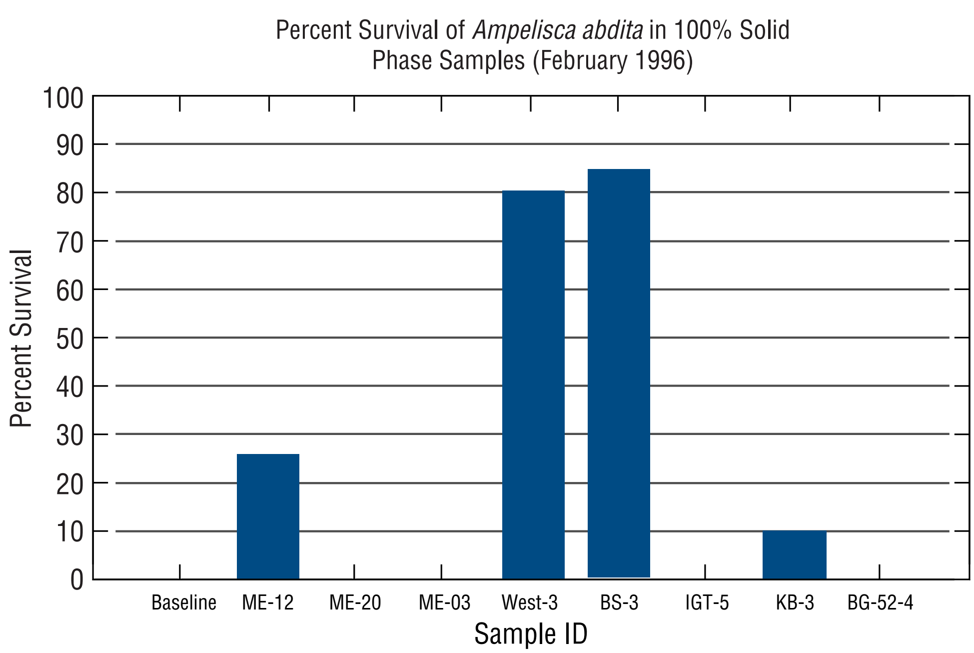


Figure 8-1. Percent survival of Ampelisca abdita in 100% solid phase samples (February 1996). Data obtained for processed dredged material samples produced by Metcalf & Eddy (ME12), Westinghouse Science and Technology Center (West-3), BioSafe (BS-3) and Marcor (KB3). The data shows that there are large variations in survival rates between the different treatment technologies. Percent survival is zero for samples where no bars are shown.

- Changes in textural or physical characteristics as they relate to the organisms' habitat.
- Significant removal of total organic carbon which may affect metal mobility/availability.

8.3 Public Outreach Activities

Public outreach is an essential component of the project. Communities in the Harbor region are highly aware of the impact of activities that relate to municipal waste, sewage sludge, incineration, and topics of that nature. The matter of dredged material is therefore one that needs to be explained in as much detail as possible to all the various stakeholders in the region. These stakeholders include citizens, elected officials, federal and state agency officials, technology development firms, university and other research scientists, and shipping interests. A listing of public outreach activities is provided in Appendix 3.

A WRDA Sediment Decontamination Citizens' Advisory Committee (CAC) was set up to serve as one focal point in outreach activities. The CAC has been put together by EPA, USACE, and BNL in conjunction with the Rutgers University Institute of Coastal Marine Sciences. Communication goals of the CAC are to:

- Engage the public in a variety of forums to discuss the decontamination technologies
- Identify and address key public concerns associated with sediment decontamination technologies and siting of future decontamination facilities
- Explore beneficial use of post-treated sediments
- Develop evaluation criteria that address key public concerns
- Provide outreach and access to information for citizens in the NY-NJ Harbor community

The CAC was developed to ensure public participation and access to project information. It is composed of interested citizens solicited from questionnaires distributed at public meetings as well as to community leaders and organizations with an interest in sediment decontamination and dredged material management. Routine CAC meetings are held in both NY and NJ.

Project information is also made available via the Internet. An e-mail listserve is in operation to permit circulation of announcements and to give a forum for discussion of contaminated-sediment-related issues. This has been quite successful. For example, a very spirited discussion related to PCBs has taken place with participation across the United States. A WRDA Decontamination Program web page is now "under construction" (http://www.wrdadcon.bnl.gov). This site is still at a draft stage, but does present the Congressional charges, information on the distribution of contamination in the harbor, and the complete text of several publications.

