# Cleaning Up Contaminated Sediments in the Nation's Waterways

**Study by the National Research Council**

SPYROS P. PAVLOU AND LOUIS J. THIBODEAUX

*Spyros P. Pavlou is technical director for environmental risk economics, URS Greiner, Seattle, Washington, and Louis J. Thibodeaux is professor of chemical engineering, Louisiana State University. Both were members of the National Research Council's Committee on Contaminated Marine Sediments and served as cochairs of the Transportation Research Board's Steering Committee for the National Symposium on Contaminated Sediments.*

Contaminated marine sediments pose a threat to ecosystems, marine resources, and human health. Moreover, controversy over the risks and costs of sediment management results in delays in dredging and/or the inability to dredge the nation's harbors. Given that approximately 95 percent of total U.S. trade passes through dredged ports, the potential economic impacts of sediment contamination may therefore be severe.

The management of contaminated sediments is a complex and difficult process. The multiple factors that contribute to this complexity exacerbate the problem, and lead to management actions that are not cost-effective and have controversial outcomes and marginal benefits. These factors include (1) high public expectations for protecting human health and the environment; (2) multiple stakeholder interests and priorities; (3) conflicting and overlapping jurisdictions of federal, state, and local regulatory authorities; (4) relatively low levels of contamination; (5) large quantities of affected sediments; (6) uncertainty in quantifying and managing the risks involved; and (7) limitations of available handling and treatment technologies.

An overview of a study performed during 1993–1996 by the National Research Council's (NRC) Committee on Contaminated Marine Sediments is provided below. The 15-member committee included national experts from academia, industry, and the professional services sector. The results of the committee's deliberations were published in an NRC report entitled *Contaminated Sediments in Ports and Waterways: Cleanup Strategies and Technologies* (March 1997). This report served as a basis for discussions and presentations at the Transportation Research Board's National Symposium on Contaminated Sediments: Coupling Risk Reduction with Sustainable Management and Reuse, held in Washington, D.C., May 27–29, 1998.

## Scope of NRC Initiative

The committee's charge was to (1) assess best management practices and emerging technologies for reducing adverse environmental impacts associated with contaminated sediments; (2) appraise interim control measures for use at contaminated sediment sites; (3) address how information about risks, costs, and benefits can be used and communicated to guide decision making; and (4) assess existing knowledge and identify research needs for enhancing contaminated sediment remediation technology. In carrying out this charge, the committee reviewed and assessed technical information; interacted closely with researchers, regulators, stakeholders, engineers, and operators; evaluated six case studies of contaminated sediment remediation; and visited a sediment remediation project site. In addition, the committee conducted workshops on interim controls and long-term technologies, summarized site assessment methods, and evaluated the application of decision tools to the contaminated sediment management process. The results thus obtained were organized into three major categories: remediation technologies, project implementation, and decision making.

## Remediation Technologies

Remediation technologies were grouped into four categories: interim control, in situ management, sediment removal and transportation, and ex situ management. The technologies were compared qualitatively according to state of maturity, frequency of usage, scale of application, cost per cubic yard, and use limitations. They were then scored and ranked according to four criteria: effectiveness, feasibility, practicality, and cost. The committee also addressed the need for remediation technology research, development, testing, and demonstration. The following conclusions and recommendations were then formulated.

1. Capping, containment, and natural recovery are effective management methods for most contaminated sediments. Where remediation is necessary, high-volume, low-cost technologies are the first choice, assuming they are feasible and can succeed in attaining the risk reduction required to protect human health and the environment. Moreover, because treatment is expensive, reducing volume is important.

2. Treatment is usually justified only for relatively small volumes of highly contaminated sediments. Advanced treatment is too costly in the majority of cases, which typically involve low-level contamination.

3. Cost data for full-scale remediation systems must be improved to allow for fair overall comparisons and the development of benchmarks for research and development and systems design. Regulatory agencies should develop guidelines for calculating the costs of remediation systems, including technologies and management methods, and should maintain a database on the costs of systems that have actually been used.

4. Natural recovery is viable and can be considered an optimum remediation solution when contaminant concentrations are low. If natural recovery is not feasible, capping may be appropriate to reduce bioavailability. Monitoring is required to test the efficacy of capping. The use of capping might be advanced if it were viewed as a permanent remedy under the Superfund.

