

Principles for Evaluating Remedial Options for Contaminated Sediment Sites

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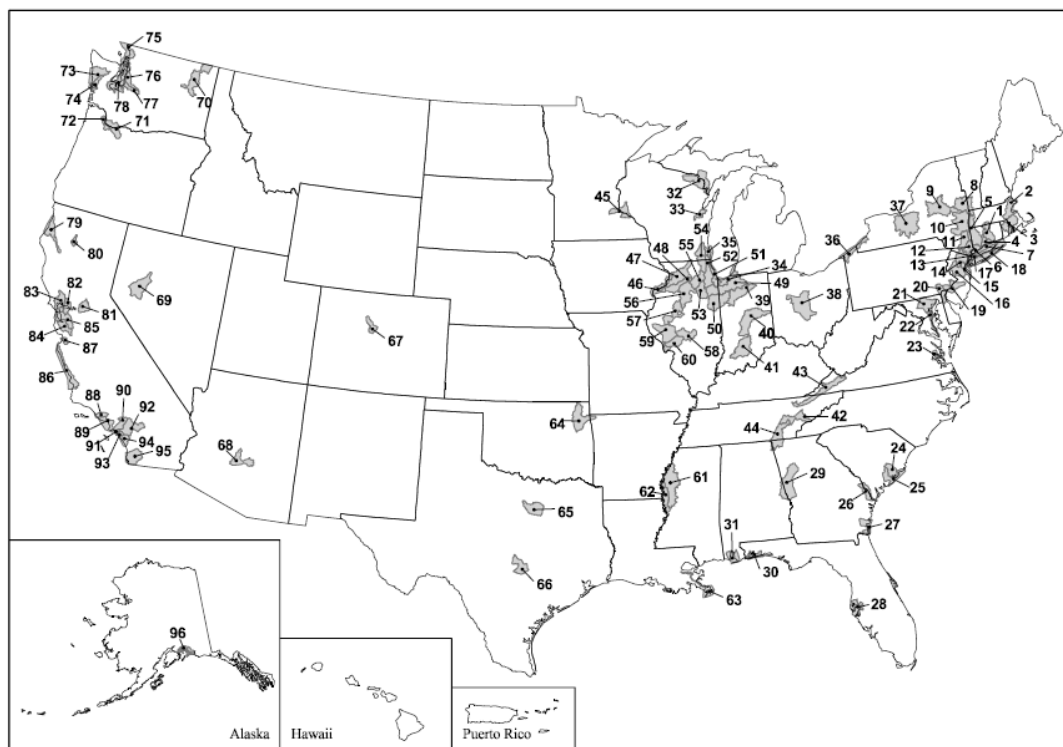
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Magnitude of the Contaminated Sediment Problem