8.4 Companion Technology Efforts

Technology assistance and cooperation is extremely important for the WRDA Program. It is essential to work with the states of New York and New Jersey and the Port Authority of New York and New Jersey (PANY/NJ). This is particularly true for PANY/NJ and the State of New Jersey since they are currently conducting sediment-treatment demonstration projects. It is also true for the State of New York which is still formulating policies for handling non-HARS material. Of equal importance is the need to work with as wide a grouping of technology development firms as possible to attempt to facilitate the creation of new private enterprise solutions and to ensure that the best available technical solutions are implemented.

8.41 Port Authority of New York and New Jersey (PANY/NJ)

The PANY/NJ began its Matrix Evaluation Project in 1997. Six technology firms have conducted treatability studies of their processes, all of which produce construction materials such as aggregate, concrete, or soil. Treatability studies were completed in summer 1998. The objective is to evaluate whether the selected processes can economically produce construction material from Harbor dredged material that meets ASTM and other applicable standards without any significant adverse environmental impacts. These end products could potentially be used for future PANY/NJ construction projects.

8.42 The Office of New Jersey Maritime Resources (ONJMR)

In March 1998, the Office of New Jersey Maritime Resources (ONJMR) issued a Request for Proposals (RFP) for pilot testing (200 gallons) and large-scale demonstration (30,000-150,000 cy) of sediment decontamination technologies. Those processes found to be successful in pilot testing in decontaminating the material to meet project specific requirements as stated in the proposals will be recommended for further funding for large-scale demonstration. Pilot scale projects are expected to be initiated in late 1999. ONJMR's goal is to assess the feasibility of technologies that can provide long-term decontamination services for the Port at full-scale costs of no more than $35/cy exclusive of dredging.

The Web Consortium (Roy F. Weston, Safety Kleen Services, and BioGenesis) and IGT were selected by ONJMR in November 1998 to receive funding for demonstration testing.

The WRDA group is working closely with ONJMR in technology transfer to speed implementation.

8.43 State of Michigan and EPA-Region 5.

The State of Michigan's Department of Environmental Quality working with EPA Great Lakes National Program Office (GLNPO) in Chicago, has been investigating the application of decontamination technologies for treatment of contaminated sediments in the Trenton Channel of the Detroit River. The WRDA Decontamination Program Group has advised on lessons learned from the demonstration in the Port of NY/NJ. The results of the first round of bench-scale testing of Detroit River sediment showed favorable reviews for the WRDA technologies demonstrated by BioGenesis, Institute of Gas Technology, and Westinghouse. It is possible that one or more of the groups will respond for proposals to test on a larger scale.

The test in Michigan is certainly of interest since it indicates that the work in NY/NJ can be used effectively in a fresh-water environment. Hence, the WRDA decontamination demonstrations and experiences can be exported around the country to wherever there is a problem with sediment contamination. The WRDA decontamination demonstration is also leading the way to show that decontamination can be executed at costs that are much lower than previously thought possible.

8.44 Technology Firms

There are many technology firms providing promising treatment processes that could make contributions to the challenges of dredged material placement. We have worked closely with several groups and made them aware of regional issues and technical problems.

One example is JCI/Upcycle Associates. They are pursuing manufacturing light-weight aggregate from the dredged material at an existing aggregate plant in NY. They have carried out a number of geotechnical tests and have developed a complete treatment train which includes dredging, de-watering and pelletizing, transport of the sediment, aggregate production, and transport and sale of the product material. The processing fee should be competitive with the methods now in use in the region. It is hoped that it will be possible to continue to work with JCI/Upcycle to assist them in commercializing their approach.

In addition, the WRDA Decontamination Program has met with other technology development firms and potential demonstration-site owners. The hope has been that it would be possible to provide additional technical advice that would stimulate the development of their business efforts.

9. Interim Findings and Recommendations

9.1 Interim Findings

The WRDA Decontamination Program to date has reached several interim findings on development of treatment trains that have potential for operation on a commercial scale. The findings include those related to technical merit of the technologies, preliminary treatment costs, public acceptance, and corporate commitment to move into commercial scale operations. The major conclusions are:

