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Hazardous Substance Research Centers

The five regional Hazardous Substance Research Centers were established in 1989 and funded by the U.S. Environmental Protection Agency (U.S. EPA). The Centers' mission is to support and conduct innovative research and technology development in hazardous substance control, cleanup and management. The Centers have an interdisciplinary group of knowledgeable scientists and engineers who can offer technical advice, review sites, and help increase understanding of hazardous contamination.

For more information visit www.toscprogram.org or call 1-800-490-3890.

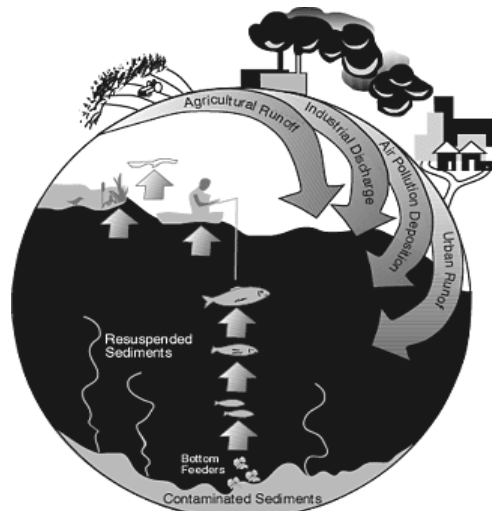


The Midwest Hazardous Substance Research Center is a consortium of Michigan State University, Purdue University, and Kansas State University

Contaminated Sediments

Overview of Contaminated Sediments

Sediment contamination is a major environmental issue because of its potential toxic effects on biological resources and often, indirectly, on human health. A large variety of contaminants, including PCBs, dioxin, pesticides, heavy metals, hydrocarbons and other pollutants from industrial, agricultural, urban, and maritime activities are associated with sediment particulates, including bottom sediments. When present at elevated levels in sediments, these chemicals can kill or harm bottom-dwelling organisms. Pollutants in sediments can accumulate in these aquatic organisms and move up the food chain to fish, shellfish and eventually humans.



The presence of contaminated sediments in many industrial and urbanized harbors and waterways contributes to environmental degradation and inhibits the ability to dredge, transport, and relocate sediments.

Removal and treatment of contaminated sediments is often difficult due to the high water content, large volumes, and fine particles that tend to contain the bulk of the contaminants. These factors conspire to make treatments developed for contaminated soils uneconomical or impractical for treatment of sediments. Cost effective means of mitigating the environmental and ecosystem impacts of contaminated sediments are needed. The problem of contaminated sediments presents regulatory and technical challenges for both navigation and remediation.

The extent of sediment contamination and its associated adverse effects have been the subject of considerable concern and study in the Great Lakes community and elsewhere. Sediments are associated with impairment of beneficial uses at 42 of the 43 Great Lakes Areas of Concern (AOCs). See EPA's web site (www.epa.gov) for further details.

Assessment of Contaminated Sediments

Assessment of sediment contamination is intended to determine whether chemical concentrations in the sediments are sufficient to cause adverse effects to either aquatic organisms or organisms higher in the food chain, including humans.

Decisions regarding the possible need for sediment remediation are made on the basis of a preponderance of evidence collected during the assessment.

Prior to addressing the potential need for remediation of those sediments, an assessment is done to answer the following questions:

- Are the sediments sufficiently "contaminated" to warrant consideration for remediation? In this context, "contaminated" refers to the presence of chemicals in the sediments that have the potential to cause adverse effects to humans or the environment.
- Is there evidence indicating that existing concentrations of sediment contaminants are adversely affecting the environment? In other words, does the presence of contaminants in the sediments cause adverse effects in organisms, either in the environment or in the laboratory?
- Are organisms exposed to the sediments accumulating contaminants with adverse effects? Are other organisms higher in the food chain being affected, including humans?
- If the sediments are sufficiently contaminated to cause such effects, how large (i.e., both horizontal and vertical) is the contamination? What are the implications of the distribution of contaminants on possible remedial alternatives?

Unfortunately, there is no single method that will measure all contaminated sediment impacts at all times and to all biological organisms. This lack is the result of a number of factors, including environmental variety and associated sampling problems, variability in the laboratory exposures and analytical variability. Other factors include differing sensitivities of different organisms to different types of contaminants, the confounding effects caused by the presence of unmeasured contaminants, the synergistic and antagonistic effects of contaminants, and the physical properties of sediments. While one method will suffice for some circumstances, it is often advisable to use

circumstances, it is often advisable to use several complementary methods rather than a single one. When several of these approaches are used together, they can provide additional insights into the nature and degree of sediment contamination problems. The use of complementary assessment methods can provide a kind of independent verification of the degree of sediment contamination, if the conclusions of the different approaches agree. If the conclusions differ, that difference indicates a need for caution in interpreting the data since some unusual site-specific circumstances may be at work. The importance of this type of verification increases with the significance of the decisions that must be made using the information obtained. The integrated application of different sediment assessment methods is therefore valuable because decisions can be made on the basis of a preponderance of evidence.