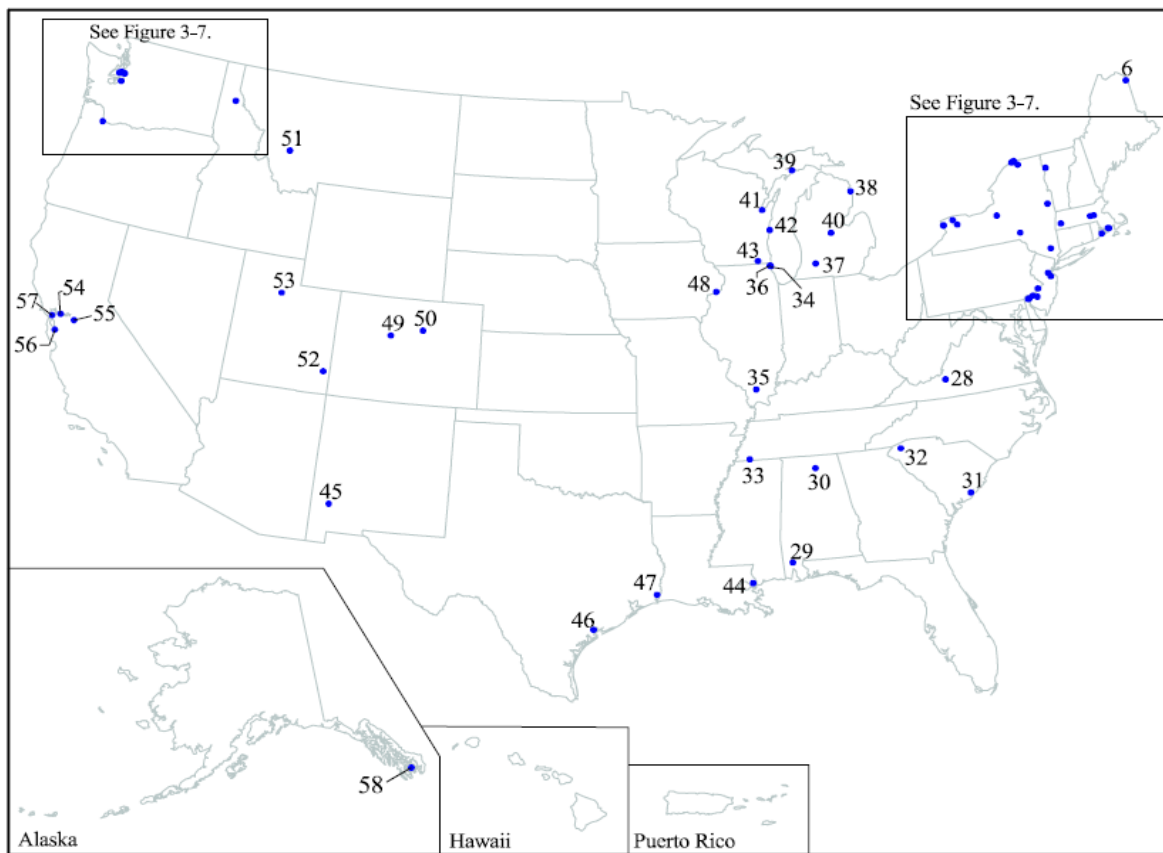
- The 2004 U.S. EPA *Updated Report on the Incidence and Severity of Sediment Contamination in Surface Waters of the United States* notes that the 2800 waterbodies with fish advisories include:
 - 33% of the nation's total lake acreage
 - 15% of the total river miles
 - 100% of the Great Lakes
- 96 watersheds were identified as being areas of probable concern for sediment contamination



From U.S. Environmental Protection Agency. 2004. The Incidence and Severity of Sediment Contamination in Surface Waters of the United States.

Magnitude of the Contaminated Sediment Problem

- The Superfund Program has decided to address sediment issues at over 150 sites
 - Over 65 of these sites are large enough that they are being tracked at the national level



From U.S. Environmental Protection Agency. 2004. The Incidence and Severity of Sediment Contamination in Surface Waters of the United States.

Costly Challenge

- Currently, there are 11 Superfund “mega” sites, which are those where the sediment portion of the selected remedy is estimated to exceed \$50M
 - Other sites are expected to become “mega” sites as remedial investigations are completed and remedies are selected
 - Amended ROD for Fox River OUs 2-5 cost estimate: \$390 M for the sediment remedy (now estimated to be higher)
 - Great Lakes Regional Collaboration cost estimate for remediating approximately 75 M cubic yards within Great Lakes Areas of Concern: \$1.5 billion - \$4.5 billion, depending on the types of remedies selected
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Need for Comprehensive Decision-Making Process

- Number, size, and high cost of sediment sites requires a comprehensive decision-making process that:
 - Integrates key lessons learned from remediation efforts at numerous sediment sites
 - Applies risk-management principles in a remedy evaluation and selection process
 - US EPA recommends using a risk management process “to select a remedy designed to reduce the key human and ecological risks.” *Sediment Guidance, p. 7-1.*
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Key Remedy Evaluation Considerations