- Dredged material is a useful natural resource. Its mineralogy and geotechnical properties qualify it for use in the manufacturer of high value beneficial use products.
- Decontamination technologies have a favorable public approval rating because of the general perception that placement of materials containing contaminants such as those that are found in the Harbor on upland sites where gaseous, liquid, or solid effluents could adversely affect either the environment or human health. The potential beneficial use of decontaminated dredged material is attractive as compared to upland placement of untreated material.
- Technologies that use chemical extraction or separation processes (solvent extraction and sediment washing) can be used to treat dredged materials that are not heavily contaminated by reducing contaminant levels to about one tenth of the original value. Beneficial use possibilities include manufactured topsoil and construction fill.
- Treatments that use high temperatures (e.g. thermo-chemical and plasma-arc vitrification) to destroy the organic contaminants are the most effective and can reduce the content by at least 99.99%. Beneficial use products include construction grade cement, glass fiber products, and lightweight construction-grade aggregate.
- Preliminary cost estimates for application of the technologies for commercial-scale operations have been developed. In all cases they appear to be competitive with current costs for handling (non-HARS)dredged material in the Harbor region when running at commercial-scale capacities of 500,000 cy/y. Estimates of treatment costs using high-temperature technologies are made competitive by the production of high-value beneficial use products. This conclusion of the WRDA decontamination testing comes as a major advance beyond previous concepts, in which costs for decontamination were estimated in the hundreds of dollars per cubic yard range.

A general method for commercialization of dredged material decontamination technologies has been developed in the context of procurements conforming to federal acquisition regulations. Technology demonstrations were observed by project members and by participating scientists from regional universities.

A new approach to proceeding from the laboratory-scale to commercial-scale treatment plants was developed based on the use of public-private partnerships. Limited federal funding is being used to supplement major contributions from private sources to enter into the construction phase.

It can be concluded that decontamination technologies provide a useful method for the environmental and economic challenges associated with the handling of dredged material in the Port of New York and New Jersey. A flexible and innovative approach to the problem is needed on the part of both public and private interests for the prompt creation of this new type of business enterprise.

Detailed design plans for commercial-scale treatment facilities have now been completed that will meet the WRDA decontamination goal of achieving operation at 500,000 cy/y by 2001. One of the major hurdles in placing any facility into an operational condition will be the issuance of permits from state and local authorities.

Treatment technologies have not been widely applied in full-scale projects for soils or sediments anywhere in the U.S. Historical cost data on the pretreatment and treatment components are very limited, and in many cases, the only data available are projections made by technology firms based on bench-scale or pilot-scale applications. Therefore, cost projections for technologies that do not already have full-scale equipment with some operating history (including all the WRDA decontamination technology developers) should be carefully considered.

9.2 Recommendations

The present results of the WRDA Decontamination Program indicate that there is good reason to believe that a self-sustaining long-term profitable enterprise in developing a decontamination industry can be created in the Port of New York/New Jersey. The major needs are to develop means for providing stable long-term supplies of dredged material to the technology companies, and to find ways to encourage beneficial use of the processed materials through permitting procedures tailored to the dredged materials encountered. Creation of joint public-private enterprise is thought to be one way to accomplish these ends.

Rapid commercialization of decontamination technologies can be helped and expedited by appropriate public policy actions on all levels of government. The major need is to devise ways in which the decontamination companies are assisted in raising private capital to pay for facility infrastructure development. At the present time, major dredging contracts are let to the lowest qualified bidder on a project-by-project basis. This is not an adequate basis for justifying business venture capital loans for construction of facilities that must run over the long term (10-30 years) in order to amortize the capital costs.

Consideration should be given to the development of mechanisms that could make long-term commitments for provision of sufficient volumes of dredged material. This would encourage the private sector to apply their own resources to the development of new decontamination businesses through the use of private funds. Retention of competitive bidding would ensure that the lowest possible prices are obtained. However, recognition should be given to optimal disposal practices for the dredged material so that environmental questions are properly taken into account. This supply could come, at least in part, by requiring application of decontamination technologies to a defined fraction of federal navigational channel dredging projects.

Government can also assist in development of markets for processed dredged material by mandating beneficial use of decontaminated material in federal and state construction projects. The use of cement, aggregate, glass, and manufactured topsoil proposed for beneficial use in the present project would all be candidates for participation in this type of program.

It can be seen that commercialization of decontamination technologies is a complex process. The need for development of public-private partnerships as a general approach to construction of a facility because of the large costs is emphasized. The formal authorization of a limited liability corporation to operate a public-private partnership with the responsibility of creating and operating a dredged material decontamination demonstration facility(ies) could be an effective approach in the Port of New York and New Jersey.

10. Appendices

APPENDIX 1

Summary of the Relevant Sections of the Water Resources Development Acts of 1990, 1992, and 1996.

Work performed on this project has been authorized by Congress under the Water Resources Development Acts (WRDA) of 1990, 1992, and 1996

• Water Resources Development Act of 1990. Public Law 101-640, Title IV, sec. 412, Nov. 28, 1990, 104 Stat. 4650.