Remediation of Contaminated Sediments

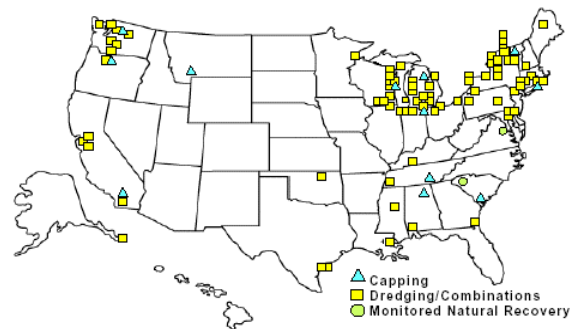
Remediation of contaminated sediment has received growing attention in the United States in recent years. The basic options for sediment remediation are well established. These include: non-removal options such as monitored natural recovery and on-site (in-situ) capping; and removal options, such as dredging with containment, and dredging with sediment treatment. Many remedies involve combinations of these options. However, the effectiveness of the options and principles for selecting a given option for large and complex sites is still the subject of much debate.

Some of the most common **remedial options** include:

- **Monitored Natural Recovery (MNR):** Monitored Natural Recovery is a remedial option that relies on natural processes to contain or reduce the bioavailability or toxicity of sediments left in place. Processes

important to MNR include burial and in-place dilution following deposition of clean sediment and natural transformation processes which convert the contaminants to less toxic forms.

- **In-Situ Capping:** In-situ capping (ISC) is an active remediation option in which a layer of clean isolating material (usually a clean sediment or soil) is placed over the sediment to contain and stabilize the contaminated sediment in place. A variety of capping materials and cap placement techniques are available, and monitoring data collected for a number of projects has indicated capping can be an effective remedy.
- **Environmental Dredging:** Removal, including both dredging and dry excavation following dewatering or stream diversion, is the most common approach for sediment remediation in the U.S.
- **Containment in CDF's, CAD's and landfills:** Containment refers to placement of dredged material in a disposal site with associated design features to hold the contaminants within the site. Confined Disposal Facilities (CDFs) and Contained Aquatic Disposal (CAD) sites are commonly used for contaminated sediments from navigation dredging and have also been used for remediation projects. But, by far, the most common containment option in the U.S. for contaminated sediments dredged for purposes of remediation has been disposal in licensed landfills.
- **Sediment treatment:** Sediment treatment refers to the use of physical, chemical, or biological processes to destroy or degrade contaminants or immobilize the contaminants within the sediment.



Distribution of completed and on-going projects in the U.S. with greater than 2000 cubic meters of contaminated sediments.

However, selection of the most appropriate and potentially effective remedy for a given project remains the most vexing issue. The basic components of an evaluation should include a thorough characterization and assessment of the problem and/or project requirements, site and sediment characterization, implementation of source controls, screening of alternatives, detailed assessment of alternatives, selection of a preferred alternative, and provisions for monitoring and management. All these evaluations should be conducted within a risk-based framework.

Ultimately, the selection of a management or remedial approach must consider a balance between environmental protection and economic efficiency.

Confined Disposal Facility

Definition and Introduction to CDF

A Confined disposal facility (CDF) is an engineered structure for containment of dredged material. The confinement dikes or structures in a CDF enclose the disposal area above any adjacent water surface, isolating the dredged material from adjacent waters during placement.

The appropriate disposal of material dredged from navigation projects is a nationwide issue but has important implications for the use, management and protection of waters. Confinement of contaminated dredged material, determined to pose an unacceptable risk to the environment, is a federal policy and is recognized as necessary by state and local governments. Concern over environmental effects of dredging and disposal of dredged material, the increasing unavailability of suitable disposal sites and role of dredging in supporting waterborne commerce are the key issues.

Why CDF's?