- Determine whether sources have been identified and controlled
 - Use and refine a conceptual site model to understand risk drivers and to evaluate which remedial alternative(s) will effectively address risk drivers
 - Recognize that mass removal does not necessarily equal risk reduction
 - Consider implementation risks and residual risks before selecting a remedy
 - Use a risk-based decision-making approach that includes the 9 NCP criteria and complies with the NCP
 - Incorporate lessons learned from experiences at other sediment sites
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Risk Management Principle #1: Source Control

- Identifying and controlling sources prior to conducting remediation is critical to the effectiveness of any sediment cleanup
 - “In most cases, before any sediment action is taken, project managers should consider the potential for recontamination and factor that potential into the remedy selection process.”
Sediment Guidance, p. 2-21 (emphasis added)
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Key Source Control Questions

- What steps have been taken to identify sources and are these steps sufficient?
 - Have continuing sources been identified?
 - Will all continuing sources be controlled prior to remediation?
 - If not, should remediation proceed and what accommodations/expectations/plans exist about those sources?
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CSM: A Valuable Tool

- Represents current understanding of risk drivers by incorporating information on:
 - Contaminant sources
 - Transport pathways
 - Exposure pathways
 - Receptors
 - CSM should be refined and updated as new information is learned and the understanding of the site changes
 - Key component of the CSM is an evaluation of the stability of contaminants in sediment
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Stability of Contaminants in Sediment

- “In most aquatic environments, surface sediments and any associated contaminants move over time. The more important ... issue is whether movement of contaminated sediment (surface and subsurface), or of contaminants alone, is occurring or may occur at scales and rates that will significantly change their current contribution to human health and ecological risk.” *Sediment Guidance*, p. 2-23
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Key CSM Questions

- Have the following data been collected and evaluated in developing the CSM?
 - Human exposure pathways & receptors
 - Biota exposure pathways & receptors
 - Contaminant transport pathways
 - If not, why not?
 - What are the principal contaminants of concern and exposure pathways driving unacceptable risk at the site?
 - Which exposure pathways are relatively unimportant and can be excluded from further consideration?
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Key Stability of Contaminants in Sediment Questions

- Have the appropriate lines of evidence been evaluated on the potential stability of the contaminants present in the sediment (as opposed to sediment stability per se)?
 - Does contaminant fate & transport through in-place sediment potentially pose an unacceptable risk to human health and ecological receptors?
 - Is movement of contaminated sediment or of contaminants alone occurring at scales and rates that will significantly change their current contribution to human health and ecological risk?
 - If yes, can in-situ remedies (e.g., capping, MNR) be designed to adequately reduce risk to human health and ecological receptors?
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Evaluating Remedial Alternatives & Selecting A Remedy



Decision-Making Tool: Comparative Net Risk Evaluation

- U.S. EPA and the NAS Committee on Remediation of PCB-Contaminated Sediments recommend using comparative net risk evaluation to aid in risk-based decision-making
 - CNRE considers:
 - Benefits of the remedial approach
 - Implementation risks
 - Residual risks
 - CNRE is consistent with the NCP
 - Failure to account for implementation risks and residual risks can result in a less effective and less protective remedy than anticipated
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Implementation Risks

- Each remedy has its own uncertainties and implementation risks
 - These risks should be considered during remedy evaluation, before remedy selection
 - “Some contaminant release and transport during dredging is inevitable and should be factored into the alternatives evaluation and planned for in the remedy design.” *Sediment Guidance*, p. 6-22
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Implementation Risks

- MNR
 - Continued exposure to contaminants while natural processes reduce bioavailability
 - Capping
 - Risk due to direct exposure should decrease rapidly after cap placement
 - Releases during placement
 - Impacts on community
 - Construction-related risks to workers
 - Disruption of benthic community
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Implementation Risks

- Dredging
 - Resuspension
 - Release
 - Impacts on community
 - Construction-related risks to workers
 - Disruption of benthic community
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Residual Risk