(b) …a plan for the long-term management of dredged material from the NY/NJ Harbor region.

The plan shall include–

(b.4) …measures to reduce the amount of contaminants in materials proposed to be dredged from the Harbor through source controls and *decontamination* technology.

(c) Demonstration project. "…. Implement a demonstration project for disposing on an annual basis up to 10 per cent of the material dredged from the NY/NJ Harbor region in an environmentally sound manner other than by ocean disposal. Environmentally sound alternatives may include, among others, capping of borrow pits, construction of a containment island, application for landfill cover, habitat restoration, and use of *decontamination* technology.

• Water Resources Development Act of 1992. Public Law No. 102-580, Title IV, sec. 405, 106 Stat. 4683.

(a) Decontamination project.

(1) Selection of technologies. Based upon a review of decontamination technologies identified pursuant to section 412 (c) of the Water Resources Development Act of 1990, the Administrator of the Environmental Protection Agency and the Secretary shall, within 1 year after the date of the enactment of this Act, jointly select removal , pre-treatment, post-treatment, and decontamination technologies for contaminated marine sediments for a decontamination project in the NY/NJ Harbor.

(2) Recommended program. Upon selection of technologies, the Administrator and the Secretary shall jointly recommend a program of selected technologies to assess their effectiveness in rendering sediments acceptable for unrestricted ocean disposal or beneficial reuse, or both.

(b) Decontamination defined.

For purposes of this section, "decontamination" may include local or remote prototype or production and laboratory decontamination technologies, sediment pre-treatment and post-treatment processes, and siting, economic, or other measures necessary to develop a matrix for selection of interim prototypes of long-term processes. Decontamination techniques need not be preproven in terms of likely success.

(c) Authorization of Appropriations - There is authorized to be appropriated to carry out this section $5,000,000 for fiscal years beginning after September 30, 1992. Such sums shall remain available until expended.

• Water Resources Development Act of 1996. Public Law No. 104-303, Title II, sec. 226, 110 Stat. 3697.

(a) Decontamination project.

(1) Selection of technologies. Based upon a review of decontamination technologies identified pursuant to section 412(c) of the Water Resources Development Act of 1990, the Administrator of the Environmental Protection Agency and the Secretary shall, within 1 year after the date of the enactment of this Act, jointly select removal, pre-treatment, post-treatment, and decontamination technologies for contaminated marine sediments for a decontamination project in the New York/New Jersey Harbor.

(2) Recommended program. Upon selection of technologies, the Administrator and the Secretary shall jointly recommend a program for selected technologies to assess their effectiveness in rendering sediments acceptable for unrestricted ocean disposal or beneficial reuse, or both.

(3) Project purpose. The purpose of the project to be carried out under this section is to provide for the development of 1 or more sediment decontamination technologies on a pilot scale demonstrating a capacity of at least 500,000 cubic yards per year.

(b) Authorization of Appropriation - The 1st sentence of section 405(c) of such Act is amended to read as follows: "There is authorized to be appropriated to carry out this section $10,000,000."

(c) Reports - Section 405 of such Act is amended by adding the end of the following:

(d) Reports - No later than September 30, 1998, and periodically thereafter, the Administrator and the Secretary shall transmit to Congress a report on the results of the project to be carried out under this section, including an assessment of the program made in achieving the purpose of the project set forth in subsection (a)(3).

APPENDIX 2

WRDA Publications and Reports

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Stern, E. A., Feng, H., and Jones, K. W. 1999. Source, Transport and Environmental Ecological Effects of Contaminated Sediments in the NY/NJ Harbor. To be presented at 20th Annual Meeting of the Society of Environmental Toxicology and Chemistry, Philadelphia, Pennsylvania, November 14-18, 1999.

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Goswami, A., Clesceri, N., Preiss, I., Stern, E., Jones, K., and Donato, K. Evaluation of Treatment, Disposal, and Managerial Options for Dredged Sediments from Newark Bay, Arthur Kill, and Newtown Creek of New York/New Jersey Harbor and Proposed Design. 1995. In Proceedings of the 50th Annual Purdue University Industrial Waste Conference, Lafayette, Indiana, May 8-12, 1995, Lewis Publishers.

McManus, M., Jones, K. W., Clesceri, N. L., and Preiss, I. L. 1995. Renewal of Brooklyn's Gowanus Canal area. The Journal of Urban Technology 2:51-64.

