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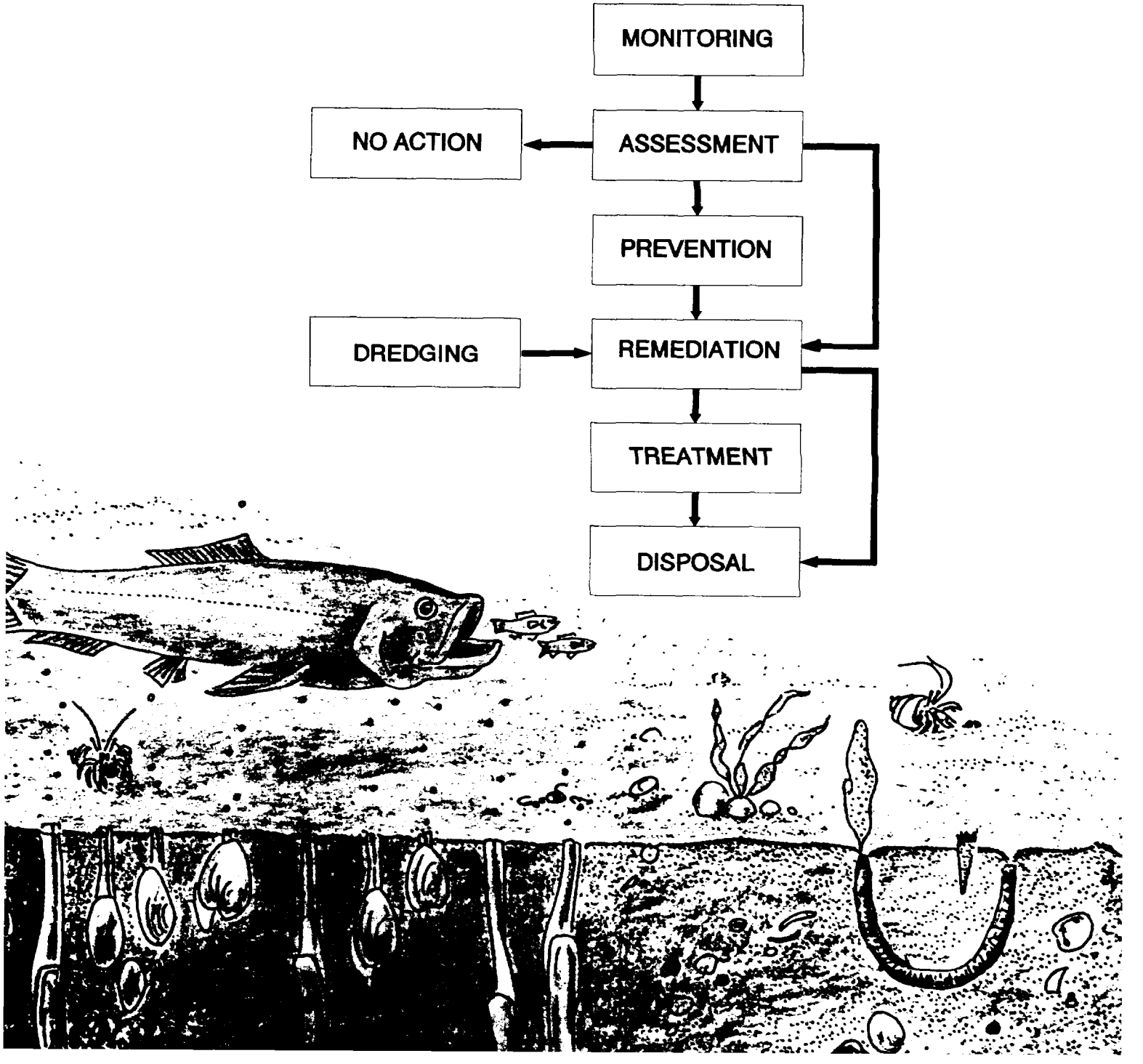
Managing Contaminated Sediments

EPA Decision-Making Processes



Managing Contaminated Sediments:
EPA Decision-Making Processes

Prepared by
U.S. Environmental Protection Agency
Sediment Oversight Technical Committee

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[1] EPA office acronyms are defined in the glossary.

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Executive Summary

The purpose of this document is to summarize how the Environmental Protection Agency (EPA) makes decisions with regard to managing contaminated sediments. Traditionally, contaminated sediments have been most closely regulated by the Office of Marine and Estuarine Protection (OMEP) under the Marine Protection, Research, and Sanctuaries Act (MPRSA) for ocean dumping and the Office of Wetlands Protection (OWP) for dredge and fill activities under the Clean Water Act (CWA). In recent years, however, it has become increasingly apparent that the scope of the contaminated sediments problem extends far beyond this traditional context. A comprehensive management program is needed in order to address the range of contaminated sediment issues.

For the purposes of this document, management activities relating to contaminated sediments are divided into the following six categories of activities:

- **Finding contaminated sediments** — Identification and monitoring.
- **Assessment of contaminated sediments** — Determining the effects of sediment contamination on the environment.
- **Prevention and source controls** — Reducing and preventing sediment contamination through permitting and enforcement activities.
- **Remediation** — Determining when, how, and to what degree contaminated sediments should be remediated.
- **Treatment of removed sediments** — Determining when and how removed sediments need to be treated before disposal.
- **Disposal of removed sediments** — Selecting appropriate disposal methods for removed contaminated sediments.

The level of development of regulatory authority and programmatic guidance under each of these categories is uneven. Because of the past emphasis on dredge and fill activities, the amount of programmatic guidance in this area is great, especially for ocean waters. On the other hand, guidance on monitoring, assessment, prevention and source controls, and treatment is not as well developed. The general status of activities under each of the six categories is as follows:

- **Finding contaminated sediments** — CWA activities are focused on effluent monitoring and water quality assessment. No national guidance on sediment monitoring is available. Some States have adopted regular sediment monitoring programs, but in most States it is done only as part of special studies. Monitoring activities are undertaken under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and Resource Conservation and Recovery Act (RCRA) programs. However, these activities are usually focused on the immediate vicinity of specific sites. Under CERCLA, States and Regions identify sites where contamination is suspected and sites are assessed to determine whether there is a hazard. Under RCRA, facilities are required to identify past releases of contaminants and may be required to search for past and present contaminant releases. CWA and MPRSA require dredged material disposal site monitoring, but, again, data is specific to sites. The Great Lakes National Program Office (GLNPO) has conducted site monitoring as part of special studies and Region X conducts monitoring as part

of its Puget Sound activities. Monitoring is needed to determine existing background levels of sediment contamination, to be able to measure trends in sediment quality and to determine when more comprehensive studies or remedial actions are needed.

- **Assessment of contaminated sediments** — National sediment quality criteria are not yet developed. Several States are in the process of developing and implementing sediment criteria. Superfund performs assessments based upon site-specific "applicable or relevant and appropriate requirements" (ARARs) rather than on general guidelines for handling sediments. Various approaches to assessment are being used in the different programs and Regions, including equilibrium partitioning-based criteria, bioassays, Apparent Effects Thresholds (AET) and reference approaches. The "Green Book," developed under MPRSA §103, provides an assessment tool for dredged material disposal in ocean waters which could have broader applicability. National testing guidance under CWA §404 similar to the Green Book is being developed. Some Regions have developed their own assessment protocols which use various approaches, particularly in implementing CWA §404 and MPRSA §103 programs. In general, consistent criteria and assessment protocols are needed.

- **Prevention and source controls** — To date, sediment contamination considerations have not been used in establishing permit limits for point sources under the CWA. Limits for pesticides have been based on benthic organism effects and controlled under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA). Toxic Substances Control Act (TSCA) limitations can also be placed on chemicals. Enforcement actions have been taken against several dischargers who were obvious sources of sediment contamination. There is presently no guidance on when and how to undertake sediment-related enforcement activities.

- **Remediation** — There is presently no national guidance specific to sediments on when remediation should take place or on the selection of possible cleanup options. Guidance on remediating Superfund sites is provided under CERCLA, but it does not explicitly target sediments. Remediation options involving the removal of sediments may use the guidance developed for dredge and fill activities by EPA, the Corps of Engineers and some States. Some remedial efforts are taking place as a result of regulatory actions under CERCLA and CWA.

- **Treatment of removed sediments** — There is no clear guidance on the selection of treatment options or determining when treatment should take place. Current decision-making is on a case-by-case basis. Several Programs are studying the efficacy of various treatment options on a demonstration scale. It is expected that guidance on the suitability and selection of treatment options will result from this work.

- **Disposal of removed sediments** — A complete set of tiered testing protocols has been established for assessing materials for ocean disposal under MPRSA §103 on the national level. Several Regions have issued guidelines for the specific procedures within the protocols. As stated above, similar CWA §404 guidance is under development. OMEP and OWP in conjunction with COE have developed a dredged material disposal strategy which is currently in draft form. The strategy aims at choosing environmentally appropriate disposal options, taking into account physical, chemical, and biological impacts.

An EPA Sediment Steering Committee is currently preparing an Agency-wide sediment management strategy to coordinate and focus the Agency's resources on contaminated sediment problems. The sediment strategy gives special attention to cross-program issues such as establishing a national

inventory of contaminated sites and sources, establishing consistent testing protocols for assessments, and utilizing/establishing enforcement authorities for sediment remediation. The strategy will also address other sediment issues relevant to EPA programs. EPA plans to have a draft sediment management strategy ready for publication in the Federal Register by the end of 1991.

Glossary

AET	Apparent Effects Threshold approach
AOC	Area of Concern (as defined by the IJC for the Great Lakes Basin)
ARARs	Applicable or Relevant and Appropriate Requirements
ARCS	Assessment and Remediation of Contaminated Sediments program under GLNPO
BAT	Best Available Technology
CAA	Clean Air Act
CAD	Confined Aquatic Disposal
CDF	Confined Disposal Facility
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COE	U.S. Army Corps of Engineers
CWA	Clean Water Act
DMASS	Dredged Material Alternative Selection Strategy
EEB	EPA Ecological Effects Branch
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
EP	Extraction Procedure (a chemical extraction defined in 40 CFR Parts 261.10 - 261.33)
EqP	Equilibrium Partitioning approach
ERL	EPA Environmental Research Laboratory
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
GLNPO	EPA Great Lakes National Program Office
GLWQA	Great Lakes Water Quality Agreement (between the U.S. and Canada)
HRS	Hazard Ranking System (under Superfund)
IJC	International Joint Commission (overseeing implementation of the GLWQA)
LC_{50}	Concentration Lethal to 50 percent of the exposed organisms
LDC	London Dumping Convention
ML	Maximum Level of chemical concentration (used in PSDDA sediment testing framework)
MPRSA	Marine Protection, Research, and Sanctuaries Act
NAAQS	National Ambient Air Quality Standards

NMFS	National Marine Fisheries Service
NOEL	No Observed Effects Level
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NSPS	New Source Performance Standards
OERR	EPA Office of Emergency and Remedial Response (for Superfund activities)
OMB	EPA Office of Management and Budget
OMEP	EPA Office of Marine and Estuarine Protection
OPP	EPA Office of Pesticide Programs
ORD	EPA Office of Research and Development
OSW	EPA Office of Solid Waste
OTS	EPA Office of Toxic Substances
OW	EPA Office of Water
OWP	EPA Office of Wetlands Protection
OWRS	EPA Office of Water Regulations and Standards
PCBs	Polychlorinated Biphenyls
PSDDA	Puget Sound Dredged Disposal Analysis
PSEP	Puget Sound Estuary Program
RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation/Feasibility Study (part of Superfund site assessment process)
ROD	Record of Decision (part of Superfund site remediation process)
SITE	Superfund Innovative Technology Evaluation
SL	Screening Level of chemical concentration (used in PSDDA sediment testing framework)
TBP	Theoretical Bioaccumulation Potential
TBT	Tributyltin
TCLP	Toxicity Characteristic Leaching Procedure
TEA	Triethylamine
TMDL	Total Maximum Daily Load
TSCA	Toxic Substances Control Act
USFWS	U.S. Fish and Wildlife Service
WLA	Wasteload Allocation

Chapter 1

Introduction

Issues related to the contamination of bottom sediments with toxic chemicals and the potential for environmental damage are receiving increased attention by the public and State and Federal Agencies. Managing contaminated sediments requires that decisions be made on assessment of environmental harm, prevention and source controls, dredged material management, and remediation.

The purpose of this document is to identify the U.S. Environmental Protection Agency's (EPA) current decision-making process (across relevant statutes and programs) for assessing and managing contaminated sediments. It is intended to provide decision-makers throughout the Agency with information that will aid them in making effective judgements regarding national or regional approaches for dealing with contaminated sediments. The document partially fulfills one of the goals of the Agency-wide sediment management strategy (discussed in Chapter 4) which calls for gathering information on EPA decision-making processes and explaining differences among Program Offices. Use of this information will allow EPA to prepare a strategy that adequately addresses gaps in current decision-making on sediments.

The discussion in this document is intended to highlight the way in which decisions are currently being made rather than on how they may be made in the future when protocols that are currently under development are adopted. However, important decision protocols that are being developed or that have been developed but are not in use are also discussed.

In order to help identify relevant contaminated sediment management issues and to provide a background for subsequent discussions on how they are being addressed by existing programs, a general contaminated sediments issues framework is presented in this chapter. It is important to emphasize that this framework is only presented to provide structure for the discussions of existing programs; it is not EPA's contaminated sediment management policy or protocol. However, the identification, in this document, of how well existing programs address contaminated sediment issues is an important step toward the development of such policies and protocols.

Management activities relating to contaminated sediments can be separated into the following six categories:

- **Finding contaminated sediments** — Identification and monitoring.
- **Assessment of contaminated sediments** — Determining the effects of sediment contamination on the environment.
- **Prevention and source controls** — Reducing and preventing sediment contamination through permitting and enforcement activities.
- **Remediation** — Determining when, how, and to what degree contaminated sediments should be remediated, and regulatory or other measures which result in EPA, responsible parties, or others performing a remedial project.

- **Treatment of removed sediments** — Determining when and how removed sediments need to be treated before disposal, and the implementation of such treatment.

- **Disposal of removed sediments** — Selecting appropriate disposal methods and locations for removed contaminated sediments, and the implementation of disposal projects.

Until recently, the EPA has not generally emphasized the quality of sediments except in relation to the disposal of dredged material removed during navigational dredging. The U.S. Army Corps of Engineers (COE), the Federal agency responsible for maintaining waterways for navigational purposes, and the EPA have developed protocols for evaluating dredged materials and disposal options. These protocols, which are currently being revised for ocean water disposal under §103 of the Marine Protection, Research and Sanctuaries Act (MPRSA) and are being adapted for freshwater and estuarine disposal under §404 of the Clean Water Act (CWA), essentially focus on the suitability of dredged materials for disposal in the aquatic environment. Other statutes control the disposal of dredged material on land.

Sediment monitoring and assessment activities are generally performed under the CWA, the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), the Resource Conservation and Recovery Act (RCRA) and MPRSA. Sediment contamination prevention and source control actions can be taken under a variety of authorities depending on the particular circumstances. Such authorities include the CWA, the Toxic Substances Control Act (TSCA), the Resource Conservation and Recovery Act (RCRA), the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), and the Clean Air Act (CAA). While there may be broad authority under CERCLA and some authority under the CWA and RCRA to remove contaminated sediments from water bodies, not many actions have been taken thus far to remediate sediments.

Sediment quality criteria are under development and have been published in preliminary form for some toxic organic chemicals (USEPA, 1988a). EPA is considering approaches to the use of these criteria in managing sediment quality (USEPA, 1989a). Such criteria may be useful in sediment assessment, to aid in determining the need for source controls, and in sediment remediation, treatment and disposal.

This document is organized as follows:

- Chapter 1 presents a contaminated sediments issues framework. The framework is used to introduce relevant contaminated sediment management issues.

- Existing decision-making programs and procedures for sediment monitoring and assessment, contamination prevention, remediation and disposal of contaminated sediments are summarized in Chapter 2. The contaminated sediments issues framework is used to structure the discussions.

- Chapter 3 identifies gaps between existing programs and the relevant issues identified in the contaminated sediments issues framework. In addition, inconsistencies and overlaps between the various existing programs are identified.

- Chapter 4 presents an overview of the sediment management strategy which is being developed under EPA's Sediment Steering Committee.

The information presented in this document is subject to modification in accordance with changes in program and/or regional approaches to managing contaminated sediments.

Contaminated Sediments Issues Framework

Contaminated sediments can pose serious threats to human health and the environment by serving as a persistent source of toxic chemicals to humans or aquatic organisms. Human exposure results from direct contact, eating fish and shellfish that have accumulated toxic materials, and drinking water which has been exposed to contaminated sediments. Aquatic organisms, particularly benthic species, are continuously exposed to the contaminants in sediments, which may result in adverse biotic effects including chronic and acute toxicity. The accumulation of toxic chemicals within aquatic organisms may be sufficient to preclude their use for human consumption and possibly pose a threat to wildlife. If the environment is to be preserved for future generations, the contaminants in sediments must be treated and/or contained in ways that eliminate current and potential exposures to humans and aquatic organisms. Further degradation of sediment quality must also be prevented.

There are several options for isolating the contaminants in sediments. They range from allowing natural sedimentation to bury the contaminants to removing and treating sediment and isolating it from the rest of the environment. In those cases where contaminated sediments occur in areas that must be dredged to maintain navigation, sediment removal is essentially the only option, but disposal then becomes problematical.

Figure 1 outlines the major options for control of sediment contamination. There are two major entry points to the selection of options: 1) when contaminated sediments are suspected, and 2) when dredging must occur for navigational reasons. In general, the decision process for sediments which are slated for dredging can skip those options that don't involve removal of the sediments. There are cases, however, where COE will avoid dredging if it is too costly relative to benefits.

At each decision point, there are generally one or more options for taking action, and a no action alternative. Thus, if contaminated sediments are encountered, the only action that may be required to be taken is the reduction of contaminant sources. However, other options can be exercised if they are necessary to obtain acceptable sediment quality. Similarly, if dredged material is removed for navigational reasons, the only actions required are treatment (if necessary) and disposal.

The remainder of this chapter discusses the important issues that arise in the process of selecting contaminated sediments management options.

Finding Contaminated Sediments

Before full-scale, potentially costly sediment assessment programs are begun, the initial identification of areas containing probable contamination problems should be attempted. The contamination of sediments is a process influenced by a number of variables including contaminant source, contaminant type, sedimentary and hydrologic environment, sediment grain size distribution and composition, presence and type of aquatic life, and historical influences.The likelihood of there being a sediment contamination problem at a particular site needs to be appraised based on readily available information. Such information may be available from ongoing monitoring or regulatory programs, previous site characterizations, dredging records, discharge permits, area maps, fishing advisories, reports of spills, fish kills and beach closings, etc. It is worth noting that sediment contamination problems need not be connected to poor water quality. The ability of sediments to retain contaminants over time makes it possible for sediments to remain contaminated while water column contaminant concentrations remain below applicable water quality standards.