5. In situ chemical treatment has conceptual advantages, but considerable R&D will be needed before successful application of such treatment can be demonstrated. Similarly, using bioremediation to treat in-place sediments requires further R&D to resolve microbial, geochemical, and hydrological issues. Given the high cost of ex situ treatment relative to dredging, dredging technologies must be improved to enable sediment removal at near-in-situ densities and precise

## New Report on Contaminated Dredged Materials

The International Navigation Association (PIANC)[1] has compiled a two-volume report on CD-ROM that provides information and recommendations on good practice in the handling and treatment of contaminated dredged materials. This report, entitled *Handling and Treatment of Contaminated Dredged Materials from Ports and Inland Waterways,* was produced by an international working group of experts representing several countries.

Volume I of the report provides general guidance for the preparation of dredging projects that involve the handling and treatment of contaminated dredged materials, and is intended primarily for use by navigation authorities, permitting agencies, and review agencies. The emphasis is on materials from maintenance dredging of ports and inland waterways; however, capital dredging and remediation of contaminated sediment and soil adjacent to the navigation channel are also addressed.

Volume II is a searchable database of 86 technology fact sheets and 18 case studies containing technical information and references to technologies and international experience in dealing with contaminated dredged materials. This information is intended for use by practicing engineers or other professionals requiring specific data and pertinent sources of technical information. Wherever possible, there is a direct link between the general material contained in Volume I and the technical sources of information contained in Volume II. To order a copy of the CD-ROM, contact Mary Jane Robertson, Administrative Officer, U.S. Section, PIANC (telephone: 703-428-6286; fax: 703-428-8171).

PIANC recently announced formation of a new international working group that will investigate and document advances in maritime intermodal freight transportation. M. John Vickerman, VZM/TranSystems Corporation, and a member of the Transportation Research Board's Standing Committee on Intermodal Freight Terminal Design and Operations, developed the terms of reference for the new study and will chair the international working group. The group's scope has been expanded to include shallow-draft as well as deep-draft port experiences and practices; as a result, another U.S. representative will be added to the working group. Individuals interested in submitting their qualifications should contact Tom Ballentine, Secretary of U.S. Section, PIANC (telephone: 703-428-7072; fax: 703-428-8171).

Ms. Robertson or Mr. Ballentine can also provide information on the 29th International Navigation Congress, to be held in The Hague, The Netherlands, September 6–11, 1998. The Navigation Congress is held every 4 years, and the 1998 event will include a series of technical presentations on deep-draft, shallow-draft, and recreational navigation, as well as environmental subjects. The International Exhibition of Ports and Navigation is held simultaneously with the Congress.

[1]PIANC, an international organization based in Brussels, Belgium, was formerly known as the Permanent International Association of Navigation Congresses. The organization's official name has been shortened to the International Navigation Association, but the PIANC acronym has been retained.

removal of contaminated sediments to limit the capture of clean sediments and water. In this manner, the volume of dredged material requiring containment or treatment can be reduced.

6. Research is needed to improve control of contaminant releases, long-term monitoring methods, and techniques for preserving the capacity of existing confined disposal facilities (CDFs).

7. The potential acceptability of constructing contained aquatic disposal (CAD) facilities at or near contaminated sites must be fully explored. Regulatory agencies should support research to improve design tools for preventing containment failure, to improve monitoring methods for assessing long-term performance, to identify means of controlling contaminant loss, and to determine risk-reduction effectiveness through contaminant isolation.

8. Regulatory agencies should support research to promote the reuse of CDFs and CADs and improve tools for the design and evaluation of their long-term stability and effectiveness.

9. R&D on ex situ treatment technologies is warranted in the search for cost-effective treatment of large sediment volumes. Bench- and pilot-scale testing of ex situ treatment technologies and ultimately full-scale demonstrations in marine systems are needed to improve cost estimates, resolve technical problems, and improve treatment effectiveness.

10. Additional R&D and demonstration projects are needed to improve existing technologies and reduce risks associated with the development and implementation of innovative approaches. The advancement of cost-effective and innovative technologies could be facilitated by peer review of R&D proposals and side-by-side demonstrations of new and current technologies. Regulatory agencies should develop a program to support such R&D and demonstration projects.

## Project Implementation

Although improvements in remediation technologies would contribute to cost-effective management of contaminated sediment, a variety of practical issues must be addressed to remove constraints on project implementation. These issues include responsibility for source control, site characterization needs and technologies, interim controls, and promotion of beneficial uses. The committee's conclusions and recommendations regarding these issues included the following.

1. Given that ports currently bear an unfair share of the responsibility for remediation and placement of contaminated sediments, project implementation would be facilitated by transferring the burden of source control to states and polluters. Federal and state regulators, together with the ports, should investigate the use of appropriate legal and enforcement tools to require that upstream contributors to the contamination share equitably in the cleanup costs.