Stern, E. A., Olha, J., Wisemiller, B., and Massa, A. 1994. Recent Assessment and Decontamination Studies of Contaminated Sediments in the New York and New Jersey Harbor, p. 458-467. In E. Clark McNair, Jr. (ed), Dredging '94. Proceedings of the Second International Conference on Dredging and Dredged Material Placement, Lake Buena Vista, Florida, November 13-16, 1994.

APPENDIX 3

Public Outreach Presentations

Harrison Community Center, Harrison, NJ, December 1, 1998

Bayonne High School, Bayonne, NJ, February 23, 1998

Harrison Community Center, Harrison, NJ, August 21, 1997

Stevens Institute of Technology, Hoboken, NJ, June 11, 1997

Staten Island College of CUNY, Staten Island, NY, February 25, 1997

Harrison Community Center, Harrison, NJ, January 21, 1997

Staten Island College of CUNY, Staten Island, NY, November 19, 1996

Stevens Institute of Technology, Hoboken, NJ, October 15, 1996

Staten Island College of CUNY, Staten Island, NY, September 24, 1996

Bayonne High School, Bayonne, NJ, July 9, 1996

Rutgers University, New Brunswick, NJ, May 8,1996

Stern, E. A., Donato, K. R., Jones, K. W., and Clesceri, N. L. 1998. Sediment Decontamination Treatment Train: Commercial-Scale Demonstration for the Port of New York/New Jersey. Presented at the Nineteenth Western Dredging Association (WEDA XIX) Annual Meeting and Conference and Thirty-first Texas A&M University Dredging Seminar (TAMU 31). Louisville, Kentucky, May 15-20, 1999.

Rehmat, A., Lee, A., Goyal, A., and Mensinger, M. Construction-Grade Cement Production from Contaminated Sediments Using Cement-Lock™ Technology. Presented at the Nineteenth Western Dredging Association (WEDA XIX) Annual Meeting and Conference and Thirty-first Texas A&M University Dredging Seminar (TAMU 31). Louisville, Kentucky, May 15-20, 1999.

McLaughlin, D. F., Ulerich, N. H., and Dighe, S. V. Decontamination of Harbor Sediments by Plasma Vitrification. Presented at the Nineteenth Western Dredging Association (WEDA XIX) Annual Meeting and Conference and Thirty-first Texas A&M University Dredging Seminar (TAMU 31). Louisville, Kentucky, May 15-20, 1999.

Amiran, M., Wilde, C. L., Haltmeier, R. L., Pauling, J. D., and Sontag, J. G., Jr. Advanced Sediment Washing for Decontamination of New York/New Jersey Harbor Dredged Materials. Presented at the Nineteenth Western Dredging Association (WEDA XIX) Annual Meeting and Conference and Thirty-first Texas A&M University Dredging Seminar (TAMU 31). Louisville, Kentucky, May 15-20, 1999.

Sediment Decontamination of New York/New Jersey Harbor Sediments. Conference on Environmental Decision-Making: Strategies for Cost-effective Compliance and Quality Management," IBM, Yorktown Heights, New York, November 19, 1998.

New York Harbor Remediation. BNL Environmental Showcase and Environmental Business Association of New York State. Brookhaven National Laboratory, Upton, New York. October 23, 1998.

Decontamination of Dredged Material from the Port of New York and New Jersey. 5th International Petroleum Environmental Conference. Albuquerque, New Mexico. October 20-23, 1998.

Dredged Material Management in the Port of New York/New Jersey: Sediment Decontamination and Lessons Learned. US Navy Workshop on Contaminated Sediments. Office of Naval Research, Division of Environmental Services - Space and Warfare Systems. San Diego, California. October 14-16, 1998.

Pollutants of Concern. Understanding Contaminated Sediments - Analysis, Interpretation and Remediation. Short Course Sponsored by Department of Engineering, University of Wisconsin, Madison, in cooperation with the NY State Department of Environmental Conservation and the Empire State Development Corporation. Albany, New York. October 6-8, 1998.

Cleaning up the NY Harbor. Environmental Fair. Brookhaven National Laboratory, Upton, New York. September 19, 1998.

Contaminated Sediments in the NY/NJ Harbor: Effects, Management, and Toxics Reduction. The Society of Environmental Toxicology and Chemistry (SETAC) - Hudson Delaware Chapter and New Jersey Maritime Resources Fall Workshop. Eatontown, New Jersey. September 18, 1998.

Reviving Gowanus - Meeting to Discuss Improvements of the Gowanus Canal to Support the Merging Gowanus Neighborhood. Gowanus Canal Community Development Corporation, Brooklyn, New York. July 2, 1998.