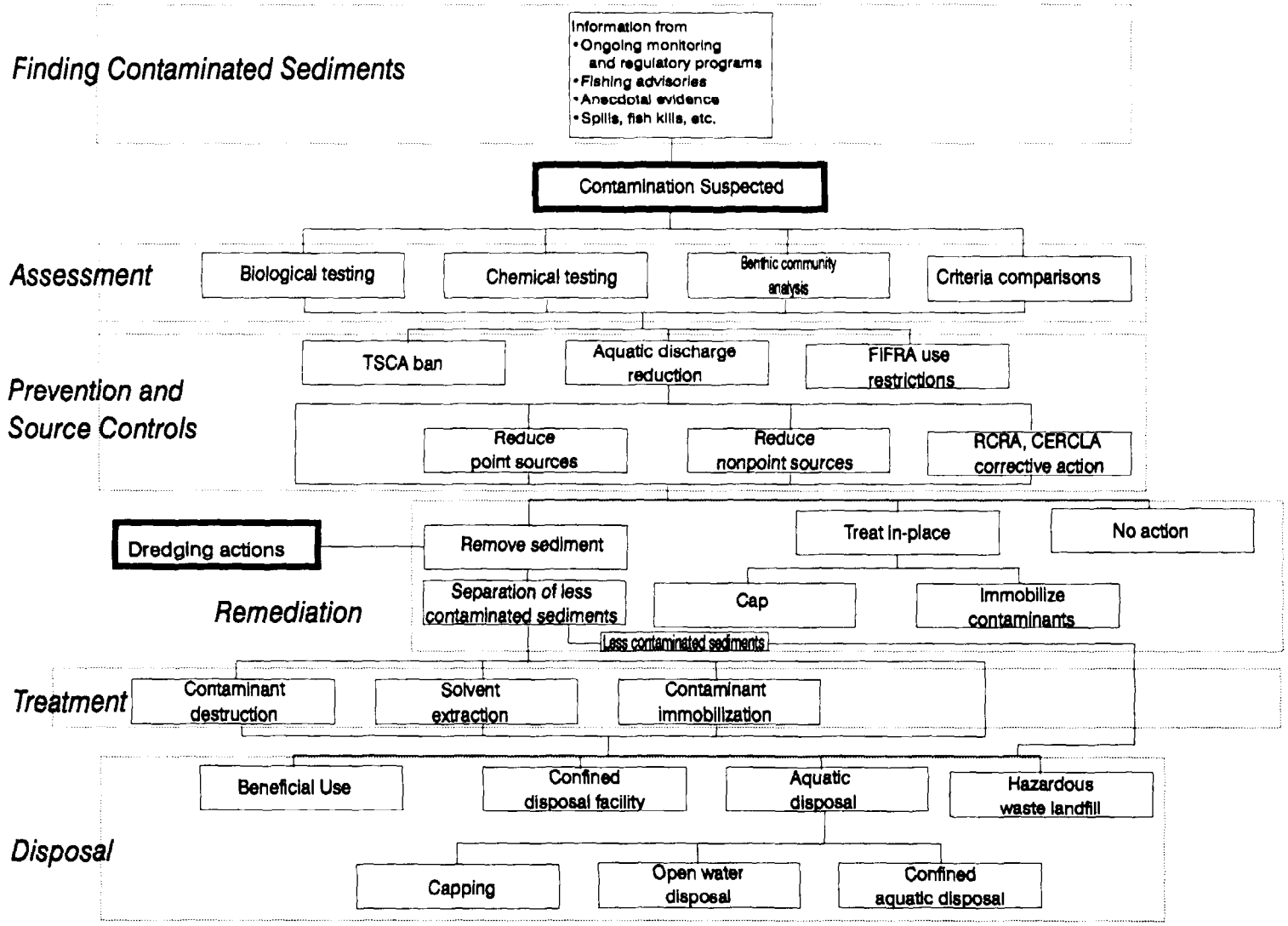

Figure 1. Contaminated Sediments Issues Framework.

Assessment of Contamination

When an initial screening indicates the possible presence of a sediment contamination problem, more complete characterization of the sediment is needed, including an assessment of the environmental threat posed by the contamination. In the selection of sediment assessment methods, the first consideration is determining what is to be protected. Assessment methods will vary in their ability to indicate effects on aquatic life, wildlife, or human health.

The simplest assessment approach is the direct comparison of observed concentrations of sediment contaminants to some pre-established criteria. Sediment quality criteria are more difficult to develop than similar water quality criteria because of the number and complexity of factors affecting the intensity of biotic effects created by a given chemical concentration. Sediment quality criteria are currently under development by EPA. A generic definition of sediment quality criteria is as follows:

> *A sediment criterion is a specific level of protection from the adverse effects of sediment associated pollutants, for beneficial uses of the environment, for biota, or for human health. The criteria may be specified in a number of ways, but most commonly as concentrations of individual pollutants, as toxic units for whole sediment toxicity, or in terms of pass/fail based on tests of acute or chronic toxicity or bioaccumulation.*

Sediment criteria are intended to accurately reflect the latest scientific knowledge:

- on the kind and extent of all identifiable effects on health and welfare including, but not limited to, plankton, fish, shellfish, wildlife, plant life, shorelines, beaches, aesthetics and recreation which may be expected from the presence of pollutants in sediments and groundwater,
- on the concentration and dispersal of pollutants, or their byproducts, through biological, physical, and chemical processes, and
- on the effects of pollutants on biological community diversity, productivity and stability, in addition to eutrophication and organic/inorganic sedimentation.

The Office of Water Regulations and Standards is developing sediment quality criteria for a number of contaminants using water quality criteria and an equilibrium partitioning (EqP) approach (USEPA, 1989b; 1990a). The EqP approach is based on a simple model that describes the partitioning of a contaminant between sediment phases which bind the contaminant and interstitial water. Interim criteria have been published for some organic contaminants (USEPA, 1988a). Sediment quality criteria may also be developed from other approaches, such as the Apparent Effects Threshold (AET) approach developed by Region X, or the bulk sediment toxicity tests used in the tiered testing strategy of the *Draft Ecological Evaluation of Proposed Discharge of Dredged Material into Ocean Waters* (USEPA, 1990b). A review of the strengths, weaknesses, and applicability of these and other approaches for assessing sediment quality is provided in the draft document *Sediment Classification Methods Compendium* (USEPA, 1989c). A brief description of the approaches is found below. They range in complexity from simple chemical characterizations of the sediments to multi-pronged approaches utilizing chemical and biological testing along with benthic community structure analysis. Except for the Reference Approach, the definitions given below are taken directly from the *Sediment Classifications Methods Compendium* (USEPA, 1989c).

- **Reference Approach** — Sediment contaminant concentrations at a site are compared with background concentrations from "unaffected" sites from the same area.
- **Bulk Sediment Toxicity Test** — Test organisms are exposed to field-collected sediments which may contain unknown quantities of potentially toxic chemicals. At the end of a specified time

period, the response of the test organisms is examined in relation to a specified biological endpoint.

- **Spiked-Sediment Toxicity Test** — Dose-response relationships are established by exposing test organisms to sediments that have been spiked with known amounts of chemicals or mixtures of chemicals.
- **Interstitial Water Toxicity Test** — Toxicity of interstitial water is quantified and identification evaluation procedures are applied to identify and quantify chemical components responsible for sediment toxicity. The procedures are implemented in three phases to characterize interstitial water toxicity, identify the suspected toxicant, and confirm toxicant identification.
- **Equilibrium Partitioning Approach** — A sediment quality value for a given contaminant is determined by calculating the sediment concentration of the contaminant that would correspond to an interstitial water concentration equivalent to the U.S. EPA water quality criterion for the contaminant.
- **Tissue Residue Approach** — Safe sediment concentrations of specific chemicals are established by determining the sediment chemical concentration the will result in acceptable tissue residues. Methods to determine unacceptable residues are based on chronic water quality criteria and bioconcentration factors, chronic dose-response experiments or field correlations, and human health risk levels from the consumption of freshwater fish or seafood.
- **Benthic Community Structure Analysis** — Environmental degradation is measured by evaluating alterations in benthic community structure.
- **Sediment Quality Triad Approach** — Sediment chemical contamination, sediment toxicity, and benthic community structure are measured on the same sediment. Correspondence between sediment chemistry, toxicity, and biological effects is used to determine sediment concentrations that discriminate conditions of minimal, uncertain, and major biological effects.
- **Apparent Effects Threshold (AET) Approach** — An AET is the sediment concentration of a contaminant above which statistically significant biological effects (e.g., amphipod mortality in bioassays, depressions in the abundance of benthic infauna) would always be expected. AET values are empirically derived from paired field data for sediment chemistry and a range of biological effects indicators.
- **International Joint Commission (IJC) Sediment Assessment Strategy** — Contaminated sediments are assessed in two stages: 1) an initial assessment that is based on macrozoobenthic community structure and concentrations of contaminants in sediments and biological tissues, and 2) a detailed assessment that is based on a phased sampling of the physical, chemical, and biological aspects of the sediment, including laboratory toxicity bioassays.

Prevention and Source Controls

When sediment contamination is found, it is usually important to determine the cause of the problem. If, for example, continuing discharges are linked to sediment contamination, controls would be considered. On the other hand, if a spill is the cause, source controls may have little effect on contamination levels.

The type of action to take is partly dependent upon the scale of contamination. If a sediment contaminant is elevated at numerous sites nation-wide, it may be relatively inefficient to deal with it only on a local basis. The sources are probably so numerous that action on individual discharges would

be inefficient. It is best under these circumstances to attempt control on a nation-wide basis through regulatory or programmatic means. On the other hand, a single contaminated site may need to be controlled at the local level, and national controls are less relevant or useful. The first significant information requirement, then, is to determine the scale over which sediment contamination occurs for each contaminant. If contamination occurs on a national or regional level, actions could be taken under TSCA or FIFRA to restrict the production, distribution, or use of the contaminant. Similarly, if the major contaminant source appears to be atmospheric, appropriate standards can be developed under the CAA.

Even with appropriate national, regional, or local guidelines for sediment contaminants, individual sites create special cases. Each site is unique and, therefore, case-by-case handling will be necessary in many circumstances. Contamination "hot spots" also deserve special handling. In such cases, it may be inappropriate to forestall source control actions until programmatic or regulatory action is taken if such a delay would result in unacceptable environmental impacts.

It is also worth noting that the presence of a particular sediment contaminant in numerous locations nationally or regionally does not necessarily indicate the need for national source controls. Sediments store contaminants and even though discharges of a given contaminant were halted some time ago, the contaminant may persist in the sediments. Clearly, efforts for this kind of contamination problem need to be focused on remediation rather than source control.

The best way to directly relate sediment contamination to possible sources is to deal on a contaminant-by-contaminant basis. Toxicity testing does not directly identify the problem contaminants, it may play a significant role in the initial screening of potentially contaminated sediments, and — through the use of techniques such as toxicity identification evaluation procedures — it can identify the contaminants most likely responsible for observed toxicity. Geographic relationships between peak sediment contaminant concentrations and possible sources can also be used to link sediment contamination to sources.

When multiple sources for a given contaminant exist (e.g., multiple producers of a given contaminant in a single harbor), additional evidence can be used to tie a sediment contaminant to its source. Concentration gradients of the contaminant may be observed across the sediment surface with the highest contamination levels observed directly below the responsible outfall. Or contaminants may increase at certain depths in the sediment column indicating the history of the production or use of a contaminant by a particular facility. Finally, it may be possible to "fingerprint" a facility by matching the occurrence or relative concentrations of other contaminants that were emitted concurrently with the contaminant of interest by a particular facility. Identification of sources in this way should be considered when a sampling and testing program is being developed.

If contamination is restricted to a local area, the first consideration is whether the contamination source is ongoing or historical. If the contamination source is purely historical (e.g., a previous spill or a now obsolete discharger), then source control can be ruled out as a method of contaminant reduction.

It is useful to consider three general categories of sources in this discussion:

- **Point sources** — Municipal and industrial effluent, combined sewer overflows,
- **Nonpoint sources** — Agricultural runoff, stormwater runoff, airborne contaminants (atmospheric deposition),
- **Other sources** — Spills, infiltration of contaminated groundwater, downstream transport of contaminated sediments, aquatic dumping.

Because of the water quality-based effluent limitations possible under the CWA, it is generally appropriate to focus initial attention on point source discharges. A number of questions need to be answered when considering the need for point source controls:

- Where are point sources located?
- What are their loadings for the contaminants of concern?
- Allowing for historical contamination, are point sources substantially responsible for the level of contamination found?
- What type of discharge is responsible for the contamination (i.e., municipal vs. industrial process vs. cooling water)
- Are required reductions in point source discharges economically and technically feasible relative to the expected benefits to be obtained?

If point sources are apparently responsible for the contamination, then the strategy for sediment contamination prevention can focus on point sources (e.g., recalculating wasteload allocations (WLAs) to account for storage capacity of sediments and modifying permit limits to reflect the new WLA).

Nonpoint sources are capable of contributing significantly to sediment contamination. They require examination in the same way as point sources. The information requirements are the same:

- Where are nonpoint sources located?
- What are their loadings for the contaminants of concern?
- Allowing for historical contamination, would nonpoint sources be substantially responsible for the level of contamination found?
- What is the pathway for the nonpoint contamination(i.e., airborne vs. agricultural, and urban runoff vs. mining seepage, etc.)?
- Are required reductions in nonpoint source discharges economically and technically feasible relative to the environmental benefits to be obtained?
- Are there point sources remotely associated with the nonpoint contaminants (e.g., an initial source of airborne contaminants) that also need to be controlled?

Under CWA, control of nonpoint sources can be somewhat problematical. While there are authorities for the control of point sources in all States, no States have comprehensive regulatory programs for the control of nonpoint source pollution. Some State and local governments have enacted ordinances, regulations, or voluntary programs for controlling specific sources of nonpoint pollution, yet none have developed a comprehensive regulatory program to control all sources.

One way to overcome the possible limitations of nonpoint source controls is to seek other methods to achieve the same end. RCRA and CERCLA allow the control of environmental releases from contaminated sites. Corrective action can be taken under the appropriate statute to prevent further contributions of contaminants to sediments. Questions about the appropriateness of using such provisions include:

- Are there existing RCRA permitted or interim status facilities or CERCLA sites that are or have been releasing the contaminants that are elevated in off-site sediments?
- At what levels are these facilities/sites releasing contaminants?

- Are there identifiable control actions that can be taken to reduce discharges from the sites?
- What are the relative costs of controls to obtain the necessary discharge levels relative to the expected environmental benefits to be obtained?

Controls for other sources of sediment contamination must be instituted on a case-by-case basis using appropriate elements of both water and hazardous waste regulatory authorities.

Remediation

Contaminated sediments have not been frequently remediated due to:

- The lack of a clear regulatory and programmatic avenue to do so;
- The generally high costs of remediation; and
- The lack of established criteria for determining action and cleanup levels.

The environmental benefits of remediation need to be weighed against the costs of remediation and its possible environmental impacts. For instance, benthic habitat may be lost due to sediment removal or by capping. Or the loss of contaminated sediments during dredging may spread contamination to other areas. Therefore, one needs to be reasonably certain that the positive benefits of a plan of remediation outweigh the negative impacts before action is taken.

Basically, sediments should be remediated when "acceptable" environmental quality will not be achieved by natural processes within a "reasonable" period of time. Both adjectives are in quotes because acceptable and reasonable are not currently defined in practical or operational terms. Theoretically, sediments that exceed sediment quality criteria and/or demonstrate adverse environmental impacts are not acceptable, but how long unacceptable sediments should be allowed to exist is problematical. In any case, the information needed to make a decision on whether or not remediation should occur is as follows:

- Will contaminated sediment be sufficiently covered over by clean, natural sediments or naturally degrade within a reasonable time frame?
- Will covered sediments be released by storms or other mechanisms?
- Have sources been controlled sufficiently that significant sediment contamination will not recur if remediation is undertaken?
- Does the contaminated sediment itself pose a danger to larger areas (transport downstream) if left unremediated?
- Are there technically and economically feasible alternatives for remediation?
- Are adverse environmental, human health, and beneficial use impairments severe enough to warrant remediation?
- Will the positive long-term benefits of remediation outweigh the possible negative short-term impacts of the action?

While it is desirable that sources of continuing contamination be controlled either prior to or concurrent with remediation efforts, it may be necessary to proceed with remediation ahead of effective source controls if the contaminated sediments pose a sufficiently great environmental hazard. A factor that must be kept in mind in the decision-making is that contaminated sediments can be transported to

downstream or offshore areas if left in-place, thereby greatly increasing the size of the contaminated area, thus making future remediation efforts much more difficult.

There are three general sediment remediation options (see Figure 2):

- Take no action and let natural sedimentation cover them over,

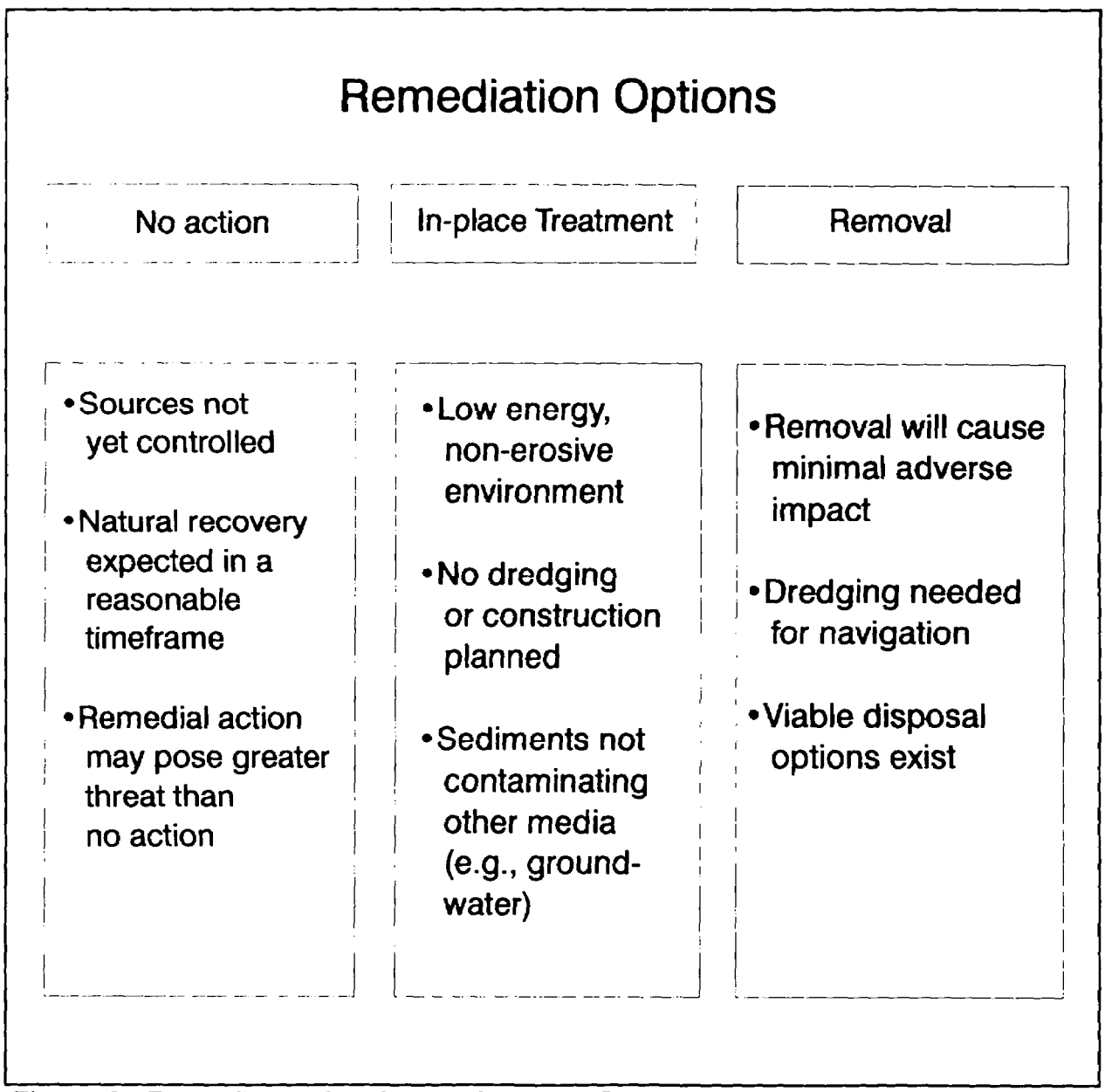

Figure 2. Remedial Action Alternatives and Considerations

- Treat them in-place, or
- Remove them to another area with or without treatment.

For any given site, however, a combination of options may be appropriate. Depending on the considerations listed below, sediments in one part of a site may be removed, while treatment in-place

or no action may be appropriate for other parts. Which options to choose are site- or locality-specific and may depend on the resources available and potential disposal options.

In general, the expected environmental benefits, possible adverse impacts, the time frame for natural recovery and the feasibility and cost of various treatment and removal options are the major determinants in selecting options for a particular location. The weight given each of these factors varies under the regulatory/programmatic framework under which remediation is performed.

Questions which need to be answered at this level include:

- How long would it take for the sediments to recover naturally to acceptable levels?
- Must the contaminated area be dredged for navigational purposes?
- Will the remedial action option significantly alter the hydrology or habitat of the area?
- Will the remedial action option be sufficiently permanent to warrant the expense (i.e., will a cap be eroded by currents or waves)?
- What are the relative costs of dredging and disposal versus treatment in-place?
- What are the relative environmental risks and benefits of the alternatives?

The **no action** option is most viable when one of the following situations exists:

- The sources of sediment contamination have not yet been significantly reduced, eliminated or controlled. Taking remedial action in this case is not effective because the sediments would soon be re-contaminated. The most prudent action is to control the sources before undertaking any remedial action on the contaminated sediments. An exception exists where sediments pose a threat of becoming a source of further contamination of downstream areas or groundwater.

OR

- The sources of sediment contamination have been eliminated or controlled and the contaminated sediments are in a low energy, non-erosive environment which will not be disturbed by dredging or construction activities or by natural means such as storms. In this case, a natural cap of clean sediment is being formed over the contaminated sediments, reducing or eliminating the transfer of pollutants from the sediments to the overlying water and biota.