2. New and improved techniques are needed to reduce the costs and enhance the precision of site assessments. The use of remote-sensing technologies, including rapid and accurate sensors, may accomplish this goal. Regulatory agencies should jointly support R&D to advance the state of science in site assessment technologies. Objectives of these efforts should include the identification and development of advanced survey approaches and new and improved chemical sensors for surveying and monitoring.

3. Where sediment contamination poses an imminent danger, administrative and engineering or structural controls can be used in the short term to reduce risks to humans and the environ-

### Mud Recycling

THOMAS H. WAKEMAN III

The Port of New York and New Jersey was facing "mudlock" when its dredged material disposal site was closed by the federal government last year. Instead of simply identifying new disposal sites, the port has embraced a new approach—mud recycling.

In the past, maintenance dredging in the port typically involved excavating fine-grained sediments. These sediments frequently have two limitations: they are salted with contaminants, and they have poor engineering characteristics. Using accepted geotechnical approaches, the sediments are now being processed to create a sediment product—processed dredged material (PDM)—which is being used in New Jersey for brownfield remediation. In New York, the Department of Environmental Conservation is issuing a Beneficial Use Determination for PDM.

PDM is being used as the foundation for a shopping mall parking lot that is being built on a former city dump in Elizabeth, New Jersey. The dredged material from several projects has been mixed with cement, fly ash, and other additives to stabilize and solidify the sediments. The process not only improves the materials' engineering properties, but also locks up the contaminants in the soil matrix.

The process design, material placement, and regulatory issues have been addressed for PDM, and mud is being recycled. Recently, two more brownfield projects involving use of PDM were permitted by New Jersey, and more are anticipated. Although recycling is more expensive than traditional disposal, there can be a net environmental and economic gain from its application.

*The author is dredging program manager, Port Commerce Department, Port Authority of New York and New Jersey.*

## Contaminated Dredged Material

### *Moving from "Mudlock" to Productive Uses*

THOMAS J. CHASE

International trade is of fundamental importance to the well-being of the United States, and the nation's ports are a critical link in the transportation system that moves international trade. More than 95 percent (by weight) of U.S. overseas trade moves in and out of U.S. ports. Ports provide the interface between the inland land and water transportation systems and the ocean-going carrier fleet. Ocean-going vessels need well-constructed and -maintained navigation channels—the nation's water highways—for safe and efficient transportation of goods. More than 400 million cubic yards of sediment is dredged each year to maintain, extend, or otherwise improve waterways, harbors, and channels.

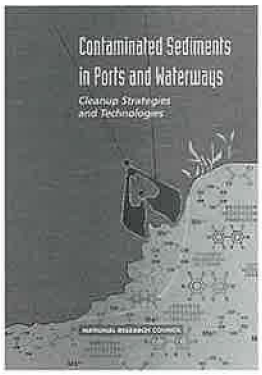
The nation's ports routinely experience controversy and delays when undertaking dredging projects. More than 90 percent of the nation's top 50 ports in foreign waterborne commerce, which handle nearly 93 percent of such trade, require regular maintenance dredging. In addition, ports sometimes need to expand channels to accommodate larger ships. Controversy can arise because of real or perceived concerns about the potential adverse effects of contaminants in the sediment during dredging or upon disposal. In addition, there may be strong public pressure for the dredged sediment to be used beneficially and not simply returned to the aquatic environment for disposal. Such concerns often cause project delays, increase project costs, and thus substantially reduce the transportation benefits of dredging.

The American Association of Port Authorities, the trade association for public port authorities throughout the Western Hemisphere, agrees with the assessment of the problem and many of the recommendations presented in the recent National Research Council report *Contaminated Sediments in Ports and Waterways: Cleanup Strategies and Technologies*, summarized by Spyros P. Pavlou and Louis J. Thibodeaux in this issue of *TR News* (see page 16). AAPA actively advocates several policy changes recommended in the report, including more consistent consideration of cost, risk, and benefits in decision making on the management of dredged material under the Clean Water Act and the Marine Protection, Research and Sanctuaries Act. AAPA also advocates changes to the Clean Water Act that would emphasize control of runoff and prevention of pollution that may contaminate sediment.