Integrated Sediment Decontamination for the New York/New Jersey Harbor. National Symposium on Contaminated Sediments (National Research Council Transportation Research Board). Washington, DC. May 27-29, 1998.

Ma, Hong, Jones, K. W., Stern, E. A., and Richman, L. R. 1998. Scientific Visualization and Scattered Data Modeling of Sediment Contaminant Concentration in the Lower Passaic River, Newark, New Jersey. Presented at 1998 Spring Meeting of the American Geophysical Union. Boston, Massachusetts, May 26-29, 1998.

Overview of Sediment Treatment - New York/New Jersey Harbor. American Association of Port Authorities Harbors Navigation and Environmental Seminar. Urban Ports: Catalysts for Environmental Enhancement and Economic Development. Philadelphia, Pennsylvania. May 13, 1998.

Dredged Material Decontamination Demonstration Project. Seminar presented at Columbia University, New York, New York. April 7, 1998.

Commercialization of Sediment Decontamination Technologies. Fourth Marine and Estuarine Shallow Water Science and Management Conference, Dredged Material Management Options Platform Session. Atlantic City, New Jersey. March 1998.

The Treatment of Contaminated Sediment in New York-New Jersey Harbor. American Association for the Advancement of Science (AAAS) Meeting, Platform Session on Coastal Habitat and Contaminated Sediment. Philadelphia, Pennsylvania. February 1998.

Environmentally Sound Disposal and Decontamination. 1997 National Dredging Conference. Our Vision of the Port: Making Needed Dredging Happen. The Maritime Association of the Port of New York and New Jersey. New York, New York. November 18, 1997.

Jones, K. W., and Song, S.-R. 1997. Elemental Analysis of Contaminated Sediments from NY/NJ and Hamburg Harbors Using Synchrotron Radiation-Induced X-Ray Emission (SRIXE). Presented at 1997 Denver X-Ray Conference. Steamboat Springs, Colorado, August 4-8, 1997.

Results and Status of Congressionally-Mandated Research and Development Technologies for Decontamination of Dredged Material. Texas A&M Twenty-Eighth Annual Dredging Seminar and Western Dredged Association (WEDA) National Annual Conference. Charleston, South Carolina. July 1997.

Processing of NY/NJ Harbor Estuarine Dredged Material. Geo-Logan '97. Logan, Utah. July 16-19, 1997.

Decontamination of Dredged Material from the Port of NY/NJ. Seminar presented at Columbia University, New York, New York. May 28, 1997.

Jones, K. W., Song, S.-R., Klein, R. C., and Shea-McCarthy, G. 1997. Elemental Analysis of Contaminated Sediments from Harbor of NY/NJ and Hamburg Using Synchrotron Radiation-Induced X-Ray Emission (SRIXE). Presented at 1997 Spring Meeting of the American Geophysical Union, Baltimore, Maryland, May 27-30, 1997.

Cleaner Bottoms: the NY/NJ Harbor Sediment Decontamination Story. US EPA National Conference on Management and Treatment of Contaminated Sediments. Cincinnati, Ohio. May 13-14, 1997.

Dredged Material Decontamination Technologies. Long Island Sound Dredged Sediment Management Study "Alternatives Workshop." Milford, Connecticut. April 24, 1997.

Use of Decontaminated Dredge Materials. Fresh Kills Landfill Conference: Closure and Beyond. Willowbrook, Staten Island, New York. March 14, 1997.

Panel - Seminar in Environmental Problem Solving: Creative Solutions of the Dredging Issues for the Port Authority of New York and New Jersey. New Jersey Institute of Technology, Newark, New Jersey. February 25, 1997.

Sediment Processing/Decontamination Project Goals. Hudson River Environmental Society - Partnerships for Research and Monitoring: Meeting the Goals of the Hudson River Estuary Management Plan. Marist College, New York. November 21, 1996.

Sediment Processing/Decontamination Project Goals. Third Annual Dredging and Trade Show. New York, New York. November 18-20, 1996.

Stern, E. A., Donato, K., Jones, K. W., and Clesceri, N. L. 1996. Decontamination of Dredged Material from the Port of New York/New Jersey. Presented at Estuarine and Coastal Sciences Association (ECSA)/Estuarine Research Federation (ERF) 96 Symposium, Middelburg, The Netherlands, September 16-20, 1996, Book of Abstracts of Oral Presentations, p. 57.