OR

- The sources of sediment contamination have been eliminated or controlled and remedial action is desirable. However, taking remedial action would be more environmentally damaging than leaving the contaminated sediment in-place untreated.

In general, **in-place treatment** is appropriate when all three of the following conditions apply:

- The sediments are in a low energy, non-erosive environment. After in-place treatment, the treated sediments will remain undisturbed by natural forces.

AND

- The sediments will not be disturbed by dredging or construction activities. Such activities could render the in-place treatment ineffective by re-exposing contaminated sediments or by breaching an established barrier. Alternatively, the treatments could make dredging or construction very difficult (e.g., if the sediments were solidified into concrete).

AND

- The in-place sediments do not act as a source for contamination of other media, such as groundwater.

Possible in-place treatments include:

- Immobilizing the sediments and contaminants by treating the sediments with fixatives to solidify them or otherwise reduce bioavailability.
- Treating the sediments with neutralizers or binders to make the pollutants less biologically available.
- Covering the sediments with barriers or sorbents to reduce transfer of pollutants from the sediments to the water column and biota (e.g., capping).

Immobilization may only be a feasible option when sediments have already been isolated from the water column by dikes in order to prevent the release of contaminants into the unconfined environment.

The **sediment removal** option is viable when:

- The removal and disposal/treatment can be done so as to prevent unacceptable adverse impacts from occurring (i.e., the adverse impacts from removal are less than those from leaving the contaminated sediments in-place).
- Sediment removal is necessary for navigation or construction purposes.
- Viable disposal options exist.

If the decision to take action, either treatment or removal, is made, then technical considerations need to be answered before a specific technique is chosen. Technical questions which need to be answered before in-place treatment or capping can be considered include:

- Will the sediments support the weight of a cap?
- Will a cap have sufficient integrity to prevent its erosion by currents or waves?
- Will a cap significantly alter the location or speed of currents in the area?
- Will a cap sufficiently prevent the migration of contaminants to the surface and the effects of bioturbation?
- Will contaminated sediments be a contaminant source to groundwater?
- Will mixing in the solidification agents cause significant releases of resuspended contaminated sediments?
- What are the relative costs of feasible capping or treatment alternatives?
- To what extent does the alternative permanently isolate contaminated sediments from the environment?

Most of the methods that have been used for in-place remediation are experimental. Of the alternatives, capping has been carried out most frequently both in the U.S. and Europe. Japan has the most experience with in-place immobilization. In the U.S., all immobilization has been done on dredged sediments destined for off-site disposal areas, not on in-place sediments.

Removal options consist mainly of conventional dredging and excavation techniques. The questions that need to be addressed when selecting removal options include:

- What are the physical and chemical characteristics of the sediments to be dredged?
- What are the physical constraints at the dredging site or for access to the dredging site?
- What is the water depth at the site?
- What losses or resuspension of contaminants from the removal operation are acceptable?
- Is equipment available that will meet the minimum loss rate requirements and what are their relative costs?
- If the minimum loss rates cannot be achieved, what other measures can be taken to mitigate impacts (e.g., silt curtains, cofferdams, downstream sediment traps, etc.)?

Treatment Options

If sediment removal is undertaken primarily to reduce the environmental or human health risk of leaving the sediments in-place, the sediments removed are more likely to be contaminated than those removed by most navigational dredging. It is unclear whether the disposal facilities used for most dredged material would be found acceptable for the highly contaminated sediments removed for cleanup purposes. Some degree of treatment may be required before disposal.

In some cases, it may be possible to separate the sediments and/or the treatment residuals into contaminated and uncontaminated fractions. Then, potentially, only the contaminated fraction would need to be handled in a secure way, while the less contaminated fraction could either be disposed of with few restrictions or, optimally, could be used in a beneficial way. This separation into contaminated and uncontaminated residuals is a strong point of some of the treatment technologies, since it can reduce ultimate disposal costs due to the reduced volumes of contaminated materials that need to be disposed of using more costly methods such as incineration or hazardous waste landfills. However, in general, to realize this potential cost savings, the treatment technologies must be able to reduce chemical concentrations, toxicity or mobility sufficiently so that the "uncontaminated" residuals can be classified as non-toxic under TSCA regulations and non-hazardous under RCRA regulations. If the treatment technology is not able to achieve the needed reductions, treatment, in some cases, could actually increase the volumes of "contaminated" material that has to be disposed of at a TSCA facility. Even in this case, however, treatment may be warranted if it reduces the hazard posed by the sediments from unacceptable to acceptable levels.

Treatment options for sediments fall into the following categories:

- **Contaminant/sediment volume reduction** — This can be used in conjunction with other treatments and involves reducing the total volume of contaminated sediment through mechanical separation of the finer sediments from the coarser sand and gravel which is generally less contaminated. Examples of such processes are hydrocyclones and soil-washing. Treatment can then concentrate on the more contaminated fine material. If contaminant levels are low enough, the coarse material may be employed for beneficial uses (such as construction fill material). Thermal processes may also reduce sediment volumes through loss of organic and volatile materials at high temperature.
- **Contaminant immobilization** — Involves mixing the sediment with materials that either bind strongly to the contaminants to prevent their leaching or solidify the dredged material into essentially unleachable solids. Solidifying agents such as Portland cement can be used. The

sediment may also be mixed with siliceous hardening agents such as fly ash or blast furnace slag and hardened into blocks or into a soil-like material. Calcium carbonate has been used to bind to metals and increase the pH of runoff from dewatered dredged material, an effective treatment for controlling the metals in runoff from sediments placed in confined disposal facilities, for example.

- **Contaminant destruction** — Contaminant destruction technologies include biodegradation, chemical detoxification and thermal techniques. Most of these techniques are appropriate for dealing with organic contaminants, but techniques do exist for inorganic contaminants as well. In general, processes which are designed for dealing with one type of contaminant (i.e., organic or inorganic) can be made less effective by the presence of the other type. However, some technologies are becoming available which destroy organics and incorporate inorganics in a solid matrix such as glass (vitrification). Bacteria and fungi are known to metabolize some toxic organic compounds, but their use has generally not been tested on a large scale. Incineration can be carried out in either rotary kilns or fluidized bed reactors, both of which can handle a solid matrix. Pyrolysis, the destruction of organics in the absence of air, is also a technology that has been applied to materials similar to contaminated sediments. Heat-related processes are all relatively expensive. Chemical detoxification processes, such as KPEG, which is an alkali metal dechlorination process for chlorinated organic contaminants, are also being evaluated.

- **Contaminant extraction** — Extraction technologies remove contaminants from sediments by partitioning them in an appropriate extractant. In general, they are much cheaper than thermal technologies, and have been more widely applied in hazardous waste cleanups. Various proprietary processes use triethylamine (TEA), methanol, acetone, liquid propane, or aqueous acids as solvents. Few solvent extraction technologies remove both organic and inorganic contaminants. The contaminants removed by the solvents may need to be further treated (or incinerated) prior to disposal, and some of the solvent remains in the treated sediments. Ideally, the remaining sediments are sufficiently decontaminated that they can be disposed of in a routine manner or used for beneficial purposes.

- **Thermal separation** — Physical mass and contaminant quantities in sediments can sometimes be reduced by low temperature (200-1000°F) thermal treatment. Thermal separation is most effective for the removal of volatile and semi-volatile organics and volatile metals and the destruction of cyanides. The removed contaminants may still require treatment and/or destruction. This process works best for sediments with relatively low water and organic carbon content.

The above processes may require modification of the sediments before treatment. For instance, most processes require that sediments be dewatered to some extent. The cost and effort involved in any such preparation for treatment need to be considered when selecting treatment options.

The major information needs to decide on whether to use any of the above treatment options include:

- Are the sediments so highly contaminated that they must be treated no matter how they are to be disposed of?

- Will treatment open up disposal options that were otherwise not available because of unacceptable environmental risks?

- Will the benefits of using the newly available disposal option offset the additional costs of treatment (and disposal of any additional wastes generated)?

And in the consideration of which treatment alternative to use:

- Are the sediment contaminants primarily organic or inorganic?
- Are the organic contaminants all soluble in the same solvent?
- Are most inorganic contaminants likely to be removed by acid extraction?
- Will side effects such as volatilization be increased or diminished?
- Are the binding agents that combine with the contaminants or the extractants compatible with the sediment matrix or other contaminants?
- Is there a commercial-scale system available?
- What is the cost of treatment relative to the available funds?

It can be inferred from the information needs that most treatment methods work well for either organic or inorganic contaminants only. While this is generally the case, certain combinations of specific organic and inorganic contaminants may be extractable with the same processes (e.g., the TEA process).

Disposal Options

Whether the contaminated sediments were treated and the success of the treatment process have a great influence on the disposal options available for the remaining sediments. To determine the disposal options, the characteristics of the contaminated sediments (treated or untreated) must be compared to the criteria specified under various environmental statutes. It is in this area that the EPA and the COE have developed procedures to assess the acceptability of certain disposal options. These evaluation procedures are described in the next chapter.

The basic disposal options for contaminated sediments consist of:

- **Unconfined aquatic disposal** — This option is usually reserved for uncontaminated sediments, but could also be applicable if the sediments could be rendered inert by treatment.
- **Benficial uses** —This option is applicable to minimally contaminated or uncontaminated sediments. Beneficial uses include beach nourishment and construction fill.
- **Confined aquatic disposal (CAD)** — This option consists of using clean sediments to cover over contaminated sediments that were disposed of at an aquatic site. This can include excavating an underwater pit in clean sediments, disposing of the contaminated sediments in the pit, and filling up the rest of the pit with a layer of clean sediment. This option is viable if the site is one of low energy so that the cap is not eroded. The cap has to be of sufficient thickness so as to prevent disturbance of the cap by burrowing aquatic organisms and possible contaminant migration through the cap. The possibility of contaminant migration into groundwater should be minimized.
- **Confined disposal facility (CDF) disposal** — This option consists of constructing an in-water dike to separate a portion of a nearshore area from surrounding waters. CDFs are frequently constructed with part of the perimeter being an existing breakwater or land area, although they are sometimes constructed to be man-made islands. Contaminated sediments are deposited within this diked area. The dike walls can be constructed of a variety of materials having different permeabilities. CDFs can lose contaminants through discharges through the dike walls or through supernatant-decanting weirs or discharge structures. These losses can be reduced through the use of liners or systems to collect and treat leachate (water within sediment interstices) and supernatant (water collected from above the settled sediments). CDFs may be suitable for moderately to highly contaminated sediments if the appropriate design features are incorporated to keep pollutant emissions to acceptably low rates.

- **Upland facilities** — This option consists of a disposal facility resembling a landfill or waste disposal facility. It can be constructed to various degrees of contaminant isolation through the use of different materials for the walls, using additional liners, installing leachate collection layers, etc. This option can be suitable for moderately to highly contaminated sediments if the appropriate design features are incorporated to keep pollutant emissions at acceptably low rates.

Chapter 2

Existing Decision-Making Procedures

Chapter 1 presented some of the relevant issues that need to be addressed in managing contaminated sediments. A contaminated sediments issues framework was used to structure the discussions. This chapter summarizes how these issues are being addressed under existing programs and what decision-making procedures and protocols are currently in use on the national and Regional levels. This chapter is organized according to the six broad categories of sediment management activities discussed in the preceding chapter.

Finding Contaminated Sediments

In general, regular monitoring and surveillance of sediment contamination is uncommon and potential sediment contamination problems are more frequently identified by other means. These means include reports of spills, discharge records, dredging records, fish kills, beach closings, previous site characterizations, etc. Information from any of these sources can provide evidence that a potential sediment problem may exist. Unfortunately, sources of these types do not generally provide information on trends in sediment contamination and several of them (such as fish kills and beach closings) indicate problems only after they have become severe. A regular program of surveillance and monitoring provides the most direct means for the early identification of potential sediment problems.

While regular monitoring of this type is not the norm, several regulatory frameworks currently have provisions which do call for sediment surveillance and monitoring.

Clean Water Act

§115 of the CWA directs the EPA to "identify the location of in-place pollutants with emphasis on toxic pollutants in harbors and navigable waterways..." and to act in conjunction with the COE to enact their removal and disposal. The $15 million designated for this purpose has never been appropriated to EPA. While the CWA does not preclude the identification of contaminated sediments in non-navigational waters, the emphasis on navigational waters is clear. Justification for the active identification of sediment contamination for other than navigational areas comes from general requirements to meet water quality standards including waters where contaminated sediments adversely affect environmental quality.

Within the CWA, special provisions are also made for toxic pollutant projects in the Hudson River and Chesapeake Bay, both of which authorize the identification of sediment-borne pollutants. For the Great Lakes region, §118(c)(1) of the CWA authorizes the Great Lakes National Program Office to carry out the U.S. responsibilities under the Great Lakes Water Quality Agreement and establish a basin-wide surveillance and monitoring system for toxic pollutants. Monitoring and surveillance of toxic sediments come within this scope.

Currently, most States conduct sediment monitoring only as part of special studies when contamination is already suspected. The most common trigger for initiating special sediment studies is the appearance of higher than background fish tissue contamination levels.

A few States have adopted regular sediment monitoring within their water quality monitoring programs. For example, New York has adopted a rotating basin intensive monitoring program of which sediment monitoring is a regular part. Several other States (e.g., Pennsylvania, Washington, and Michigan) are in the process of implementing similar programs.

Marine Protection, Research and Sanctuaries Act

Title II, §201 of MPRSA directs the Department of Commerce, the Treasury and the EPA, to conduct a continuing monitoring and research program for the purpose of determining the effects of dumping into marine coastal waters. §202 calls for the monitoring and research to assess the impact of all pollutants on marine environments.

The Office of Marine and Estuarine Protection (OMEP) uses a tiered approach to developing monitoring plans for specific sites (Fredette et al., 1986). In this approach, the expected severity of impacts determines the intensity of the necessary monitoring program. The Regions have responsibility for the development of site management/monitoring plans for individual dumpsites. Dumpsite monitoring activities are generally not delegated to the States. Dumpsites are typically monitored on an annual basis.

Resource Conservation and Recovery Act

RCRA permittees are generally required to identify past releases of contaminants. They may then be required to search for past and present contaminant releases, including those that have migrated beyond the facility boundary. Also, interim status facilities may be required to clean up contaminated sediments.

Comprehensive Environmental Response, Compensation, and Liability Act

Under Superfund, States and Regions identify sites with potential contamination problems for possible inclusion on the NPL. These sites are assessed to determine the extent of hazards. While not a direct monitoring program, these listings can provide first indications of possible sediment contamination.

Great Lakes Water Quality Agreement

The Great Lakes Water Quality Agreement (GLWQA), Annex 11, calls for the monitoring of all inputs, outputs and transformations within the Great Lakes system. This includes the monitoring of sediments. It should be noted that the GLWQA itself is not legally binding. However, §118 of the CWA gives EPA responsibility for overseeing U.S. progress in attaining the goals embodied in the GLWQA.

The GLWQA calls for monitoring to be performed to fulfill three major goals:

- **Ambient Monitoring** — Used to establish the baseline of sediment quality and how it changes over time. This can be used to indicate the relative importance of sediment contamination vs. other system inputs.
- **Assessment Monitoring** — Used on a project-specific basis to determine compliance with existing regulatory programs and to determine the need for taking remedial actions.
- **Research Monitoring** — Used for the identification of emerging problems, the development of standard protocols and the development of quality assurance/quality control procedures.

Both ambient monitoring and research monitoring can be used in the identification of new problem areas.

Puget Sound Estuary Program and Puget Sound Dredged Disposal Analysis

Monitoring within the Puget Sound area is performed under two programs. Under Puget Sound Dredged Disposal Analysis (PSDDA), dumpsites approved for dredged material disposal and navigable waterways are monitored. Under the Puget Sound Estuary Program (PSEP), monitoring of other areas is performed usually as part of special case studies.

The State of Washington is currently in the process of developing a database of sediment monitoring data for the Sound including the PSEP and PSDDA data as well as data collected as part of Superfund site projects within the Sound.

Assessment Options

As mentioned previously, present sediment assessment decision-making protocols and procedures are well developed for dredging-related projects but are generally poorly developed for other kinds of contaminated sediments situations.

The majority of the assessment protocols presented in this section were developed specifically for testing related to dredged material disposal under MPRSA §103 and CWA §404. Under MPRSA, a general testing framework for dredged material has been developed and a similar framework is under development under CWA. Furthermore, several of the Regions have developed Region-specific protocols for use within these frameworks.

In Region X, the State of Washington is developing State sediment management standards and dredged material management standards which will guide dredging activities, discharge permit development, and remediation of sediments. These standards describe narrative processes for testing and evaluating each program activity, and also contain numeric sediment values as screening and trigger levels for further study or action (including biological testing). These sediment quality criteria were developed largely using the apparent effects threshold (AET) approach and include values generated by the equilibrium partitioning (EqP) approach. (AETs are also being developed for San Francisco Bay the Southern California coastline, and portions of the Great Lakes.) Because AETs are derived from empirical data, these values are highly specific to a locale and should not be used on a broad basis. Regional screening levels are being developed by Region X for dredged material management. Several states, such as Wisconsin and California, are also in the process of developing sediment quality criteria. National criteria are under development by the EPA Office of Water Regulations and Standards.

Under the GLWQA, the Sediment Subcommittee of the International Joint Commission (IJC) has developed a method of sediment assessment aimed toward sediment contamination problems associated with Great Lakes Areas of Concern (AOC). AOCs are contamination "hotspots" located within the Great Lakes Basin which have been given first priority for cleanup. Of the 42 identified AOCs cited by the IJC, 41 have associated sediment contamination problems.

Comprehensive Environmental Response, Compensation and Liability Act

Assessment and remediation of sediments at Superfund sites is carried out on a site-specific, case-by-case basis. The Office of Emergency and Remedial Response (OERR), which is responsible for Superfund activities, employs a risk analysis-based strategy in which the potential for environmental and human health impacts is assessed. A 1989 analysis of a preliminary OERR study suggests that 24% of the 1,175 NPL sites may have contaminated sediments. A subsequent evaluation of Records of Decision (RODs) for 486 Superfund sites identified 69 sites with contaminated sediments. The ROD

is the official description of the selected remediation alternative for a site including a discussion of the reasoning behind the alternative selection.

As part of the process of nominating sites to Superfund's National Priorities List (NPL), initial site assessments are conducted on sites where a problem is suspected. Results from the initial site assessment are used to determine a Hazard Ranking System (HRS) score. States, or EPA itself, collect information on sites for scoring by EPA under the HRS. HRS scores are used by EPA to determine which sites should be placed on Superfund's NPL as priorities for cleanup funds and for more detailed evaluations.

The HRS is a detailed, systematic scoring system for estimating the level of danger to human health or the environment resulting from a given contaminated site. Individual scores are assigned for each of four exposure pathways: surface water, groundwater, soil exposure, and air.

Within each of these pathways, three factors are considered: likelihood of release, waste characteristics, and targets. The HRS provides numerous tables which give specific values to be assigned for individual factors according to the magnitude of various affecting sub-factors (e.g., annual rainfall, container type, substrate type, chemical persistence, number of drums, distance to nearest well, etc.).

The HRS, as recently revised, evaluates both human health and ecological impacts due to contaminated sediment exposures. Human health impacts from contaminated sediments occur through the transfer of chemicals from sediments into fish and wildlife which are then consumed by humans.

The summation of each of the factors are combined to provide scores for the four exposure pathways above which are then normalized on a 0 to 100 scale. The final score is the mean of the scores from the four pathways.

For sites on the NPL, EPA then carries out a detailed analysis of the risks posed by the site to human health and the environment and the feasibility of various remedial action alternatives to reduce the risk. The analysis is carried out through the preparation of a Remedial Investigation/Feasibility Study (RI/FS). The document *Risk Assessment Guidance for Superfund, Volume II - Environmental Evaluation Manual* (USEPA, 1989d) presents a broad framework for the assessment of human health and environmental impacts (Figure 3). This strategy is not designed specifically for sediments but, rather, is created for the purpose of assessing all exposure routes from contamination at Superfund sites (which may or may not include sediments). Another guidance document pertaining to Superfund's risk assessment process is *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (USEPA, 1988c).

The first step of the process consists of identifying the contaminants of concern. Contaminants are divided into three non-mutually exclusive categories depending on whether they pose a threat to humans, the environment, or both. The second step quantifies the releases of the contaminants and determines their migration paths and fates by use of fate and transport models and direct measurements of environmental concentrations. The third step consists of the identification of the rates of exposure, again divided into categories dependent upon the potential impacts. Finally, health and ecological effects studies are undertaken so that a final evaluation of impacts can be made.