U.S. ports, in conjunction with their partner in building navigation channels, the U.S. Army Corps of Engineers, have been leaders in developing beneficial uses of dredged material. Thousands of acres of wildlife habitat have been constructed and many contaminated brownfields revitalized using dredged material. However, funding for such projects is becoming increasingly scarce, and additional beneficiaries must be found to help share the costs of such projects. AAPA supports approaches, such as those outlined by Anne Montague in this issue (see page 21), aimed at developing markets for dredged material products. AAPA believes that if a market were developed for these products, the private sector could build processing facilities and take dredged material from the ports and the Corps of Engineers. Clearly much work needs to be done if such a market is to be established. AAPA is currently working with the Corps of Engineers and others to see whether there are any regulatory or institutional barriers to private-sector innovation in this area.

Dredged material must be placed somewhere, yet traditional disposal alternatives are increasingly limited, controversial, and expensive. AAPA believes all disposal and management options must be considered, including open-water disposal, to meet the goals of maximizing national transportation benefits and minimizing environmental harm. These goals will be achieved only if efforts continue on research and development of innovative approaches to the management and reuse of dredged material.

*The author is director of environmental affairs, American Association of Port Authorities.*




The National Research Council report *Contaminated Sediments in Ports and Waterways: Cleanup Strategies and Technologies* is available from the National Academy Press, National Research Council, Washington, D.C.

ment from exposure to contaminated sediments until a more permanent remedy can be implemented.

4. Beneficial uses of dredged contaminated material can provide disposal alternatives that are socially acceptable. These uses could include, for example, creation of islands for seabird nesting, landfills for urban development, beach nourishment, wetlands, shoreline stabilization, and topsoil for landfill covers. Existing regulatory policies that allow for such beneficial uses of contaminated sediments should be enhanced. Regulatory agencies involved in contaminated sediment disposal should develop incentives for and encourage implementation of such alternatives. Funding should be continued for R&D of innovative beneficial uses of contaminated sediments, as well as the development of technical guidance and procedures for environmentally acceptable beneficial reuse.

## Decision Making

Factors influencing decision making include regulatory realities, stakeholder interests, site-specific characteristics and data uncertainty, and availability of remediation technologies. The committee examined all these factors and developed the following conclusions and recommendations.

1. Stakeholder involvement early in the decision process is important to avoid disagreement and build consensus among all parties involved. When decisions are complex and divisive, consensus among stakeholders can be facilitated through the use of formal analytical tools such as decision analysis.

2. The trade-off evaluation of risks, costs, and benefits and the characterization of associated uncertainties in selecting a preferred management alternative offers the best chance for effective management and communication of the decision-making process to stakeholders.

3. Risk analysis is an effective means of selecting and evaluating management alternatives and remediation technologies. More extensive use of appropriate methods for cost-benefit analysis also has the potential to improve decision making.

4. Regulatory agencies should sponsor research to quantify the relationship between contaminant availability and corresponding human health and ecological risks. The main goal is to evaluate sediment remediation projects using performance-based standards, i.e., reduction of risks from in-place sediments; disturbed sediments; and sediments under a variety of containment, disposal, and treatment scenarios. This information is critical to the trade-off evaluation of risks, costs, and benefits required to make technically defensible decisions in selecting a preferred management alternative.

5. The use of systems engineering can strengthen project cost-effectiveness and acceptability. In choosing a remediation technology, systems engineering can help ensure that the solution meets all removal, containment, transport, and placement requirements while satisfying environmental, social, and legal demands.

6. Federal, state, and local agencies should work together with appropriate private-sector stakeholders to interpret statutes, policies, and regulations in a constructive manner so that negotiations can move forward, and sound solutions will not be blocked or obstructed.

7. Regulatory agencies should continue to develop uniform or parallel procedures for addressing human health and environmental risks associated with freshwater, marine, and land-based disposal, containment, or beneficial reuse of contaminated sediments.

8. Regulatory agencies should develop and disseminate information to stakeholders regarding the availability and applicability of decision analytical tools; appropriate risk analysis techniques to be used throughout the management process, including the selection and evaluation of remedial alternatives; and the demonstration and appropriate use of decision analysis in an actual contaminated sediment remediation case.

9. Existing cost-benefit analysis guidelines and practices developed by regulatory agencies should be modified to ensure comprehensiveness and uniformity in method application.

## Summary

There are no simple solutions to the problems created by contaminated marine sediments. However, the NRC study summarized here indicates that careful problem formulation and good information can provide the foundation for sound decisions in managing contaminated sediments. Incremental improvements in remediation technologies, project implementation, and decision making can be made and may result in cost-effective, socially acceptable, and environmentally sound solutions.