The use of confined disposal facilities continues to be necessary. Originally, the main CDF program envisioned use of such facilities for a 10-year period. It was believed that progress in pollution control particularly from municipal and industrial point sources would sufficiently reduce the contamination of sediments and thereby eliminate (or reduce) the need to use CDFs. However, the extensive accumulation of contaminated bottom sediments particularly in industrial harbor areas and tributary river reaches and continuing land use practices that create erosion, sedimentation and related pollution require on-going confinement of large quantities of polluted dredged material. Remediation or clean up of polluted material from a CDF or elsewhere has been demonstrated to be technologically feasible through various means, but is relatively expensive compared to placement/storage in a CDF. However, as long as contaminated sediments are removed to maintain safe navigation or for environmental remediation, there will be a continued need for CDFs.

Design of a CDF

The size and design of each CDF is site-specific, depending on the location, the nature and potential amount of sediments and how it will be used or function once it is full and/or no longer receives dredged material. Dikes for in-water CDFs are usually constructed in layers with heavy, protective stone on the outside and progressively smaller stones to sand on the inside. Some CDFs incorporate liners or steel sheet pile in the dike walls. As dredged material is pumped or placed in a CDF, the sediments settle out and the accompanying water evaporates or percolates through the walls or into the ground. When permeability is reduced over time because of sediment sealing, a variety of water release mechanisms including overflow weirs (dams) and filter cells are used.



An example of a Confined Disposal Facility Effectiveness of a CDF

A major concern relates to how effective CDFs are in keeping the material from contaminating the surrounding environment. Contaminants often bind with fine sediments such as silt and clay. To the extent that this form of pollution is confined to the CDF and bioaccumulation of pollutants by plants and animals in or near CDFs is not significant, then CDFs are presumed to be relatively efficient. Volatilization of contaminants is another potential problem but it varies from site to site.

There is no system-wide, continual monitoring program for CDFs. However, CDF water quality monitoring generally occurs during dredging and disposal operations and 12 CDFs do have monitoring wells in dike walls. The effectiveness of these monitoring wells has been questioned and may have limited value. A 1993 CDF report prepared by the Army Corps of Engineers' North Central division summarized the overall environmental status of CDFs as reported in studies to date. The Corps reported, "The results of water quality monitoring has confirmed that CDFs are highly efficient at retaining the sediment solids and attached contaminants." CDF influent typically has suspended solids levels around 100 mg/Liter whereas effluents are normally around 1 mg/Liter. With respect to contaminant losses from in-water CDFs, detailed studies at several facilities show a high level of efficiency at keeping pollution within the CDF itself.

Even though CDFs appear to be efficient regarding retention of the contaminants, more research is needed to describe the potential contaminant exposure pathways associated with CDFs and test mitigation strategies such as capping, eliminating or neutralizing sediment exposure.

Future of CDF (Transition from Storage to Treatment facility)

Many CDF's are nearing or exceeding design capacity. Acquiring land for a new CDF is difficult because choice land areas located near dredging projects are already in use and undeveloped lands near dredging projects are often wetlands with ecological functions that make them too valuable for use as CDF's. The combination of these factors has produced the following impacts:

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- ❑ Continued demand for CDFs to manage contaminated dredged material for navigation
- ❑ Increased demand for CDFs to manage contaminated sediments dredged for remediation
- ❑ More stringent environmental requirements for new CDFs increase the costs of new CDFs
- ❑ Fewer ports and local governments are capable of sponsoring new CDFs

Design of CDF's as treatment structures, groundwater and surface water protection, and overall contaminant retention is a high priority. There is an ongoing research for developing bioremediation, electrochemical remediation and other such technologies for treatment of contaminated dredged material.

Sources of information for this fact sheet:

- ❑ Fact sheet by Great Lakes Dredging Team: <www.glc.org/dredging/oureach/cdffs.html>
- ❑ Michael Palermo, US Army Corps of Engineers (various Papers), see: <<http://www.envirotools.org/factsheets/remediationofcs/VeniceConference-OverviewofSedRemUS-wCR.PDF>>
- ❑ Detailed document on CDF's from US Army Corps of Engineers website: <www.lrd.usace.army.mil/gl/cdf98.pdf>
- ❑ US EPA's website on Assessment and Remediation of Contaminated Sediments (ARCS): <<http://www.epa.gov/grtlakes/arcs/EPA-905-B94-003/B94-003.ch7.html>>

The TOSC Program promotes citizen participation in the environmental cleanup process by providing educational services and technical assistance to communities, including the review of technical documents. TOSC is funded under a grant from the U.S. Environmental Protection Agency. For more information, please contact Kirk Riley, TOSC Program Manager at B100 Research Complex-Engineering, Michigan State University, East Lansing, MI 48824. Call (517) 355-7493, or send e-mail to rileyki@egr.msu.edu