Under CERCLA, Superfund remedial action must meet any Federal standards, requirements, criteria, or limitations that are determined to be legally applicable or relevant and appropriate requirements (ARARs). Water quality criteria established under §304 or §303 of the CWA should be attained by cleanup where the criteria are relevant and appropriate. If sediment quality criteria are promulgated and enforceable and meet all requirements of CERCLA and the National Contingency Plan, then they can be considered as ARARs. Testing requirements mandated by the CWA §404 and MPRSA §103 regulations could also serve as ARARs. If no ARARs exist for a particular contaminant, site-specific levels are developed from risk assessments or guidance documents.

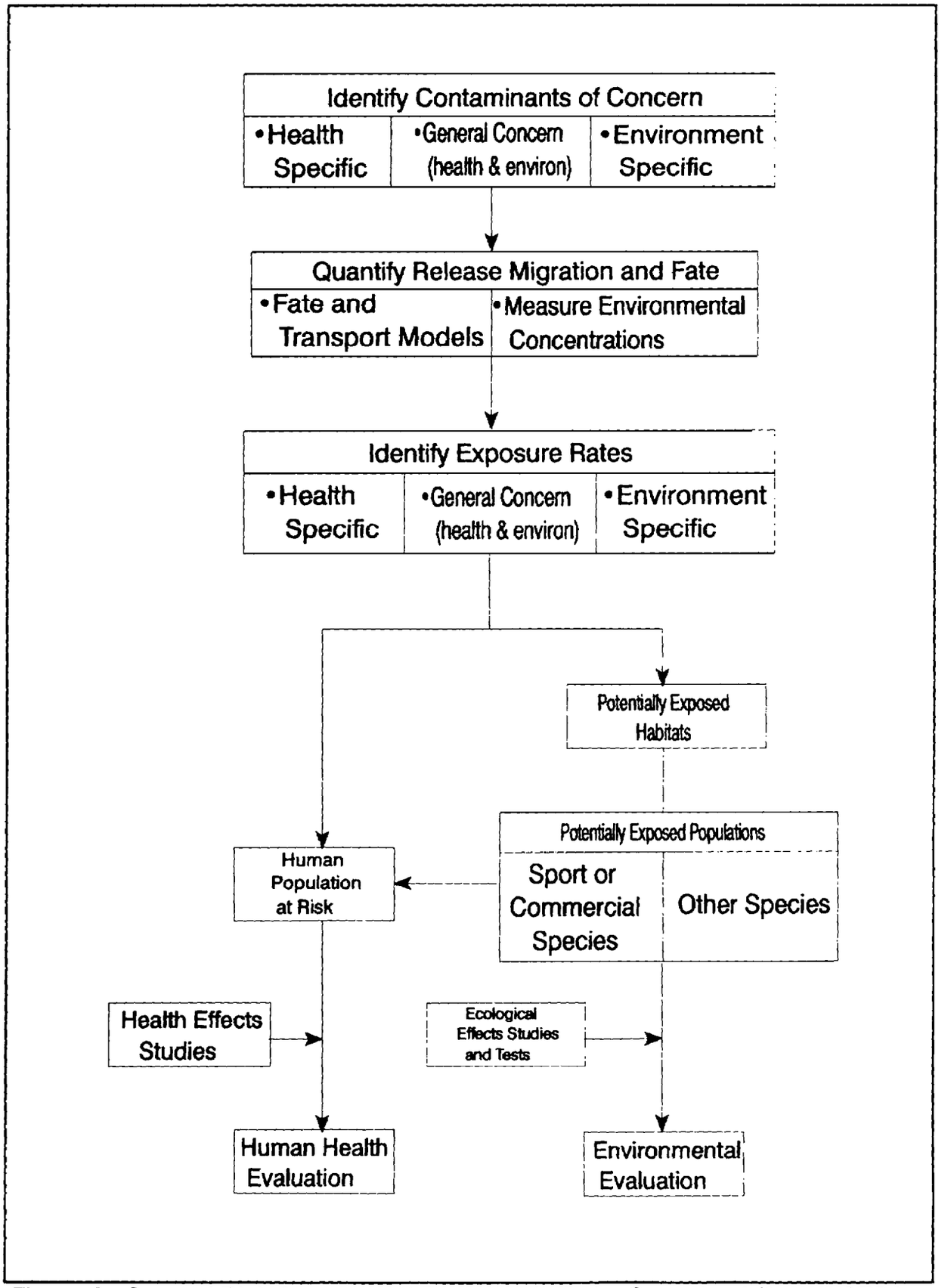

Figure 3. General Risk Assessment Framework Under Superfund (from USEPA, 1989d).

Interim sediment quality criteria for some non-ionic organic pollutants, derived from water quality criteria using the equilibrium partitioning approach, were used at the Sullivan's Ledge Superfund site in Massachusetts to identify contaminated locations and the areal distribution of contamination for possible remedial action. At New Bedford Harbor, Massachusetts, risk assessments were performed based on sediment pore water concentrations of PCBs. At Waukegan Harbor, Illinois, modelled losses of PCBs to Lake Michigan under various cleanup options were used to determine the cleanup level. In Commencement Bay, Washington, sediment quality values derived from the AET approach (USEPA, 1989c), in conjunction with site-specific biological effects data, were used to determine cleanup goals.

Marine Protection, Research, and Sanctuaries Act

Although the assessment protocol developed under MPRSA §103 is specifically for assessing dredged materials for ocean dumping, it is a strategy with possibilities for broader application.

Permits for the ocean dumping of dredged material issued by the COE are reviewed by the EPA according to several environmental criteria and either approved or denied by the EPA. These criteria have been codified in the Ocean Dumping Regulations (40 CFR 220-228), and EPA and the COE have jointly developed a tiered protocol to determine whether dredged material from a particular project meets the criteria. The protocol is presented in the Office of Marine and Estuarine Protection document *Draft Ecological Evaluation of Proposed Discharge of Dredged Material into Ocean Waters* (the "Green Book") (USEPA, 1990b). The draft protocol consists of four tiers. At each successive tier, the level of effort involved is more intensive in both time and effort. However, the ability of successive tests to provide definitive information for permitting decisions is greater.

Emphasis is placed in the protocol on evaluative techniques such as toxicity tests (bioassays) and bioassessments, which are used as surrogates for potential environmental impact. Separate testing schemes are required at each tier for benthic and water column biota. The general protocol is presented in Figure 4.

At each of the first three tiers, three outcomes of the testing are possible:

- Information derived from testing is sufficient to conclude that proposed dumping is impermissible without management action,
- Information from testing is adequate to conclude that proposed dumping is permissible provided that all other aspects of the Ocean Dumping Regulations and other pertinent regulations are met, or
- Information from testing is inadequate to make a decision and further testing is required at the next tier.

At the fourth tier, only the first two outcomes are possible.

The first tier has two objectives: to attempt to make a decision on compliance using only existing information, and to identify contaminants of concern for the dredged material.

In the evaluation of existing information on the sediments, the following factors are considered to increase the likelihood that a sediment will be acceptable for open-water disposal:

- It is composed predominantly of sand, gravel, rock, or other natural bottom material with particle sizes greater than silt,
- It is found in areas of high current or wave energy,
- It is composed of grain sizes compatible with the material at the proposed disposal site,

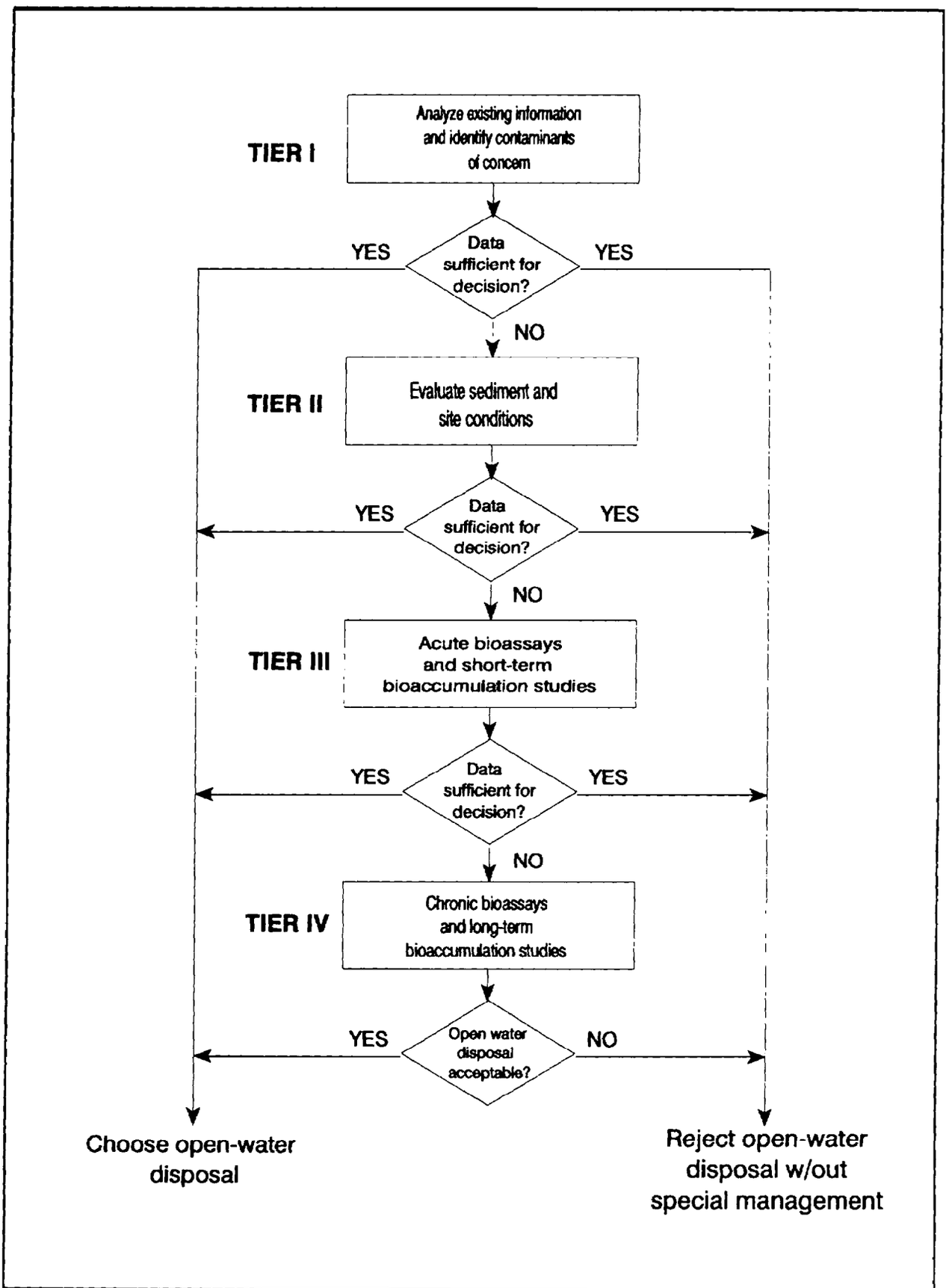

Figure 4. Dredged Material Testing Framework Under MPRSA.

- The dredging project is isolated from known or suspected, current or historical contaminant sources.

If the converse of these are true (i.e., a fine material close to a contaminant source), then the acceptability of open-water disposal is less likely. Situations between the two may require testing at the next tier.

Identification of contaminants of concern must be accomplished on a case-by-case basis. The process begins with an examination of existing information which may aid in their identification. Such information can consist of previous dredging records, field studies, various toxicity and environmental data bases, spill records, etc. The more complete the information, the more likely that a regulatory decision can be made at the first tier. Initial testing for the presence and concentrations of contaminants within the sediments may be done to augment the information acquired from existing sources.

Contaminants of concern are then identified on the basis of:

- Presence in the dredged material,
- Concentration in the sediments relative to background concentrations,
- Toxicological importance,
- Tendency to persist in the environment,
- Potential for bioaccumulation.

Tier II consists of an evaluation of the chemical and physical characteristics of the dredged material and the overall environmental conditions at the site. Water column impacts are evaluated by comparison of dissolved contaminant concentrations after initial mixing with the applicable water quality criteria. If water quality criteria are not available or if synergistic effects among several chemicals are suspected, then toxicity testing at Tier III is necessary, as explained in 40 CFR 227.13. Evaluation of benthic impacts is less straightforward at Tier II. Bioavailability of non-polar organic contaminants is evaluated on the basis of theoretical bioaccumulation potential (TBP) and/or sediment quality criteria, when they are promulgated in the Federal Register. However, this type of calculation cannot be performed for some types of contaminants (e.g., polar organics, metals, organometals, etc.). Bioaccumulation of contaminants by benthic organisms must be evaluated at Tiers III and/or IV if:

- Any of the contaminants of concern is other than a non-polar organic contaminant for which calculation of TBP is not valid,

OR

- All contaminants of concern are non-polar organic in nature but TBP values calculated exceed those for the reference sediment.

Testing at Tier II will either be adequate to make a regulatory decision or may indicate the need for additional testing at Tier III.

Tier III evaluations consist of acute bioassays and bioaccumulation tests on appropriate sensitive organisms to determine the likelihood of adverse environmental impacts. Results are compared to those from identical tests run with reference sediments. For the bioassays, mortality is taken as the biological endpoint due to ease of interpretation. Benthic bioassays are conducted using site sediments and representative benthic organisms. Water column assays are performed with appropriate water column organisms.

Benthic bioaccumulation studies are performed over 10-day (for metals) and/or 28-day (for other contaminants) periods. Tissue concentrations are compared to two endpoints:

- FDA Action Limits for Poisonous and Deleterious Substances in Fish and Shellfish for Human Consumption (protective only of human health from fish consumption),
- Tissue concentrations of organisms similarly exposed to reference sediments.

If FDA limits are exceeded, the dredged material does not comply with the bioaccumulation aspects of the benthic criteria in 40 CFR 227.13. The decision of whether such material might be allowable for ocean disposal under MPRSA is beyond the scope of the Green Book.

If FDA limits are not exceeded, then comparison is made with reference tissue concentrations. If reference tissue concentrations are not statistically exceeded, the dredged material complies with the bioaccumulation aspects of the benthic criteria and the material can be considered for ocean disposal (given that benthic toxicity effects and potential water column impacts have also been considered). If the reference tissue concentrations are statistically exceeded, case-specific criteria should be developed by the local COE and EPA authorities which account for case-specific factors. These factors include and are affected by the number of organisms which are affected, the propensity for the chemical to bioaccumulate, the number of chemicals which bioaccumulate, the magnitude with which bioaccumulation exceeds reference bioaccumulation, etc. Based upon consideration of these factors, one of the following decisions is reached:

- The dredged material complies with the case-specific criteria and ocean disposal is acceptable if toxicity and water column tests are also passed, or
- The available information is insufficient to determine compliance with the bioaccumulation aspect of the benthic criteria.

Insufficient information to make a regulatory decision indicates that testing at the fourth and final tier is required.

Tier IV testing continues and augments bioassays and bioaccumulation studies conducted at Tier III. Whereas the 10- to 28-day studies conducted under Tier III may not be of sufficient duration to reflect steady-state conditions (e.g., they may only reflect initial tissue concentrations), Tier IV tests are designed to reflect long-term exposures of the most sensitive organisms to the expected site conditions using the most sensitive indicators (e.g., reproduction, survival, etc.). Design of Tier IV bioassays is project-specific, depending upon the nature of the material, the organisms present and the contaminants of concern.

Bioaccumulation studies at Tier IV are likewise designed to reflect steady-state conditions. Samples can be collected from laboratory specimens exposed to the dredged material or from specimens collected in the field, if appropriate (field collected organisms are those collected in the vicinity of the proposed disposal site). Tissue concentrations are compared successively to three endpoints:

- FDA Action Limits (as described above),
- Tissue concentrations from reference material, or
- Tissue concentrations from field collected benthic organisms.

If FDA limits are exceeded, the dredged material does not comply with the bioaccumulation aspects of the benthic criteria in 40 CFR 227.13. The decision of whether such material might be allowable for ocean disposal under MPRSA is beyond the scope of the Green Book. Non-exceedence of FDA action limits leads to comparison with reference tissue concentrations. Non-exceedence of reference tissue

concentrations is considered compliance with benthic criteria and the material can be considered for ocean disposal (given that benthic toxicity effects and potential water column impacts have also been considered). If reference tissue concentrations are exceeded, then comparison with field tissue concentrations is required. If field tissue concentrations are not exceeded, then the material can be considered for ocean disposal. If the material is in exceedence, then the results of bioaccumulation and bioassay testing are weighed considering the following factors:

- The number of species for which criteria are exceeded,
- The number of contaminants for which criteria are exceeded,
- The magnitude of exceedence of reference concentrations,
- The toxicological importance of the contaminants,
- The diversity of the species for which criteria are exceeded,
- The propensity for contaminants to biomagnify.

After the weight of these factors is considered, one of the following decisions must be reached:

- The dredged material complies with the criteria of §227.13(c), or
- The dredged material does not comply with the criteria of §227.13(c).

Clean Water Act

The Office of Wetlands Protection (OWP) oversees the CWA §404 program which regulates the discharge of dredged or fill material in §404 waters. Currently, there is no broadly applied analog to the Green Book for MPRSA decisions. Evaluations are handled on a case-by-case basis. However, COE and OWP are currently in the process of developing a §404 testing manual for dredged material (§404 Testing Manual) which will use the same tiered testing strategy as the Green Book with appropriate testing procedures for §404 waters.

The current national guidance for §404 testing procedures is contained in the §404(b)(1) guidelines. These guidelines provide only a general framework under which testing is to be performed. Several Regions have developed guidance for use within their jurisdictions (i.e., Regions I, V, IX and X). The Regions' guidances are in various stages of implementation. The Regional guidance documents generally follow the pattern of the Green Book with modifications for freshwater systems and local biota and chemicals of concern.

Subpart G of the §404(b)(1) guidelines sets forth the following steps in the evaluation process:

1. **General Evaluation of the Material** — This step examines existing information (i.e., records of spills, discharge records, fish tissue contamination, etc.) and general material characteristics (i.e., grain size, relative carbon content, etc.) to determine if there is "reason to believe" that the material needs to be tested for potential adverse effects.
2. **Chemical and Biological Testing** — If the first step indicates possible contamination, then further chemical and biological testing may be carried out. This includes chemical characterization of the sediment, water column effects (elutriate) testing, and benthic effects testing. Under some circumstances, benthic community structure analyses of the dredging and disposal sites may be required.

3. **Evaluation of Physical Effects** — This step examines the possibility that the placement of the dredged material may affect the physical and biological environment of the dumpsite. This includes changes in the substrate, hydrology, salinity, etc.

Under the §404 program, unlike the ocean dumping program, discharge sites for dredged material are specified on a project- or permit-specific basis. As with the assessment of dredged material, the evaluation of the impacts on the discharge site are done in accordance with the requirements of the §404(b)(1) Guidelines. One of the primary requirements of the Guidelines is that no discharge can be permitted if there is a practicable alternative with less adverse impact on the aquatic environment (unless the identified alternative poses significant environmental problems). In addition, no discharge can be permitted under the Guidelines if it: violates State water quality standards; violates toxic effluent standards; jeopardizes the continued existence of an endangered species; or violates any requirements enacted to protect any federally-designated marine sanctuary. Discharges are also not in compliance with the Guidelines if they will cause or contribute to significant degradation of the waters of the U.S. Finally, the Guidelines require that all appropriate and practicable measures to minimize potential harm to the aquatic ecosystem be taken.

Region I Testing Guidance under CWA §404 and MPRSA §103

Regional guidance which supersedes the Green Book has been developed by Region I EPA in conjunction with the New England Division of COE. The document, *Guidance for Performing Tests on Dredged Material to be Disposed of in Open Waters*, uses the tiered strategy of the Green Book but specifies the selection of appropriate bioassay organisms and chemical analytes.

This document is important in that, unlike the Green Book, it applies to both MPRSA §103 and CWA §404 waters. The document was developed with the full cooperation of New England COE aided by the National Marine Fisheries Service and the U.S. Fish and Wildlife Service.

Within the document, Region-specific protocols are given for:

- Selection of sampling sites for dredged, reference, and control sediments,
- Specific requirements for physical and bulk chemical analysis of sediments including a list of chemicals of concern and analytical detection limits,
- Tiered evaluation testing requirements consisting of:
  - A liquid phase assay,
  - A suspended particulate assay,
  - A whole sediment assay, and
  - Bioaccumulation analysis,
- Elutriate testing procedures, and
- A set of quality assurance procedures for all of the above activities.

Open water disposal at Regional disposal sites (of which there are 13) is overseen by the Region I Marine and Estuarine Protection Section. All other dredge and fill activities are overseen by the Region I Wetlands Protection Section.