Decontamination Technology for Treating Sediments for the Gowanus Canal. Gowanus Canal Community Task Force Meeting. Gowanus Canal Community Development Corporation, Brooklyn, New York. July 2, 1996.

Possible Solutions for Dredging and Processing Contaminated Sediments. The Northeast-Midwest Congressional Coalition Congressional Briefing on Treatment Technologies and Beneficial Uses of Dredged Materials. Washington, DC. June 26, 1996.

Management of Dredged Material - EPA and the Corps - The Harbor Estuary Program, the CCMP and the DMMP. The Business of Dredging Conference. Somerset, New Jersey. June 20, 1996.

NY/NJ Harbor Sediment Decontamination Technology Demonstration Project. Exhibit at the Great Greenpoint Regatta and Street Fair. Brooklyn, New York. June 1, 1996.

Public Information Meeting - NY/NJ Harbor Sediment Decontamination Technology Demonstration Project. Polish-Slavic Center, Brooklyn, New York. May 18, 1996.

Solution Options/Model Programs - Decontamination. The Northeast-Midwest Congressional Coalition Meeting on America's Ports: Enhancing the Nation's Economy and Environmental Quality. Washington, DC. April 23, 1996.

Meet the Technologies - NY/NJ Harbor Sediment Decontamination Technology Demonstration Project. New York Technical College, Brooklyn, New York, April 16, 1996.

NY/NY Harbor - Project Update. Lecture - Rensselaer Polytechnic Institute Department of Environmental & Energy Engineering, Environmental Process Design II. Troy, New York. April 10, 1996.

Meet the Technologies Forum - NY/NJ Harbor Sediment Decontamination Technology Demonstration Project. City Hall, Bayonne, New Jersey. March 6, 1996.

Meet the Technologies - NY/NJ Harbor Sediment Decontamination Technology Demonstration Project. Ironbound Community School, Newark, New Jersey. January 25, 1996.

NY/NJ Harbor Sediment Decontamination Demonstration. Dredging '95. Dredging Conference and Trade Show. New York, New York. November 30, 1995.

Sediment Decontamination Activities for Newark Bay. EPA Public Meeting for the Diamond Alkali Superfund Site and Passaic River Study Area. Harrison, New Jersey. November 14, 1995.

Demonstration Project: Technologies for Decontamination of NY/NJ Harbor Sediments. Gowanus Canal Community Development Corporation, Brooklyn, New York. November 6, 1995.

NY-NJ Harbor Cleanup. New York School of Journalism (Science & Environmental Journalism). Brookhaven National Laboratory, Upton, New York. November 2, 1995.

Meeting on Action Initiative on Industrial Applications of Decontamination of Dredged Materials. Governor's Office, Newark, New Jersey. November 1995.

Demonstration Project: Technologies for Decontamination of NY/NJ Harbor Sediments. Lecture - Rensselaer Polytechnic Institute Department of Environmental & Energy Engineering, Environmental Process Design Class. Troy, New York. October 18, 1995.

NY-NJ Harbor Project Overview. Concerned Citizens of Bensonhurst. Bensonhurst, Brooklyn, New York. September 19, 1995.

Status of Pilot Decontamination Projects-Brookhaven National Laboratory. Governor Whitman's Dredged Materials Management Team Meeting. Governor's Office, Newark, New Jersey. August 3, 1995.

Technologies for Decontaminating Dredged Estuarine Sediments from NY/NJ Harbor. Summer Meeting of Society of Environmental Toxicology and Chemistry. Plymouth, Massachusetts. July 15-16, 1995.

Overview of NY/NJ Harbor Dredging Project. New Jersey Transportation Planning Authority, Inc. Newark, New Jersey. May 24, 1995.

Risk Assessments. Concerned Citizens of Bensonhurst. Bensonhurst, Brooklyn, New York. April 18, 1995.

Contaminated Sediments in the NY-NJ Harbor. Nassau Community College, Physical Sciences Department (Tour of Brookhaven National Laboratory). Upton, New York. March 6, 1995.

NY/NJ Harbor Fast Tract Sediment Decontamination Demonstration. Rensselaer Polytechnic Institute Environmental Engineering Seminar Series. Troy, New York. February 3, 1995.

Department of Energy/Brookhaven National Laboratory Role in Partnerships of Public and Private Groups Concerned with Sediments and Soils in the New York/New Jersey Region. Stevens Institute of Technology, Hoboken, New Jersey. October 13, 1994.

Urban Problems: The Gowanus Canal and Surrounding Areas. US Department of Energy. Washington, DC. July 28, 1994.