Region IX Testing Guidance under MPRSA §103

Region IX, in cooperation with COE, has issued specific guidance for dredged material testing in the document *EPA Region 9 General Requirements for Sediment Testing of Dredged Material Proposed for Ocean Dumping*. This guidance became effective in August 1989.

The guidance is largely similar to that issued by Region I in its scope but differs in the specific chemicals of concern and bioassay species which are recommended for testing. Again, the guidance utilizes the Green Book's tiered strategy.

Region V Draft Interim Testing Strategy for Navigational Dredging

The EPA Region V Environmental Review Branch, in conjunction with Great Lakes COE district offices, has produced interim guidance for sampling and testing efforts related to navigational maintenance dredging under CWA §404 (USEPA, 1988b). This strategy is being developed as guidance for compliance with NEPA and other environmental regulations, as well as CWA §404. The guidance is in interim form and the COE currently has the option of choosing whether or not to follow it. Region V currently works on a case-by-case basis and may or may not require that the procedures in the guidance be used and may also use the IJC *Guidelines and Register for Evaluation of Great Lakes Dredging Projects* (IJC, 1982) as part of the approach (see "IJC Dredging Guidelines" later in this chapter in section on disposal). The interim testing guidance uses a combination of chemical and biological tests (Figure 5).

The guidance divides the process of testing into five basic stages:

- **Pre-design stage** — This stage consists of the collection of relevant historical information on the dredging project and the "initial delineation" of sediments within the dredging project area into three categories based on the probable extent and severity of contamination. The three categories are:
  - **Type I** — Sediments with a very low probability of contamination problems which are generally coarse-grained and located well away from contamination sources.
  - **Type II** — Sediments which are in the transition zone between Type I and III sediments and for which the level and extent of contamination is not clear based on initial information (the so-called "gray area").
  - **Type III** — Sediments which are known to be heavily contaminated based on historical data. These are generally fine sediments located in close proximity to contamination sources.
- **Preliminary design stage** — This stage consists of the design of a sampling and testing strategy based upon the results of the first stage analysis. Emphasis is placed on the characterization of Type II sediments.
- **Final design stage** — The preliminary design is put through a regulatory review for possible revisions. This review must precede the execution of any part of the actual sampling and testing.
- **Execution** — The sampling plan and testing are implemented following procedures and protocols outlined in the guidance document.
- **Reporting of data** — Again, specific protocols and procedures are presented for the reporting of sampling and testing results.

Region X/Puget Sound Dredged Disposal Analysis

The Puget Sound Dredged Disposal Analysis (PSDDA) was developed in a comprehensive interagency effort that began in 1985 and was completed in 1990 (PSDDA, 1989a and 1989b). PSDDA's

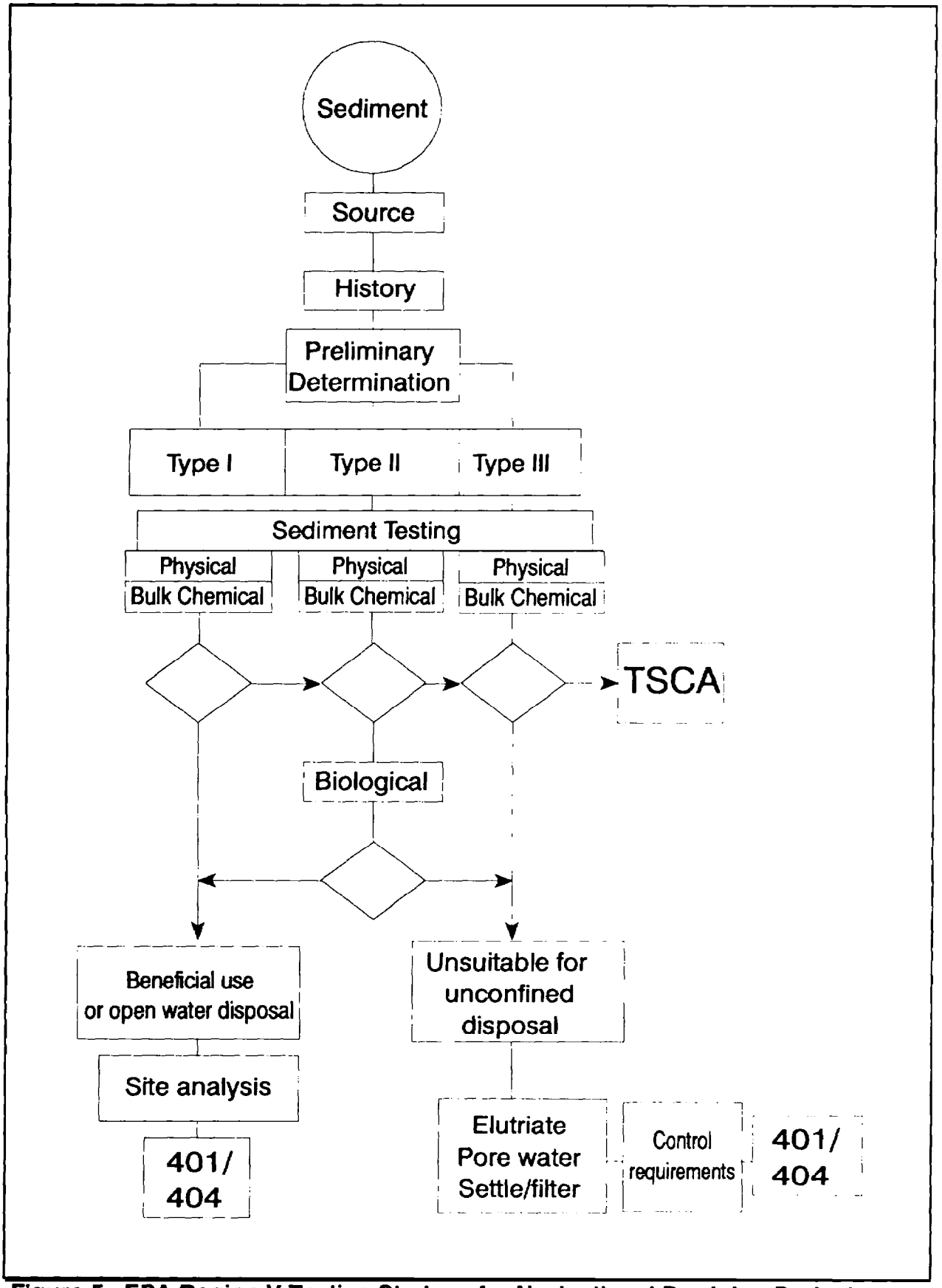

Figure 5. EPA Region V Testing Strategy for Navigational Dredging Projects (from USEPA, 1988b).

focus was on identifying and managing disposal sites and developing evaluation procedures to determine suitability for unconfined, open-water disposal of sediments dredged from federal and non-federal navigation projects throughout the Sound. It was developed as a site-specific application of the COE strategy (which is described in the section of this chapter on disposal) that incorporates the requirements of the CWA §404(b)(1) guidelines and general and specific criteria of the MPRSA guidelines. Procedures for regulating/managing sediments that are unsuitable for open-water disposal are currently under development.

PSDDA describes comprehensive evaluation and monitoring requirements. Both are basically tiered systems like the MPRSA (USEPA, 1990b) and IJC (IJC, 1982) protocols and are concerned with managing the "effects" of chemical contamination rather than the presence of contaminants. It is the PSDDA evaluation procedures for determining the acceptability of dredged material for open-water disposal that have received the most attention. The procedures address sampling requirements, chemical and biological testing, test interpretation, and disposal guidelines. PSDDA's testing and decision framework is shown in Figure 6.

A tiered testing approach was adopted by the PSDDA agencies. Tier I is a "reason to believe" review of the existing data looking for evidence of contamination. Tier II includes chemical testing of sediments for 58 chemicals of concern. Sediment concentrations of these chemicals are compared to screening levels (SLs) and maximum levels (MLs) for each contaminant. Concentrations below the SL indicate that open-water disposal is acceptable. Concentrations above the ML indicate that open-water disposal is unacceptable. Concentrations between the two require biological testing at Tier III using a prescribed battery of tests including acute toxicity and, if necessary, bioaccumulation tests. Tier IV tests are possible when concentrations exceed MLs but tests for this Tier have not yet been fully defined.

SLs and MLs are derived primarily from AET values, but also include EqP derived values (PSDDA, 1989b). AET values are derived using matched chemical and biological data from selected reference (uncontaminated) sites and a series of contaminated sites. For each constituent of interest, the AET is determined as the highest sediment concentration that is not associated with a statistically significant difference in one or more biological parameters (e.g., total abundance, diversity, sediment toxicity) between reference and contaminated sites. However, the AET values that have been calculated for the Puget Sound area are location-specific, and according to EPA's Science Advisory Board, should not be used as National sediment quality criteria (USEPA, 1989e).

Other Regions

Other Regions which have developed their own testing guidance use a variety of approaches. Most of these approaches use the Green Book as a starting point. The following Regions are presented as examples of typical programs.

Region II has no Regional protocols for testing under the Green Book. In MPRSA §103 waters, the 1977 Green Book is applied awaiting finalization of the current draft. In CWA §404 waters, the §404(b)(1) guidelines are used, except in the Great Lakes where a combination of the reference approach found in the EPA Region V document *Guidelines for the Pollutional Classification of Great Lakes Harbor Sediments* (USEPA, 1977) and the approach found in the IJC's *Guidelines and Register for Evaluation of Great Lakes Dredging Projects* (IJC, 1982) are utilized.

Region III applies the Green Book to ocean dumping activities. Sediment assessments for §404 waters are performed using the Extraction Procedure (EP) toxicity test, and other tests as necessary, in addition to the §404(b)(1) Guidelines' requirements.

Region IV applies the Green Book in its ocean dumping program and loosely applies the Green Book approach to §404 waters. For the Ohio River in Kentucky, a set of guidelines known as the

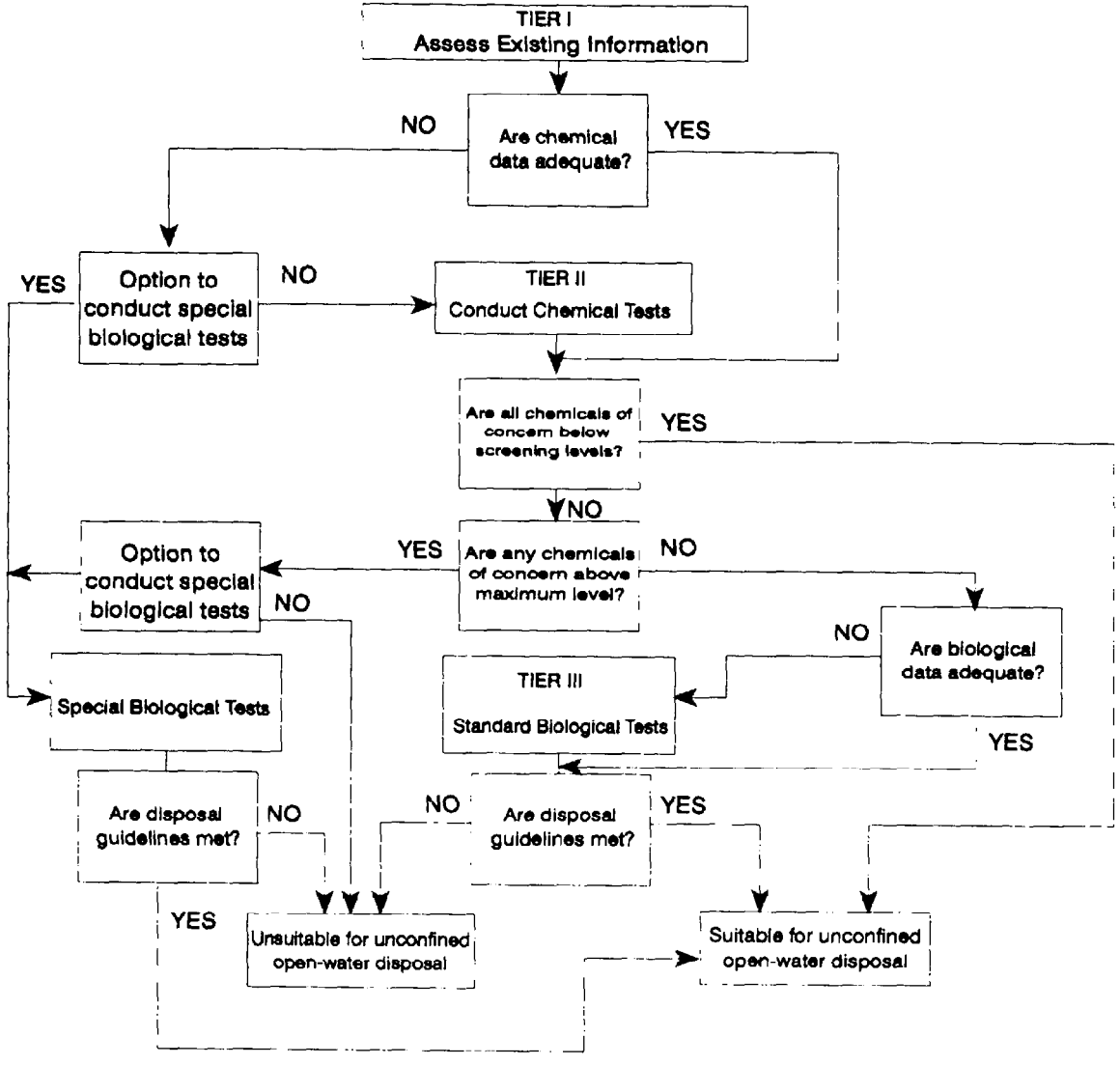

Figure 6. Dredged Material Testing Sequence Under PSDDA (after PSDDA, 1989b).

"Louisville Guidance" has been developed based on an approach borrowed from the Region V *Guidelines for the Pollutional Classification of Great Lakes Harbor Sediments* (USEPA, 1977), which is a reference approach.

Region VII contains no coastal States and is, therefore, not affected by MPRSA regulations. All dredge and fill reviews are managed under CWA §404(b)(1) guidance with no specific Regional guidance as exists in some other Regions.

IJC Sediment Subcommittee Sediment Assessment Strategy

Although this sediment assessment approach is not currently used within EPA, it deserves note as one of the few well developed assessment schemes that are aimed specifically at contaminated sediments outside the navigational dredging context.

The sediment assessment approach proposed by the IJC Sediment Subcommittee in the document *Procedures for the Assessment of Contaminated Sediment Problems in the Great Lakes* (IJC, 1988a) is basically a multi-pronged approach designed for use in fairly large-scale remediation projects where the remediation costs and effort are expected to be relatively high, thereby justifying a comprehensive evaluation. Chemistry, toxicity, and infaunal community structure form the basis of a three-pronged evaluation approach.

The strategy is implemented in two stages (Figure 7):

- **Stage I: Initial Assessment** — Only *in situ* methods are employed. These include a limited physical description of sediments, bulk chemical analyses (nutrients, metals, persistent organics, etc.), carp and benthos contaminant body burdens and external abnormalities, and benthic community structure (qualitative estimates at the family level).

The criteria for passing to the next phase include any one of the following:

  - Sediment metals concentrations exceed background levels,
  - Concentrations of persistent organics are above detection levels in sediments or fish and benthos tissues,
  - Absence of a healthy benthic community,
  - Presence of external abnormalities on fish.

- **Stage II: Detailed Assessment** — Stage II is conducted in four phases. The information for each previous phase should be used to guide and limit the requirements for the succeeding phases. None of the phases should be skipped and all tests should be completed, although their extent may be limited by the results of previous ones.
  - **Phase 1** — A 3-dimensional map of the study area is created so that depositional areas and areas of homogeneous sediment characteristics can be mapped to guide further sampling.
  - **Phase 2** — A more detailed collection of benthic fauna is made along with detailed measurements of surficial chemistry.
  - **Phase 3** — Surficial sediments, sediment cores, and indigenous fish are collected from sites which are shown to be impacted from the results of Phase 1 and 2 tests. Bioassays are conducted using the sediment samples, and detailed chemical characterizations of the sediments are made. Detailed histopathologic examinations are made on fish, focusing on liver tissues.

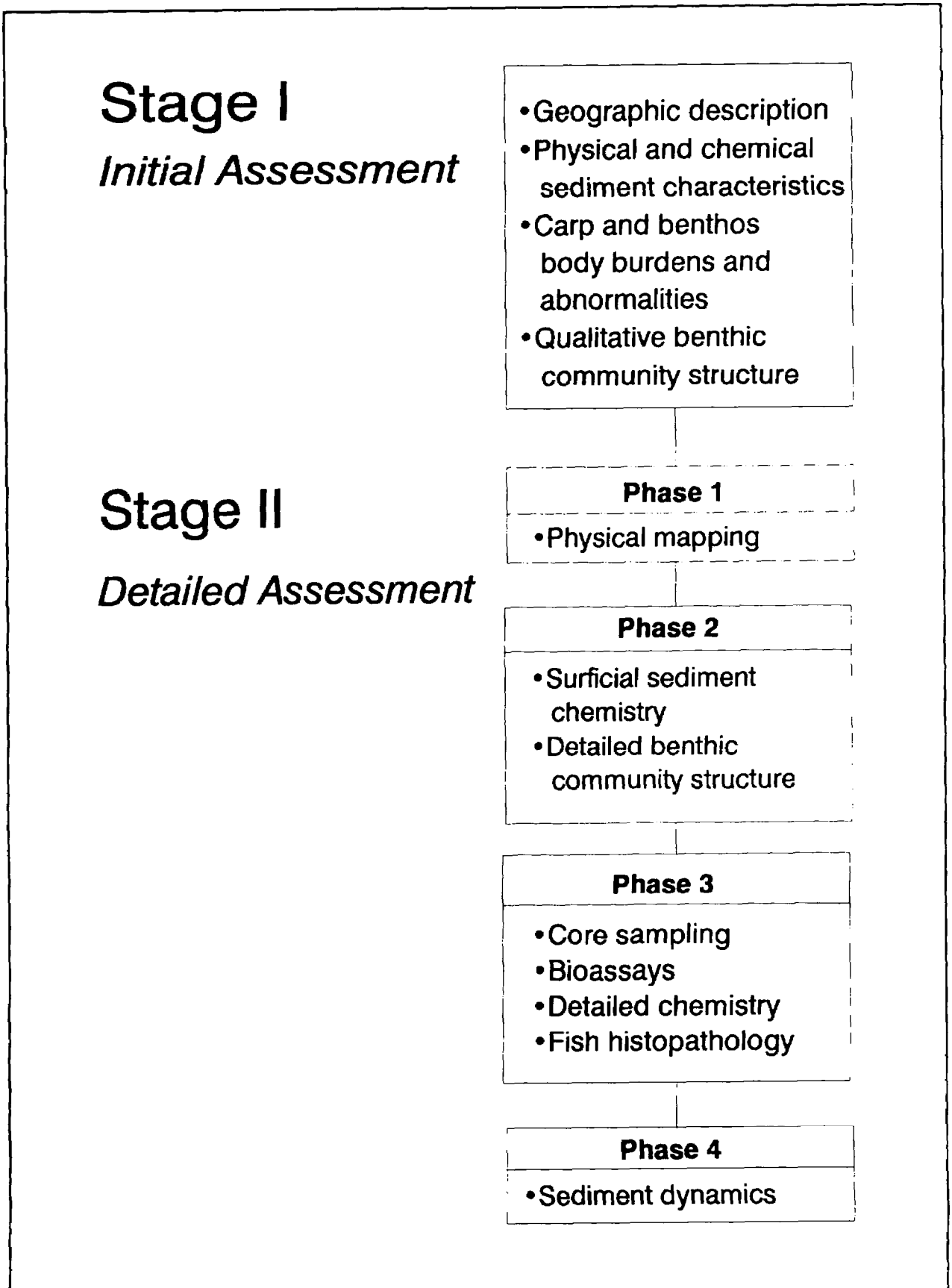

Figure 7. IJC Sediment Subcommittee Sediment Assessment Strategy. (IJC, 1988a)

- **Phase 4** — Sediment dynamics are studied in detail to determine the potential impacts of sediment resuspension, movement to other areas and redistribution of contaminants through the water column. This information is considered essential for the development of remedial action plans

Prevention and Source Controls

At the national or regional level, sediment contamination can be controlled only by the wide-spread application of one of two basic types of restrictions:

- Restrictions on the production, distribution, or use of a chemical, or
- Restrictions on the amounts of a chemical that can be released to the environment.

The first restriction applies primarily to chemicals that are produced for a certain use, while the second applies primarily to by-products or wastes of production or use. By judicious applications of these restrictions, EPA can achieve considerable control over contaminants that are or have the potential to be ubiquitously distributed. This then leaves individual contaminated sites to be dealt with.

On a local or site-specific basis, however, specific actions can be taken to deal with particular sites. It is for these situations that most of the criteria and procedures have been developed.

National or Regional Scale

On the national or regional scale, four laws and an international agreement have provisions for controlling sediment contamination: TSCA, FIFRA, CWA, CAA and the GLWQA. The first two laws are concerned primarily with the production and use of particular chemicals, the latter two with wastes or by-products released to the environment. The GLWQA has provisions addressing all aspects of environmental quality in the Great Lakes. The major provisions, criteria, and procedures that can be used in the control of sediment-related contaminants are described below.

Toxic Substances Control Act

One of the most powerful authorities for regulating toxic substances in contaminated sediments is found in §6 of TSCA. Under this Section, EPA can prohibit or limit the production and distribution of any chemical substance or mixture if it poses or could pose an unreasonable risk of injury to health or the environment. Actions taken under this section include the ban on production of polychlorinated biphenyls (PCBs), a wide-spread chemical contaminant (e.g., in Great Lakes and Hudson River sediments). Sediment contamination was not one of the major considerations in banning the production of PCBs, but the effects of sediment contamination were considered.

There are no uniform criteria or methods under TSCA that are applied to determine when unreasonable risk of injury to health or the environment has occurred or might occur. On a chemical-by-chemical basis, EPA makes a decision based on a wide variety of considerations including the chemical's use, distribution in the environment, persistence, toxicity and other factors. TSCA testing procedures are being revised to include three tests with exposures through sediments: a 30-day tadpole subchronic toxicity test, a 14-day chironomid toxicity and bioaccumulation test, and a site-specific aquatic microcosm test which includes natural sediments. Once a decision is made, based on the weight of evidence from all sources, procedural regulations require that a Notice of Proposed Rulemaking be published in the Federal Register so that public comments can be received prior to taking action. In extreme cases, however, public notice is not required.

Federal Insecticide, Fungicide, and Rodenticide Act

All uses of biocides are regulated by the EPA under FIFRA. Before a pesticide can be sold in the U.S., it must be reviewed and registered by EPA for one or more specific uses, such as a fungicide, herbicide or disinfectant. The registration process is the method by which EPA examines data regarding a chemical's toxicity to humans and non-target plants and animals, efficacy, and environmental fate to determine the need for restrictions governing the chemical's use and disposal. EPA must examine not only the characteristics of the chemical itself, but also the characteristics of the product's other ingredients, impurities, metabolites and degradation products.

The Office of Pesticide Programs (OPP) uses the procedure outlined in the document *Hazard Evaluation Division, Standard Evaluation Procedure: Ecological Risk Assessment* (USEPA, 1986) (also known as SEP). In general, the assessments follow these four steps:

1. Review of Toxicological Hazard Data — The nature of possible hazards is determined by examining available laboratory and field toxicological data (e.g., LC_{50}s,NOELs).
2. Determine Dose/Response Relationships — Quantitative relationships are determined between dose and response, commonly involving the use of safety factors.
3. Determine Possible Exposure Levels — This includes rate governing factors such as intensity, frequency, and duration of exposure.
4. Estimate Risk Probability — The above data is combined to produce an estimate of the probability of hazardous exposures of organisms to the chemical in the environment under the given exposure conditions.

Based upon the analysis, the Ecological Effects Branch (EEB) issues a statement assessing the ecological risk from the use of the pesticide and recommends one of several regulatory actions:

- Require additional data,
- Require restricted use classification to reduce risk,
- Require use restrictions on label,
- Initiate special reviews based on risk criteria, or
- Recommend against registration.

In those cases where an endangered species is indicated as one of the species at risk, the EEB consults with the National Marine Fisheries Service (NMFS) or the appropriate Region of the U.S. Fish and Wildlife Service (USFWS). USFWS and/or NMFS then supplies an opinion, based upon their review of the supplied data and potential hazards, on the probable effects of the chemical under consideration.

Based upon their own review and the USFWS and/or NMFS opinion, the EEB can recommend one of three options:

1. Label restrictions designed to eliminate risks to endangered species,
2. Recommendation against registration of the pesticide, or
3. A request for further consultation with USFWS or NMFS if there is disagreement with the final opinion.

Once the appropriate use of a product has been set, information regarding how it is to be handled, used, and disposed of is listed on the label. Any deviation from the instructions found on the label is

considered a violation of law and is subject to penalties. When necessary, use of a pesticide is restricted by limiting who can use the product or how and where the product can be applied. Examples of restrictions include allowing only certified applicators to use the product or prohibiting its use within 25 feet of a body of water.

If a pesticide is commonly found in contaminated sediments, its registration can be questioned by any interested person who submits a petition with information supporting the need for reevaluating the product's use. EPA uses a Special Review to reevaluate a product's registration. Criteria for Special Review include (40 CFR 154.7):

- Does a product's use result in residues in the environment of non-target organisms at levels which equal or exceed concentrations acutely or chronically toxic to such organisms, or at levels which produce adverse reproductive effects in such organisms, as determined from tests conducted on representative species or from other appropriate data?
- Does a product's use pose a risk to the continued existence of any endangered or threatened species?
- Does its use result in the destruction or other adverse modification of any critical habitat of a threatened or endangered species?
- Does it otherwise pose a risk to humans or to the environment which is of sufficient magnitude to merit a determination whether the use of the product offers offsetting social, economic, and environmental benefits that justify its continued use?

Upon completion of the Special Review, the Agency may initiate formal proceedings to cancel or reclassify use of a product, or to return the pesticide to the registration process.

An example of a special review based on probable effects on benthic organisms is the special review given to tributyltin (TBT) compounds (USEPA, 1987). OPP is considering restrictions on the use of TBT compounds in marine paints based on the effects of these compounds on benthic organisms. Since TBTs are hydrophobic, sediments are considered to be a significant repository and source for these compounds. Sediment exposures are considered in the risk assessment for TBTs.

Clean Water Act

There are no provisions in the CWA that allow nation-wide direct discharge limitations for particular chemicals. The closest provisions to national limitations are the effluent guidelines developed for determining Best Available Technology (BAT) standards for various industries. Because discharge limitations that are based on the effluent guidelines are constrained by treatment technology, discharge limitations based on State water quality standards (water quality-based limits) are frequently the more protective way to implement limitations on particular chemicals.

It is possible that sediments could continue to be contaminated by point source discharges even where water quality-based permits have been issued and permit limitations are being met. Water quality criteria do not consider the sediment pathway and hence may not be stringent enough to protect sediment quality. This is the result of sediments' ability to store contaminants.

Water quality criteria are set on water-borne exposure of organisms (including humans) to contaminants, and do not consider the accumulation of contaminants in sediments. For many chemicals, failure to consider contaminant accumulation in sediments may not be important, but for relatively insoluble toxic chemicals that sorb to sediment particles, relatively low continuous inputs may result in extensive sediment contamination. Sediment quality criteria that have the same force as water quality criteria may need to be formally implemented in order to control such discharges, and evidence of

wide-spread contamination by a few chemicals could set priorities on those chemicals for which sediment quality criteria are needed. Once EPA establishes recommended sediment quality criteria, they could be incorporated into State standards and could be used to further limit discharges. Once adopted as standards, they can be used to require more stringent effluent limitations than BAT under the provisions of CWA §301(b)(1)(C).

Clean Air Act

Existing implementation of the CAA focuses primarily on the establishment of national ambient air quality standards (NAAQSs) and does not address the airborne toxics deposition that results in sediment contamination. Seven major ubiquitous pollutants have NAAQSs: particulate matter, sulfur oxides, carbon monoxide, nitrogen oxides, ozone, volatile organic compounds (mostly hydrocarbons) and lead. The CAA also requires EPA to set uniform national maximum emission standards for each industry. These New Source Performance Standards (NSPSs) are set based on costs, energy requirements, and public health and welfare considerations.

With sufficient evidence that airborne emissions are causing sediment contamination, and are thus threatening public health or welfare, both NAAQSs or NSPSs might be revised to be more restrictive for problematical sediment contaminants. There are, however, no criteria or methods currently available for accomplishing this.

Great Lakes Water Quality Agreement

The GLWQA between the United States and Canada contains a number of provisions that apply to contaminated sediments within the Great Lakes basin:

- Annex 1 provides a process for setting specific objectives for persistent toxic substances which have been found in or which have the potential to contaminate water, sediments or aquatic biota.
- Annex 2 provides the basis for the designation of the Areas of Concern in the Great Lakes Basin. Forty-one of the 42 Areas of Concern are suspected of having contaminated sediment problems.
- Annex 7 calls for coordinating the U.S. and Canadian programs regulating dredging and dredged material disposal.
- Annex 11 calls for surveillance and monitoring programs of all media including sediments in order to assess achievement of the specific objectives, the evaluation of water quality trends and to identify emerging problems.
- Annex 14 calls for the two countries to address a wide range of contaminated sediment issues including assessment, remedial options, disposal and management programs.

The implementation of the provisions of the GLWQA are overseen by the IJC and its boards and committees.

Local or Site-Specific Scale

In the majority of situations, national or regional scale restrictions will not be necessary to effectively prevent sediment contamination. Local or site-specific limitations are possible under a number of environmental statutes, including the CWA, RCRA, and CERCLA. Most of the decisions under these statutes (except CERCLA) relate to permitting actions on individual facilities for the discharge, emission, or release of potential sediment contaminants. The major provisions, procedures, and criteria

that apply to the prevention of sediment contamination under each of these statutes are described below.

Clean Water Act

Currently, wasteload allocations (WLAs) are developed with achievement of water quality criteria and water quality standards as their primary goals. Until recently, sediment quality was not considered. Using appropriate sediment quality monitoring and models in conjunction with sediment criteria, WLAs could be redone to protect sediment and water quality. Under such a system, the more stringent of the two allocation levels (water quality-based or sediment quality-based) would form the basis for permit limitations and nonpoint source allocations.

As mentioned previously, the CWA has provisions for including water quality-based considerations into permits for industrial and municipal dischargers. Total maximum daily load (TMDL) could be calculated for the segments in which sediment quality criteria were being exceeded, and WLAs could be done for each point source discharge using models with capabilities for dealing with sediment fate and transport. Water quality-based permit limits could then be written for each of the dischargers, limiting the discharges to levels that maintain sediment quality.

Nonpoint source control for the protection of sediment quality can be somewhat more problematic. Currently, nearly all States and Territories (e.g., Puerto Rico) have developed assessment and management reports under §319 of the CWA which have been reviewed and approved by EPA. Upon approval of their §319 reports, States receive monies for nonpoint program development, but, to date, none of this money has been used directly on projects related to sediment remediation.

CWA §319 does not provide the EPA with direct regulatory authority to control nonpoint sources. Instead, States are to include plans for the implementation of best management practices in their §319 assessment reports to reduce nonpoint source loadings. The enactment of these plans is left to State discretion. EPA authority for nonpoint source control may indirectly exist in §303 (d) of the CWA. Under this section, EPA can require States to establish TMDLs for waters not meeting beneficial uses. If the State does not develop TMDLs, then the EPA must develop them.

Within Region X, a multiple state TMDL for dioxin is being performed in the Columbia River with sediment contamination being considered.

The States have the authority to adopt sediment quality criteria and standards. The State of Washington is preparing to issue sediment management standards including numerical sediment criteria derived largely using the AET method.

Under §301(h), the Office of Marine and Estuarine Protection has developed a benthic assessment methodology for assessing the quality of the marine environment and monitoring changes to the environment that might result from the discharge of municipal wastes. The methodology is used to modify §301(h) waiver conditions when adverse environmental effects are detected.

Comprehensive Environmental Response, Compensation and Liability Act

The need for remedial action under CERCLA authority is determined through the Remedial Investigation/Feasibility Study (RI/FS) process, an activity generally reserved for sites on the NPL. If remedial action requires limited resources ($2,000,000 or less, or less than 12 months), such action could be taken on a site, even if it is not on the NPL, if the site poses an immediate threat to human health or the environment. The HRS, as recently revised, may allow sediment contamination levels to be used for evaluating contaminated aquatic sites and for confirming releases to surface waters. The ultimate impact of the new HRS on the listing of sites with contaminated sediments is not yet clear.

Resource Conservation and Recovery Act

Under RCRA, corrective action provisions can be applied to any RCRA hazardous waste management facility if a release of a hazardous waste or constituent has occurred. These requirements are in effect even though the specific regulations for the implementation of corrective action provisions are not yet final requirements.

Whether or not it can be demonstrated that sediment contamination results from permitted (e.g.,NPDES) point source discharges, RCRA corrective action at permitted and interim status hazardous waste facilities may be applicable. Appropriate actions may include investigating the extent of contamination and carrying out interim and long-term corrective measures.

Refuse Act of 1899

This Act has not, to date, been used in cases involving contaminated sediment cleanup but it includes provisions which may apply. The Refuse Act is enforceable by the COE but could be enforced in conjunction with EPA. Under the Act, parties responsible for introducing "refuse" into navigable waters which obstruct navigation can be compelled to remove the obstruction or pay penalties. Where sediment contamination interferes with navigational dredging activities, parties responsible for the contamination could potentially be compelled to remove the contaminated sediments.

Remediation Options

There are three major remediation options: no action, treatment in-place and removal (see Figure 2). Of these, there is a much greater body of knowledge concerning removal of sediments because of the COE navigational dredging program.

Some demonstrations of alternative dredging and disposal methods for highly contaminated sediments have been done at the New Bedford Harbor, Massachusetts Superfund site. A number of different dredges were evaluated and CDF and CAD disposal were also tested (USACOE, 1990).

To date, treatment of contaminated sediment before disposal has only been done on a pilot-scale. Although a number of promising technologies exist — some borrowed from wastewater treatment facilities, some developed to remove or immobilize contaminants in hazardous wastes— the costs associated with treating large volumes of contaminated sediment are extremely high. Superfund has been evaluating treatment technologies through its Superfund Innovative Technology Evaluation (SITE) program, though, to date, this program has focused mainly on soils rather than sediments. EPA's Great Lakes National Program Office (GLNPO) is implementing a contaminated sediment treatment technology demonstration program as part of the Assessment and Remediation of Contaminated Sediments (ARCS) program mandated by CWA §118(c)(3). The IJC Sediment Subcommittee recently developed a summary on the state-of-the-art in remedial options for contaminated sediments (IJC, 1988b).

No Action

Adequate evaluation of the no action alternative to contaminated sediment problems has been hampered by a lack of evaluation tools such as proven sediment (and associated contaminants) fate and effects models and risk evaluation protocols for in-place contaminated sediments. The key questions in evaluating the no action alternative are:

- How soon will conditions improve and how much will they improve? and
- If we don't do anything, will conditions deteriorate further?

Recent advances in understanding and predicting the fate and effects of in-place contaminated sediments have occurred as a result of studies of aquatic sites by EPA Superfund (New Bedford Harbor, Massachusetts), EPA GLNPO (Green Bay, Wisconsin), EPA Office of Research and Development (Trenton Channel/Detroit River, Michigan), EPA Region X, the State of Washington (Puget Sound), and others.

Treatment In-Place

The U.S. has had little experience with treating contaminated sediments in-place. In-place treatment has generally not been considered as an option, although the PCB-contaminated sediments in Waukegan Harbor are to be isolated from the rest of the environment by encapsulating them in-place using a cofferdam (sheet pile retaining wall) and slurry walls (clay fill to prevent groundwater migration). There are no criteria or methods currently available that can be used to determine when in-place treatment is appropriate.

Sediment Removal

Strategies for evaluating treatment and disposal needs for contaminated dredged material have been developed by the COE. These were further refined and tested on Puget Sound in the State of Washington as described below.

Dredged Material Alternative Selection Strategy

The COE developed a Dredged Material Alternative Selection Strategy (DMASS) for Puget Sound (Cullinane et al., 1986) which includes detailed evaluation procedures for the selection of treatment and disposal options, as well as the testing and monitoring that would accompany the decision-making process. While originally developed for Puget Sound, the framework has broader applicability.

The DMASS consists of five phases:

- **Presumption of contaminant pathway** — Consists of identifying whether the sediments are contaminated enough to require some restrictions on disposal.
- **Confirmation of site-specific contamination** — Is an in-depth look at the potential contamination pathways that could occur from disposal in particular locations.
- **Alternative development and screening** — Consists of developing alternative ways to eliminate or minimize the site-specific contamination problems identified in the previous phase.
- **Detailed evaluation and ranking** — Involves determining ranking criteria and applying them in a systematic manner to the alternatives developed in the previous phase in order to choose the most desirable alternatives.
- **Alternative selection** — Is the final step in which the "best" alternative is selected by whatever process the decision-makers have agreed to use to reach the final decision.

The procedures established in the DMASS could be very helpful in selecting the appropriate disposal/treatment alternatives for contaminated sediments when it is decided that sediment removal is needed.

There are several alternative dredging technologies, each with its own unique ability to deal with sediments of different types. The selection of the type of dredge to use in a particular situation is generally dependent on the physical nature of the sediments, the level of sediment consolidation, the

disposal method to be used, the proximity of the disposal site to the dredging site, and the level of contamination expected to be caused by sediment resuspension during dredging.

The CWA generally requires that State water quality standards be met during dredging, although many States have specific exemptions in their standards for dredging activities. For uncontaminated sediments, such provisions are appropriate, particularly with unconsolidated sediments of larger grain sizes that are not easily resuspended. For contaminated sediments, however, sediment resuspension is a much more significant issue, and the minimization of the environmental transport of resuspended sediments is a primary concern. There are no criteria or methods currently available that can be used to decide when to use different types of dredging methods.

Treatment of Removed Sediments

The U.S. has had little experience with the treatment of sediments removed from water bodies. On an experimental or pilot basis, various treatment alternatives have been tested to determine whether their use is appropriate for specific highly contaminated sediments. Although the technologies that can be used are similar to the technologies applied to other contaminated semi-solid or solid wastes,they have not often been used for contaminated sediments, primarily because of their expense. The evaluation procedures and strategies developed by the COE and described above could also be applied to the treatment of materials resulting from sediment cleanups. Superfund has evaluated contaminated sediment treatment options for sites on a case-by-case basis. The EPA GLNPO's ARCS Program will develop guidance on the selection of treatment options based on their studies. The IJC Sediment Subcommittee's summary of the state-of-the-art in remedial options for contaminated sediments included a discussion of some of the considerations involved in selecting treatment options (IJC, 1988b).

With sufficient concern about the environmental effects of disposal of highly contaminated sediments, treatment alternatives have been and are being tested on a bench- or pilot-scale to determine their effectiveness.

Disposal of Removed Sediments

Disposal of dredged material into waters of the U.S. and ocean waters are regulated under §404 of the CWA and §103 of the MPRSA, respectively. In general, the CWA §404(b)(1) guidelines specify that the disposal of dredged material must not result in significant degradation of the aquatic environment, including human health and welfare considerations, while MPRSA requires that the disposal of dredged material shall not unreasonably degrade or endanger human health, amenities, or marine life. Under each of these statutes, EPA, in conjunction with the COE has developed a series of protocols and criteria which simplify decision-making. In the case of ocean dumping, MPRSA protocols relate only to the acceptability of the dredged material for disposal in the ocean. In addition, RCRA and TSCA provisions restrict the disposal options for dredged sediments, as explained in the sections following those on MPRSA and the CWA.

Materials which are to be disposed of within the baseline of the territorial sea (including estuaries, rivers, the Great Lakes, and other rivers and lakes) are regulated entirely under the CWA. Outside of the territorial sea (beyond 3 nautical miles from the baseline) only MPRSA applies. Within the territorial sea (0 to 3 nautical miles seaward of the baseline), there is some overlap between CWA and MPRSA. In general, within this region, CWA regulates fill material (which may include dredged material discharged for the purpose of fill, such as beach nourishment) while MPRSA regulates dredged material disposal.

Two international agreements are considered here as well. Both the GLWQA and the London Dumping Convention (LDC) contain provisions relating to disposal of dredged material. Dredging and disposal guidelines have been developed by the IJC Dredging Subcommittee as called for in Annex 7 of the GLWQA (IJC, 1982).

Draft EPA/COE Dredged Material Disposal Strategy

The framework for evaluating dredged material disposal options utilized by the EPA OMEP, Office of Wetlands Protection (OWP), and COE is outlined in the draft *Dredged Material Disposal Strategy Document* (USEPA, 1990c). The strategy combines the considerations of both MPRSA and CWA on the disposal of dredged material into a single framework. The document also provides a discussion of the factors that need to be considered in various aquatic disposal environments (e.g., estuaries, continental shelf, rivers, lakes, etc.), and upland disposal environments. As required under CWA §404, these factors include biological, chemical, and physical impacts of the dredged material on the aquatic environment.