The New York, New Jersey Harbor Decontamination Technology Assessment Opportunities. Staten Island Chamber of Commerce. Staten Island, New York. May 26, 1994.

Workshop on K-Ph.D. Environmental Education. New York City Technical College, Brooklyn, New York. April 9, 1994.

APPENDIX 4

Participating Technology Development Firms

Bench-Scale Testing

Battelle Memorial Institute
Environmental Technology
505 King Avenue
Columbus, Ohio 43201-2693

BioGenesis Enterprises Inc.
Suite B-208
7420 Alban Station Boulevard
Springfield, Virginia 22150-2320

BioSafe Inc.
Fresh Pond Square
10 Fawcett Street
Cambridge, Massachusetts 02138

Institute of Gas Technology (IGT)
1700 South Mt. Prospect Road
Des Plaines, Illinois 60018

International Technology Corporation (IT)
312 Directors Drive
Knoxville, Tennessee 37923-4700

Marcor Environmental of Pennsylvania, Inc.
540 Trestle Place
Downingtown, Pennsylvania 19335

Metcalf & Eddy Inc.
30 Harvard Mill Square
Post Office Box 4071
Wakefield, Massachusetts 01888-4043

US Army Corps of Engineers
Waterways Experiment Station
3909 Halls Ferry Road
Vicksburg, Mississippi 39180-6199

Westinghouse Science & Technology Center
1310 Beulah Road
Pittsburgh, Pennsylvania 1235-5098

Pilot-Scale Testing

BioGenesis Enterprises Inc.
Suite B-208
7420 Alban Station Boulevard
Springfield, Virginia 22150-2320

Institute of Gas Technology (IGT)/ENDESCO
1700 South Mt. Prospect Road
Des Plaines, Illinois 60018

Metcalf & Eddy Inc.
30 Harvard Mill Square
Post Office Box 4071
Wakefield, Massachusetts 01888-4043

US Army Corps of Engineers
Waterways Experiment Station
3909 Halls Ferry Road
Vicksburg, Mississippi 39180-6199

Westinghouse Electric Corporation
Science & Technology Center
1310 Beulah Road
Pittsburgh, Pennsylvania 1235-5098

Full-Scale Dredged-Material Demonstration Planning

BioGenesis Enterprises Inc.
Suite B-208
7420 Alban Station Boulevard
Springfield, Virginia 22150-2320

Institute of Gas Technology (IGT)/ENDESCO
1700 South Mt. Prospect Road
Des Plaines, Illinois 60018

Westinghouse Electric Corporation
Science & Technology Center
1310 Beulah Road
Pittsburgh, Pennsylvania 1235-5098

APPENDIX 5

Acronyms

ARCS	Assessment and Remediation of Contaminated Sediments
ASTM	American Society for Testing and Materials
AUD	Alternate Use Determination
BCD	Base-catalyzed decomposition
BNL	Brookhaven National Laboratory
BUD	Beneficial Use Determination
CAC	Citizens Advisory Committee
CDF	Confined disposal facility
cy/y	cubic yards per year
cy	cubic yard
DMMP	Dredged Material Management Plan
FARs	Federal Acquisition Regulations
FBT	Fluidized bed treatment
HARS	Historic Area Remediation Site
IGT	Institute of Gas Technology
IT	International Technology Corporation
M&E	Metcalf & Eddy Inc.
MDS	Mud Dump Site
MPRSA	Marine Protection Research and Sanctuaries Act
MSA	Multi-State Alliance
NJ	New Jersey
NJDEP	New Jersey Department of Environmental Protection
NOAA	National Oceanic and Atmospheric Administration
NY	New York
NYSDEC	New York State Department of Environmental Conservation
ONJMR	Office of New Jersey Maritime Resources
PAHs	Polynuclear aromatic hydrocarbons
PANYNJ	Port Authority of New York & New Jersey
PCBs	Polychlorinated biphenyls
ppb	parts per billion
ppm	parts per million
PRA	Priority Remediation Area
RFP	Request for Proposals
S/S	Solidification/stabilization
SEIS	Supplemental Environmental Impact Statement
SITE	Superfund Innovative Technology Evaluation
TCLP	Toxicity Characteristic Leaching Procedure
TEF	Toxicity Equivalent Factor
TEU	Twenty-foot Equivalent Unit
TOC	Total organic content
USEPA	US Environmental Protection Agency
USDOE	US Department of Energy
USACE-NYD	US Army Corps of Engineers-New York District
WES	Waterways Experiment Station
WRDA	Water Resources Development Act