Marine Protection, Research, and Sanctuaries Act

MPRSA gives EPA the authority to designate acceptable dumpsites for the disposal of dredged material in the territorial waters of the U.S. The COE is given the authority to issue ocean dumping permits where it is determined that "such dumping will not unreasonably degrade or endanger human health, welfare, or amenities or the marine environment, ecological systems, or economic potentialities." §§102(a)(B) through 102(a)(D) require the consideration of human health and ecological effects in creating permitting criteria. All material considered for dumping must meet the criteria set forth in Ocean Dumping Regulations (40 CFR Parts 220-228) or a waiver of the criteria must be requested.

§103 of MPRSA specifies that all proposed operations involving the transportation and dumping of dredged material into ocean waters must be evaluated to determine the potential environmental impact of the dumping. In addition, EPA requires that the ocean dumping of dredged material be done at EPA-designated dump sites. Sites that have not yet been formally designated have been given an interim designation until Environmental Impact Statements (EIS) can be prepared for their designation.

In the formal dump site designation process, acceptable sites are chosen using a screening technique that selects a zone of siting feasibility (a distance from the dredging site within which it is feasible to transport dredged material), then eliminates from this zone hard bottom areas, areas of significant or unique habitat, habitats of endangered species, and areas of historical value, among others. Once these areas have been eliminated, potential dump sites are selected.

Potential sites are then surveyed to determine the characteristics of the bottom sediments, the nature of the biota of the site, and the general nature of water column and near-bottom currents. The site nearest the dredging site that would result in acceptable adverse impacts caused by the dumping is designated. This evaluation process is formalized in an EIS for dredged material dump site designation.

A complete assessment process for determining the suitability of dredged materials for dumping in ocean waters has been developed jointly by EPA and COE and is explained in the document *Draft Ecological Evaluation of Proposed Discharges of Dredged Material into Ocean Waters* (the "Green Book") (USEPA, 1990b). This assessment strategy was described earlier in the section of this chapter on assessment options.

Clean Water Act

A testing manual for evaluating the discharge of dredged materials into CWA §404 waters is under development. The manual will follow the tiered testing framework of the Green Book. Also, several of the Regions have developed their own testing protocols under the §404(b)(1) guidelines and adaptations of the Green Book. Details of these programs were discussed in the section of this chapter on assessment options.

Resource Conservation and Recovery Act and Toxic Substances Control Act

Under both RCRA and TSCA, there are restrictions placed on the options that can be used for the disposal of dredged material. Under RCRA, any characteristic hazardous waste (a waste that has one or more hazardous characteristics per RCRA-prescribed testing methods) must be disposed of by RCRA-approved methods. Contaminated sediments may be toxic under the toxicity characteristic leaching procedure (TCLP) test, a test that compares the concentrations of various chemicals in the leachate from the dredged material with levels established to protect human health and the environment. When a leachate concentration exceeds the established level, then the dredged material exhibits the "toxicity characteristic," and generally must be managed in a RCRA-permitted or interim status facility (a Subtitle C Hazardous Waste Landfill or equivalent) and must conform to treatment standards consisting of a specified level of hazardous constituent or specific treatment technology. It should be noted that the COE's position is that dredged material is not subject to RCRA requirements. COE maintains that dredged material is not a solid waste; EPA maintains that dredged material is a solid waste under RCRA, but as part of its Sediment Strategy (see Chapter 4), EPA will solicit public comments on the appropriate statutory and regulatory framework for managing dredged sediments.

The RCRA hazardous waste program has a statutory directive to prohibit land disposal of untreated hazardous wastes beyond specified dates for particular wastes. This prohibition, authorized under §3004 of RCRA is known as "land ban." As the specified dates for most hazardous wastes have passed, EPA has prohibited or restricted most hazardous wastes from land disposal without treatment.

COE Management Strategy

A predecessor to the MPRSA guidance discussed above was the COE strategy for selecting disposal options for dredged material and the accompanying testing required (Francingues et al., 1985). The COE strategy is summarized in Figure 8.

IJC Dredging Guidelines

The Dredging Subcommittee of the IJC Water Quality Board published an evaluation procedure for selecting disposal options for Great Lakes dredging projects in response to the GLWQA Annex 7 requirement for the development of compatible evaluation guidelines. The basic procedure (Figure 9), in *Guidelines and Register for Evaluation of Great Lakes Dredging Projects* (IJC, 1982), is similar to the tiered protocol developed under MPRSA for ocean disposal.

London Dumping Convention

The Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, more commonly known as the London Dumping Convention (LDC), was signed in 1972 and entered into force in 1975. The conventions of the treaty affect all dumping seaward of the baseline of the territorial sea and include specific limitations and bans on the dumping of certain substances within its several annexes. The Ocean Dumping Guidelines and the testing protocols within the Green Book implement the goals of the LDC within U.S. coastal waters.

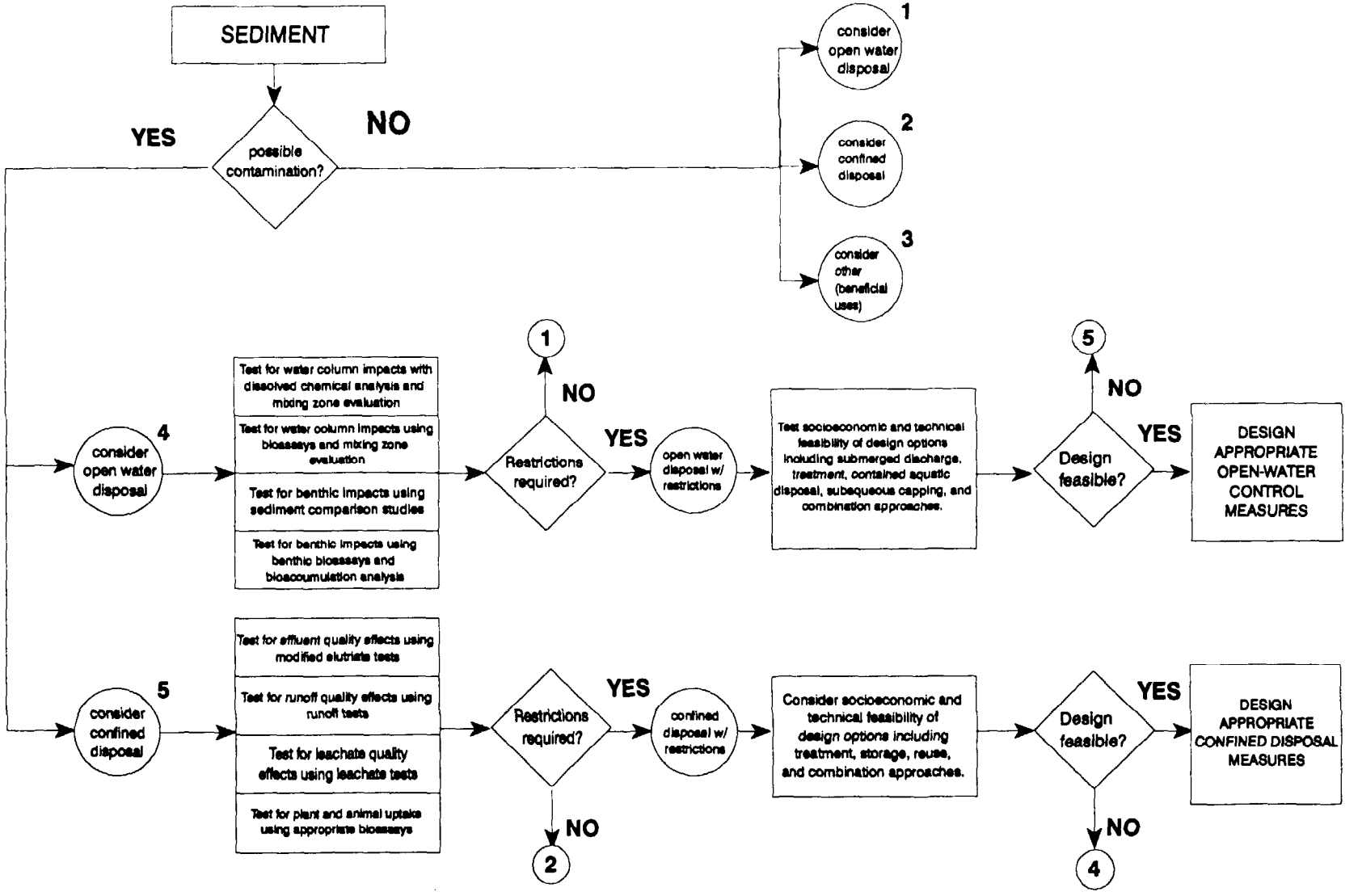

Figure 8. COE Dredged Material Management Strategy (after Francingues et al., 1985)

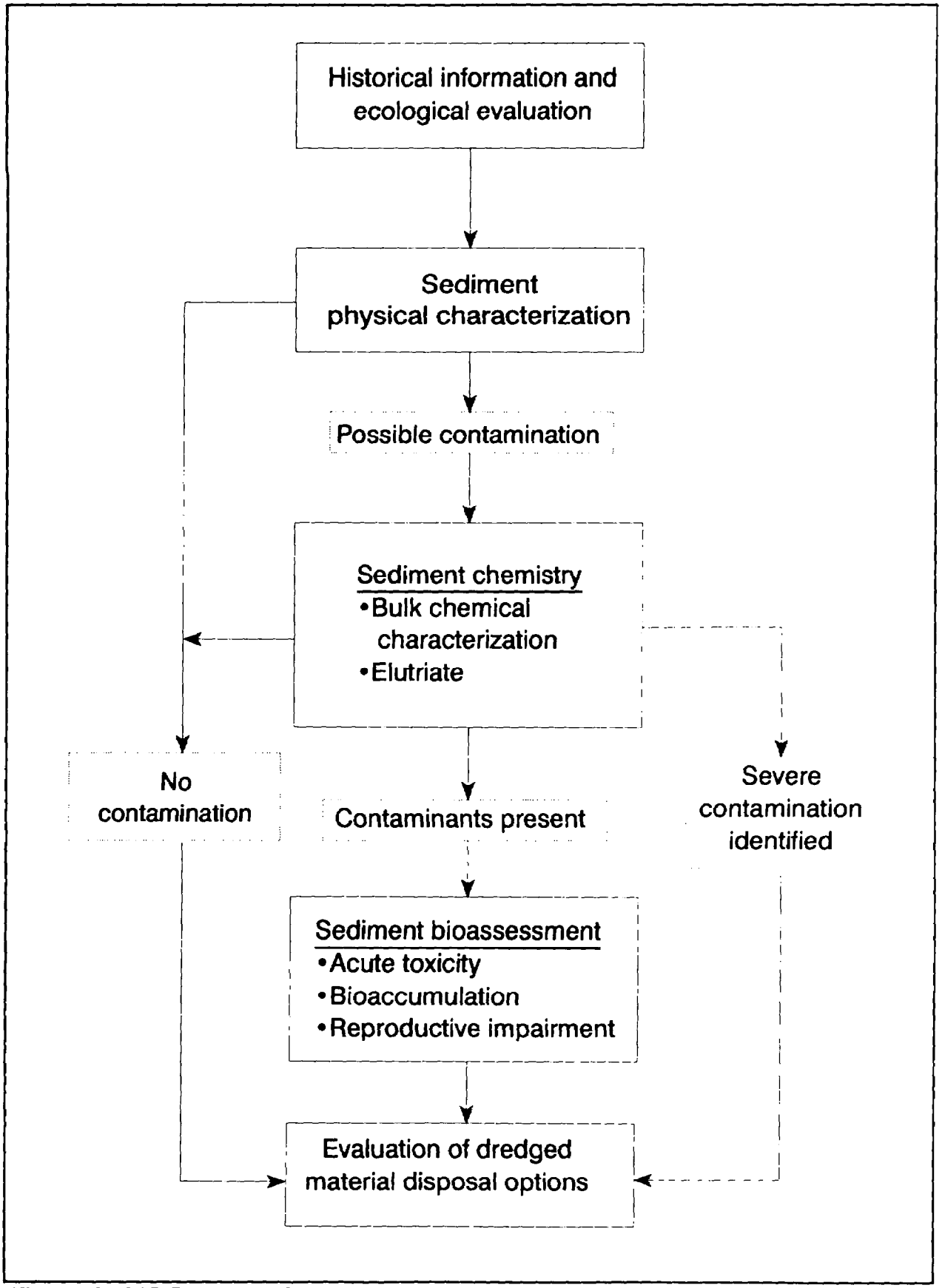

Figure 9. IJC Dredging Subcommittee Dredging Project Evaluation Framework (after IJC, 1982).

Annex 1 prohibits entirely the dumping of extremely hazardous substances such as organohalogen compounds, cadmium, mercury, oil, plastics, and high-level radioactive wastes. The dumping of dredged material which contains these substances is forbidden if they are present in "other than trace amounts." Annex 2 includes somewhat less hazardous substances such as pesticides, cyanides, zinc, arsenic, lead, copper and organosilicon compounds. The dumping of Annex 2 substances may be conducted only under a special permit. Pursuant to Annex 3, the dumping of all other substances requires permits issued by the appropriate nation after consideration of factors that are set forth within the Annex.

Chapter 3

Comparison of Existing Decision-Making Procedures for Contaminated Sediment Management

In this chapter, the existing programs and procedures that were described in Chapter 2 are compared to identify gaps and inconsistencies in the current decision-making process for managing contaminated sediments. Some areas, such as dredged material testing for open-water disposal, have decision protocols which are in a fairly advanced state. However, other areas, like assessment of the need to take remedial action on in-place contaminated sediments, are at a less developed stage and are only now beginning to be addressed.

The following sections overview the decision frameworks from Chapter 2 and identify programmatic gaps and inconsistencies. The order followed is the same as that followed in the previous chapters.

Finding Contaminated Sediments

Finding contaminated sediments can involve reviewing existing data to decide whether there may be a reason to suspect contaminated sediment problems or actually conducting monitoring surveys to produce the necessary data. If problems are suspected, then one would advance to the next stage in the process — assessment. Table 1 summarizes how existing programs assist in finding contaminated sediments.

Although there is a great deal of monitoring data available from surveillance and monitoring programs under the CWA, to date these programs have been focused on effluent and water quality rather than sediment quality issues (excepting §404 dredge and fill activities). As a result, both Federal and State monitoring programs sample sediments on an irregular basis at best. Even though the effluent and water quality monitoring data can be used to help identify potential sediment contamination problems (since sediment quality problems usually reflect water quality problems), direct monitoring of sediments is desirable. One of the main reasons for this is that many of the chemicals that are of the most concern for sediment and wildlife contamination have such low partitioning into water that they are often not detected in water analyses, whereas they are detectable in sediment analyses.

Some sediment monitoring is now accomplished on the State and Regional level in conjunction with special programs (e.g., the Chesapeake Bay Program, the Great Lakes National Program Office, PSDDA) and as part of expanded State monitoring programs (e.g., the State of Washington and New York).

The surveillance and monitoring programs called for under the GLWQA are to include sediment monitoring. However, because the actual monitoring is done by the Federal, State and Provincial agencies who do not routinely undertake sediment monitoring, this component is often neglected. The

Table 1. Finding Contaminated Sediments.

Program or Statute	Comments	
Clean Water Act	§115	Requires EPA to identify "In-place pollutants". Program currently not funded.
	NPDES and water quality monitoring	Primarily oriented toward effluent and water quality monitoring. Sediment monitoring not routinely done. Regions and most States monitor on a case-by-case basis when other evidence (i.e., fish contamination levels) indicates possible problem. Several States adopting intensive basin surveys which include regular sediment sampling
	§404 dredge and fill activities	Navigational dredging project evaluations and permitting collect significant volumes of information on sediment quality but information is not readily accessible for other purposes such as characterization of sediment contamination and must be retrieved manually. Monitoring data is biased – typically only available from navigational channel sediments or from disposal sites.
Great Lakes Water Quality Agreement	Sediment monitoring an integral part of surveillance and monitoring plans, but reliance on ongoing monitoring programs by the Parties means sediment components of monitoring often get last priority. Remedial Action Plan development process for Areas of Concern can require sampling.	
Marine Protection, Research and Sanctuaries Act	§201 establishes monitoring requirement for designated dumping sites. OMEP uses a tiered approach for establishing site monitoring needs. Sites are typically monitored annually. §202 requirement for monitoring impact of all pollutants.	
Chesapeake Bay Program	Sediments intensively sampled for toxics and nutrients.	
Great Lakes National Program Office	Ongoing sediment monitoring program for Great Lakes rivers and harbors both inside and outside of navigation channels.	
Puget Sound Dredged Disposal Analysis and Puget Sound Estuary Program	PSDDA monitoring focuses on disposal sites. PSEP monitoring focuses on areas outside of dumpsites and navigation channels.	
Resource Conservation and Recovery Act	Interim status facilities and permittees or facilities creating an "imminent and substantial endangerment" from past releases may be required to sample sediments.	
Comprehensive Environmental Response, Compensation, and Liability Act	States and Regions identify sites with possible contamination problems for possible inclusion on the NPL.	

Remedial Action Plan process for the Great Lakes AOCs is heightening awareness of the importance of including sediments in surveillance and monitoring programs. As a result sediment monitoring is being incorporated into the monitoring plans for the AOCs.

Regular monitoring is performed in Puget Sound as part of PSDDA and PSEP in navigation channels, around dumpsites, and in other parts of the estuary. A database is being developed which will include this information as well as data from Superfund sites in the area.

The CWA and MPRSA programs for the permitting of aquatic disposal projects collect large amounts of data from project proponents which could be used to identify potential contaminated sediment problems. However, for the most part, this data is not in a readily accessible form for use outside the originating program. Much of the monitoring data from these programs is only available in hard-copy form which makes searching for, retrieving and using the information difficult. In addition, these programs are not designed to provide an overall sediment quality characterization of an area because they usually only sample within the navigational dredging project areas.

CERCLA can provide intensive contaminated sediment monitoring data for some locations, but it is focused most heavily on listed sites. RCRA provides for sampling of sediments when it is done under the corrective action portion of the program.

The current state of monitoring activities with regard to sediments indicates that, as a general rule, sampling is performed only as part of special studies where existing evidence indicates a probable contamination problem. The most common trigger for special sediment studies (as stated by the various Regions) is elevated fish tissue concentrations of contaminants.

While this approach does provide for a channeling of resources into the most egregiously contaminated areas, it does not provide for the development of a database on background levels and general trends in contamination. Developing contamination problems may not be discovered until levels become high enough to cause adverse environmental effects. There is also not a single set of criteria which are used to determine when special studies should take place.

Assessment of Contamination

The significance of the deleterious effects of in-place contaminated sediments has only been recognized recently, whereas the issue of determining disposal options for dredged material has a long history. As a result, the assessment protocols that have been developed to date have focused primarily on the issue of what the disposal options are once sediments are removed from a water body. It is becoming increasingly apparent that there are situations where something will have to be done to mitigate the negative impacts of contaminated sediments, possibly including removal, even though dredging is not needed for any other purpose. What is needed in this case is an assessment protocol that determines the environmental impacts and risks from the in-place contaminated sediments. The existing program that currently performs this kind of assessment best is CERCLA (Table 2). In the case of aquatic Superfund sites, a very comprehensive risk assessment is typically performed including sediment/water/biota/human interactions.

The IJC Sediment Subcommittee's assessment protocol (IJC, 1988a) provides a comprehensive, tiered assessment program for in-place contaminated sediments. The U.S. and Canadian Federal agencies responsible for the Great Lakes are evaluating the usefulness of the IJC assessment protocol. The EPA GLNPO ARCS program called for by CWA §118(c)(3) is developing a standard sediment assessment protocol, using the IJC protocol as the starting point. The ARCS program is performing simultaneous testing of sediments with a wide variety of chemical and biological tests with the aim of eventually reducing the number of tests to those that provide the needed information in the most resource-effective manner. Therefore, proven cost-effective contaminated sediment assessment protocols for freshwater should become available in the near future.

The Puget Sound program has developed comprehensive sediment assessment protocols for in-place contaminated marine sediments in that area. Many of the principles from that program can be applied to other marine sites.

Table 2. Assessment of Contamination.

Applicable Existing Programs	Comments
Comprehensive Environmental Response, Compensation and Liability Act	Office of Emergency and Remedial Response assesses sites as part of RI/FS process for aquatic sites. Assessments are often very comprehensive and include information to allow risk assessments to human health and the environment from no action and various remedial action alternatives. Sediments assessed relative to site-specific ARARs. ARARs set based on possible receptors and exposure routes and available criteria/standards.
Puget Sound Program	Includes a comprehensive sediment assessment program. Sediments assessed relative to region-specific AET-based and EqP-based criteria. State of Washington promulgating sediment management standards.
Clean Water Act	EPA mandated to develop environmentally protective criteria. Currently working toward establishing sediment quality criteria and assessment protocols. Assessment protocols under development to serve function of a Green Book for §404 waters. 404(b)(1) guidelines offer general guidance on dredged material testing. Several Regions have developed local §404 guidance.
Marine Protection, Research, and Sanctuaries Act	§103 guidance developed for the evaluation of dredged materials for ocean disposal. Various Regions have specific testing protocols for use within this guidance.
Chesapeake Bay Program	Planning implementation of sediment triad strategy for bay-wide assessment of sediment contamination.
Great Lakes National Program Office ARCS Program	Developing sediment assessment tests and protocols starting from the IJC Sediment Subcommittee assessment protocols.

Currently, the application of sediment assessment strategies to sediments which are not being removed as part of dredge and fill activities is, at best, inconsistent. While EPA headquarters is now involved in the development of numerical sediment criteria and standardized bioassays, there is no existing continuity in sediment assessment.

The Office of Emergency and Remedial Response, under CERCLA, has performed a number of sediment assessments. These have involved application of various methods for setting ARARs for sediments (including the application of equilibrium partitioning approach-based criteria). Consistent sediment quality criteria would lend continuity to the Superfund program.

In different sections of the country, a number of sediment assessment methods and strategies have been applied. In Puget Sound and the West Coast, AET criteria have been applied. Within the Great Lakes, a reference approach has been traditionally applied which has evolved to include bioassays as well. A broad strategy using an expanded "triad" approach has been recommended. Several States have begun development of sediment quality criteria and standards. The State of Washington is in the process of implementing sediment management standards that include sediment quality criteria.

Implementation of national sediment quality criteria should be accompanied by a consistent assessment strategy within which the sediment quality criteria would be used.

Prevention and Source Controls

Table 3 summarizes the existing control programs that can be used to prevent or control sediment contamination.

The existing program that is most likely to be used in preventing and controlling sediment contamination is the CWA point source control program and the nonpoint source programs which are under development. However, no known NPDES permit limits have been written to date which directly protect sediment quality. There is no guidance on the use of sediment quality criteria or other assessment methods in the development of point source permits.

Table 3. Prevention and Source Controls

Applicable Existing Programs	Types of Controls Possible
Clean Water Act	Point source discharge controls through NPDES permitting program. No known permit limits written which directly protect sediment quality within Regions or States. Nonpoint source discharge controls through nonpoint source management programs. May be controlled by setting TMDLs.
Toxic Substances Control Act	Prohibition or limiting of production or distribution of harmful substances nation-wide. No known prohibitions based upon sediment contamination.
Federal Insecticide, Fungicide and Rodenticide Act	Office of Pesticide Programs uses a four step assessment procedure to decide whether to place restrictions on uses and disposal of biocides. Special assessments have been based on benthic organisms.
Clean Air Act	Establishment and enforcement of air quality standards and new source emission standards for toxics. Not known to have been based on sediments.
Comprehensive Environmental Response, Compensation and Liability Act	Whatever remedial action is justified based on risk analysis and cost/risk reduction analysis.

In order to effectively incorporate sediment quality considerations into point source permitting decisions, two tools are needed: sediment quality criteria and WLA models that incorporate sediment and associated contaminant fate and transport. Much progress is being made in both these areas through the research efforts of the EPA Office of Water, Office of Research and Development, Superfund, and the GLNPO. Currently, nearly all States have developed EPA approved assessment reports and management programs for nonpoint source pollution under CWA §319. However, States have not typically addressed the contaminated sediment issue in their nonpoint programs. This is possibly due to the paucity of information available on the extent of in-place pollutants in some States and competing State priorities that need to be addressed with §319 funds. While no remediation of sediments has occurred under this program, some of the funded projects will result in prevention of further sediment contamination.

Programs other than CWA are less likely to be used for control of contaminated sediment problems because contaminated sediments do not fall within their jurisdictions as readily and those programs do not have the resources that would be needed to expand their scope to include sediment issues on a routine basis. On the other hand, in the isolated cases when these programs do become engaged in contaminated sediment issues, they have some of the most powerful tools in existence for prevention

and remediation (e.g., the power to ban chemicals or to carry out or enforce cleanups). A strategy needs to be developed for the judicious application of these other programs in those cases where the problem is severe and where CWA authorities are not sufficient to address it.

The revised version of the CERCLA HRS gives increased attention to contaminated sediment issues, which will increase its usefulness for identifying in-place contaminated sediment sites. However, given the numbers of other sites competing for cleanup resources, aquatic sites may not get high priority.

Under CWA, CERCLA, and the Refuse Act of 1899, dischargers who can be shown to be directly responsible for sediment contamination problems can be compelled to remove and/or remediate contaminated sediments. Enforcement actions have been taken on this basis (e.g., Waukegan Harbor, New Bedford Harbor, Black River, Grand Calumet River). Enforcement actions can be difficult since the sources of sediment contamination are, more often than not, difficult to tie to individual dischargers, especially in harbors with multiple dischargers. There is no current guidance on conducting enforcement actions using sediment contamination as a tool to compel dischargers to clean up.

Remediation

As summarized in Table 4, CERCLA has a systematic process of developing and evaluating remediation alternatives for in-place contaminated sediment situations. Although there are no specific protocols for evaluating sediment contamination problems per se, the nature of the RI/FS process is such that a very thorough examination of remedial alternatives is performed. In addition, the CERCLA program has resources to do needed laboratory and pilot-scale studies of promising remedial tech-

Table 4. Remediation

Applicable Existing Programs	Comments
Comprehensive Environmental Response, Compensation and Liability Act	RI/FS process systematically evaluates alternative remedial options based upon a variety of factors including degree of protection, permanence, costs, adverse impacts to the environment, etc. Guidance for remediation of all media, including sediments, follows consistent framework that has an orientation toward the entire site. Laboratory and pilot-scale studies of remedial alternatives undertaken as needed. Various remediation strategies employed including removal and capping.
Clean Water Act	No national guidance on when or how to remediate. Great Lakes National Program Office ARCS program developing guidance on selecting remedial actions and conducting laboratory and pilot-scale studies on promising remedial alternatives. Dredged material testing protocols developed for §404 evaluations could be used to assess feasibility of remedial alternatives involving removal of sediments.
Marine Protection, Research and Sanctuaries Act	Dredged material testing protocols developed for MPRSA evaluations could be used to assess feasibility of remedial alternatives involving removal of sediments.

nologies in order to arrive at the best alternative. Remediation activities at aquatic Superfund sites like New Bedford Harbor, Massachusetts will provide a model for such activities elsewhere.

Outside of CERCLA, there is no guidance on when remediation should take place or on how remediation options should be chosen. This gap will be partially filled by the implementation of sediment quality criteria. Criteria can provide a "yardstick" for determining when sediments need to be remediated.

The Great Lakes National Program Office ARCS program is carrying out a series of laboratory and pilot-scale studies of promising remedial alternatives for contaminated sediments. The knowledge gained in these studies will be combined with results of other efforts including those of Superfund to produce a guidance document on remedial alternative selection for contaminated sediments.

For remedial activities where removal is chosen, proven existing protocols such as the Green Book, DMASS, PSDDA, and the upcoming §404 Testing Manual for freshwater can be used effectively to select dredging and disposal options and any accompanying control measures that may be necessary.

Treatment of Removed Sediments

Treatment options for contaminated sediments are currently chosen on a case-by-case basis. This is true under all applicable programs and regulations. Currently, little information is available on the practicability of various treatment options for contaminated sediments. The state of knowledge for sediment treatment lags behind that for the treatment of soils.

The EPA Superfund SITE and Great Lakes National Program Office ARCS programs are testing the practicability of various treatment options for contaminated sediments and may be providing information that can be used to aid in the selection of treatment options. Most of the options to be tested are methods created for the treatment of soils. Few treatment methods have been created specifically for sediment treatment.

Disposal of Removed Sediments

Testing protocols (Table 5) for the disposal of removed sediments are readily available from the CWA and MPRSA dredged material regulatory programs.

In MPRSA §103 waters, testing protocols are well developed. The Green Book provides national guidance on dredged material testing for ocean disposal. Based on the national guidance, several Regions (i.e., Regions I, II, IX and X) have developed Region-specific protocols on the type of analytical procedures to be applied in this testing.

Testing protocols under CWA §404 are more highly variable across the Regions. No national guidance has been issued to date. However, the Office of Wetlands Protection is cooperating with COE on the development of a Green Book-equivalent for §404 waters. Several of the Regions, in cooperation with their respective COE counterparts, have developed and are implementing their own guidance for §404 waters (i.e., Region I and X), while others have produced interim guidance (i.e., Region V) which is still not fully implemented. These guidances are variable in their scope, ranging from basic bulk chemical testing to detailed, tiered biological/chemical testing and *in situ* biota evaluations.

The IJC *Guidelines and Register for Evaluation of Great Lakes Dredging Projects* (IJC, 1982), developed under the GLWQA, contains a tiered protocol employing physical, chemical and biological testing. Although this protocol is not formally being used by EPA, elements of it appear in testing protocols such as the Region V testing strategy for navigational dredging projects.

Figure 5. Disposal of Removed Sediments

Applicable Existing Programs	Testing Protocols
Marine Protection, Research and Sanctuaries Act	Well-defined testing protocols established and under revision. Includes tiered biological/chemical testing protocol. Guidance for the designation of disposal sites based upon environmental and human health effects and possible beneficial use impairments. Calls for disposal site monitoring. Region-specific guidance developed or in progress within Regions I, II, VI, IX and X.
Clean Water Act §404	Office of Wetlands Protection developing dredged material disposal testing protocols for §404 waters. No national protocols in use. Impacts on disposal site evaluated under requirements of CWA §404(b)(1) guidelines. Specific testing requirements developed within Regions I, V and X (not fully implemented in Region V). Tests range from minimal to very detailed, from basic bulk chemistry to detailed, tiered biological/chemical testing and **in situ** biota evaluations. Parts of EPA Region V **Guidelines for the Pollutional Classification of Great Lakes Harbor Sediments** also used by the other Great Lakes Regions (Regions II and III).
Great Lakes Water Quality Agreement	Tiered assessment protocol in IJC **Guidelines for Evaluation of Great Lakes Dredging Projects** includes physical, chemical and biological testing. Parts of the protocol are used by the Great Lakes Regions (II, III, and V).

There is a possibility that guidance for dredged material disposal may differ somewhat between the National and Regional levels following the implementation of the national guidance being developed by OWP and COE for §404 waters (i.e., the §404 Testing Manual). The national guidance is expected to consist of a general framework which closely follows the tiered strategy in the Green Book used for MPRSA §103 activities. This framework will allow Regions to use local guidance relevant to local biota and chemicals of concern.

Chapter 4

Future Directions: The EPA Sediment Strategy

The first three chapters of this document have concentrated on the state of decision-making regarding contaminated sediments as it currently exists within EPA. The final chapter examines future directions in decision-making with special emphasis on the sediment management strategy being developed by EPA to coordinate sediment-related activities Agency-wide.

The Sediment Strategy

In 1989, the Office of Water organized a Sediment Steering Committee chaired by the Assistant Administrator for Water and composed of the Deputy Assistant Administrators of all the offices involved in sediment-related activities and the Deputy Regional Administrators for EPA's ten Regional Offices. On January 17, 1990, the Committee decided to prepare an Agency-wide sediment management strategy to coordinate and focus the Agency's resources on sediment problems. The goals of the strategy are to eliminate ongoing contamination of bottom sediments, to reduce existing contamination as much as possible, and to reduce or eliminate other adverse effects that sediments may cause. The objectives of the strategy include:

- Promoting consistent, environmentally protective decision-making across EPA offices, Regions, and States, taking into account technical and economic feasibility,
- Explaining differences in decision-making with respect to sediments among EPA program offices,
- Promoting coordination of EPA and State research, technical, and field activities,
- Defining relationships between EPA and the States where EPA seeks new statutory authority or seeks to use authorities that it has not implemented,
- Describing the extent and severity of contaminated sediments,
- Focusing public attention on the problem, and
- Focusing Federal, State, and private resources on the problem.

To study the technical and regulatory issues related to these objectives, four workgroups were formed in February 1990. The workgroups are staffed by 80 members taken from Office of Water; Office of Solid Waste and Emergency Response; Office of Pesticides and Toxic Substances; Office of Research and Development; Office of Policy, Planning and Evaluation; Office of General Counsel; Office of Enforcement; Office of Federal Activities; and each of the Regions. In August 1990, the workgroups completed draft options papers on how to improve the Agency's efforts to assess, prevent, remediate, and manage the disposal of contaminated sediment. Most of the papers concentrate on how

to use existing authorities better, but options for remediation and nonpoint source issues also look at statutory changes that could be implemented in reauthorization of an existing law or in passage of new legislation. The Deputy Assistant Administrators of the offices working on the strategy were briefed on the options papers in September and October 1990.

Major Issues

The four workgroups have focused on resolving 13 major issues. Workgroup members identified options for responding to each of the issues and are presenting these options to the Steering Committee for consideration. The major issues are:

1. National Inventory of Contaminated Sites and of Facilities that Contaminate Sediments
2. Ranking Sites and Facilities on an Inventory List for Further Action
3. Consistent, Tiered Testing Approach to Assessment of Sediment Quality
4. Point Source Control
5. Nonpoint Source Control
6. Revising Pesticide Registration Assessment Procedures
7. Revising Toxic Chemical Registration Assessment Procedures
8. Roles and Responsibilities for Remediation
9. Identification of Sediments needing Remediation
10. Identification of Sediment Remediation Goals
11. Enforcement-Based Authority to Require Remediation
12. Managing Dredged Material
13. Applicability of RCRA to Dredged Material Disposal.

Once the Steering Committee has approved the range of options offered for each major issue, EPA will consult with other Federal agencies and representatives of ten State governments selected from across the Regions. The Federal agencies included in the consultation will be the U.S. Geological Survey, National Oceanic and Atmospheric Administration, the Army Corps of Engineers and the Department of the Interior's Fish and Wildlife Service, among others. For the State consultations, each of EPA's ten Regional Offices will select one State government representative who is very familiar with contaminated sediment issues in that Region. The views of these government officials will be presented to the Steering Committee when they make a preliminary selection of the options in April 1991. The preferred options will then be discussed with environmental and public interest groups before the Steering Committee makes a final decision on the options. After continued consultation with the Office of Management and Budget (OMB) and the Federal agencies, EPA plans to have a draft sediment management strategy ready for publication in the Federal Register by the end of 1991.

Cross-Program Issues

Three issues related to contaminated sediments have been identified as cross-program issues. These are:

National Inventory of Sites and Sources

To date, no agency has completed a comprehensive, national inventory of sites with contaminated sediments or of facilities causing sediment contamination. Existing sediment data have been compiled to some degree, but the use of varying sampling and analytical methods make it difficult to compare sites across the country or even within States or Regions. Most data on sediment quality are currently drawn from anecdotal studies conducted by various State and Federal offices.

A comprehensive sediment inventory of sites and sources could aid decision-makers in managing the allocation of resources toward activities with the greatest potential for environmental benefit. An inventory could have utility for decision-making in several aspects of sediment management, including:

- Finding contaminated sediments — Monitoring and surveillance programs could be focused on those areas where contamination is suspected and where little or no information on sediments is available.
- Prevention and source controls — An inventory could aid in targeting individual facilities or types of facilities responsible for sediment contamination so that permit limits could be written with sediment quality as a consideration.
- Remediation — Contaminated sites could be compared and remediation priorities could be determined.

Consistent Testing Protocols

As discussed earlier in this report in the sections on assessment of contaminated sediments, most programs do not currently utilize a single set of biological and chemical testing protocols for the assessment of contaminated sediments. The major exception to this rule is the MPRSA §103 ocean dumping program which uses an established tiered testing strategy.

Adopting a consistent tiered testing methodology would encourage consistency in data generation which would, in turn, provide a uniform basis for Agency decisions regarding the regulation and remediation of contaminated sediments. The primary disadvantage of adopting such a methodology would be the difficulty in defining a consistent methodology that simultaneously meets the needs and falls within the regulatory mandate of prevention, remediation, and dredged material disposal programs.

Enforcement-Based Remediation

EPA recognizes that a number of sites with contaminated sediments pose a significant risk to public health or the environment and warrant remediation. A variety of EPA's statutory authorities include enforcement provisions that may be used to:

- Compel parties to clean up the sites they have contaminated,
- Recover costs from responsible parties for EPA-performed cleanups, and/or
- Coordinate with natural resource trustees to seek restitution of natural resource damages.

Part of the resolution of this issue involves determining whether EPA should use existing authorities (i.e., CWA, CERCLA, RCRA, etc.) or if new authorities are needed (in the form of new legislation) to deal adequately with sediment-related enforcement issues.

Potential Impact of the Management Strategy

As discussed previously in Chapters 2 and 3, numerous gaps and inconsistencies currently exist with regard to the management of contaminated sediments across EPA regulatory programs, offices, Regions and States. Clearly, a coherent Agency-wide strategy could resolve numerous issues related to contaminated sediment management.

The following discussion looks at the potential impact of a comprehensive strategy on the individual program offices in EPA.

Finding Contaminated Sediments

The proposed national inventory of sites and sources, and subsequent ranking in terms of environmental and human health impacts (Issues 1 and 2, above), could provide a valuable resource for the identification of sites with sediment problems and the allocation of resources toward the highest-risk sites. Existing monitoring and surveillance programs could use the inventory to direct their resources to focus on sites for which additional monitoring information is needed. Listings of sources could also be used to guide monitoring programs toward possible contamination problems.

Assessment of Contaminated Sediments

Consistent, scientifically sound protocols need to be developed to assess the impacts of contaminated sediments on human health and the environment. There is real need for sediment assessment tools outside of those programs not related to dredged material disposal. The identification of this issue as a cross-program one indicates this. Work toward establishing sediment quality criteria for the protection of aquatic life now underway within the Agency should provide an important tool. However, criteria are only one assessment tool which needs to be implemented as part of a total assessment protocol. The creation of a consistent tiered testing scheme (Issue 3, above) for sediment assessment could help to fill this gap. The difficulty in the creation of such a scheme is accounting for the varied needs of different programs (i.e., CERCLA vs. dredge and fill vs. NPDES). These issues are being addressed by the Steering Committee.

Prevention and Source Controls

Four of the thirteen major issues listed above directly address prevention (Issues 4, 5, 6, and 7, above). Extensive discussion is taking place on the control of point and nonpoint sources that are responsible for sediment contamination. To date, no NPDES permits have been written which explicitly consider sediment contamination as an endpoint in establishing permit limits. Nonpoint source control programs are just becoming established in many States. Sedimentation problems are addressed in these programs; however, few programs direct resources toward controlling nonpoint sources of sediment contamination.

The Office of Pesticide Programs (OPP) is considering incorporating sediment testing into their assessment of whether or not a new or existing pesticide should be banned or restricted in its use. The Office of Toxic Substances (OTS) is considering the same approach for their reviews of new and existing chemicals and has begun development of three testing protocols.

Remediation

Remediation issues may also be given high priority in the strategy (Issues 8, 9, 10, and 11). The Office of Emergency and Remedial Response (OERR), Office of Solid Waste (OSW), and Office of Water (OW) are considering options for remediating contaminated sediments. Enforcement is additionally identified as one of the cross-program issues. There are a number of legal actions under a variety of authorities underway by the Agency to compel responsible dischargers to remediate contaminated sediments.

Treatment of Removed Sediments

To date, sediment treatment options are not directly being considered as part of any one of the major issues covered within the strategy. The state of knowledge regarding treatment options for contaminated sediments is poor. Several programs, including the Superfund SITE program and the Great Lakes National Program Office ARCS program, are currently testing treatment technologies on a pilot scale to determine feasible options.

Disposal of Removed Sediments

Dredged material disposal is the most advanced of the sediment management categories with regard to the availability of detailed guidance and developed testing protocols. CWA §404 and MPRSA §103 programs utilize extensive guidance issued on both national and Regional scales. Some issues remain unresolved, such as the applicability of RCRA to dredged material and the role of economics in the evaluation of dredged material disposal. These issues are being addressed within the strategy (Issues 12 and 13, above).

* * * * *

In summary, the development and implementation of EPA's sediment management strategy will make significant progress toward addressing the key issues identified in this document.

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