- Risk to human health and ecological receptors from contaminated materials or residuals that remain after remedial action has been concluded
 - All remedial approaches leave some contaminants in place after remedial actions are complete
 - These residual risks must be considered before selecting a remedy
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Residual Risk

- MNR
 - Possibility that clean sediment overlying buried contaminants may move to such an extent that unacceptable risk is created
 - Possibility that groundwater flow, bioturbation, or other mechanisms may move buried contaminants to the surface in an amount and at a rate that could cause unacceptable risk to human health or ecological receptors
 - Capping
 - Possibility of cap erosion or disruption exposing contaminants
 - Potential for contaminants to migrate through the cap
 - Risks from contaminants remaining in uncapped areas
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Residual Risk

- Dredging
 - Residuals: undisturbed and generated
 - Empirically demonstrated to be 2-9% mass of last production pass
 - Resuspension can contribute to near field or far field recontamination and residuals
 - Releases can contribute to fish uptake of contaminants with both short term and long term effects
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Key MNR Residual Risk Questions

- What evidence is there that the system is recovering?
 - Is the pattern of recovery expected to change in the future? Will change result in unacceptable risk?
 - If yes, can institutional controls reduce human health risks?
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Key MNR Residual Risk Questions

- Is the rate of recovery sufficient to reduce risk within an acceptable time frame?
 - If no, can the recovery process be accelerated by engineering means?
 - If no, can human health risks be addressed by institutional controls?
 - Are groundwater flow, bioturbation, or other mechanisms likely to move contaminants to the surface at a rate and concentration that may pose an unacceptable risk?
 - Can a monitoring plan be designed to evaluate risk reduction and protectiveness?
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Key Capping Residual Risk Questions

- Is erosion or disruption of the cap likely to occur in a way that may pose an unacceptable risk?
 - If likely, can cap design, maintenance, or institutional controls reduce risk to an acceptable level?
 - Is contaminant migration through the cap likely to occur at a rate that may pose an unacceptable risk?
 - If likely, can activated carbon or other material be incorporated into the cap to reduce risk to an acceptable level?
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Key Capping Residual Risk Questions

- Is NAPL migration through the cap likely to occur at a rate that may pose an unacceptable risk?
 - If likely, can impervious material or reactive material be incorporated into the cap to reduce risk to an acceptable level?
 - Is gas migration through the cap likely to occur at a rate that may pose an unacceptable risk?
 - If likely, can the cap be designed to reduce risk to an acceptable level?
 - Can the monitoring plan be designed to detect significant erosion or contaminant movement before unacceptable risk occurs?
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Key Dredging Residual Risk Questions

- Is it likely that:
 - Resuspension will pose an unacceptable risk?
 - Releases will pose an unacceptable risk?
 - Residuals will pose an unacceptable risk?
 - If residuals are estimated to exceed cleanup levels:
 - Should an engineered cap be considered as an alternative to dredging?
 - Can cleanup levels be achieved with backfill?
 - If backfill is used to achieve cleanup levels, how is it intended to function?
 - As a dilution layer?
 - As a cap?
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Key Dredging Residual Risk Questions

- If backfill is intended to act as a dilution layer
 - Is the added material going to change the amount of contaminant mass that is bioavailable?
 - Would thin layer placement without dredging be more appropriate?
 - If backfill is intended as a cap
 - Has it been evaluated for erosion potential?
 - Has it been evaluated for the effects of groundwater advection?
 - Would engineered capping be more appropriate?
 - Can the monitoring plan be designed to ensure the backfill is functioning as designed?
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Key Remedy Selection Principles

- There is no presumptive remedy for any contaminated sediment site, regardless of the contaminant or level of risk
- Risk management goals should be developed that can be evaluated within a realistic time period, acknowledging that it may not be practical to achieve all goals in the short term
- Evaluate uncertainties concerning the predicted effectiveness of various remedial alternatives and the time frames for achieving cleanup levels, remedial goals, and RAOs

Adapted from U.S. EPA 2005

Key Remedy Selection Principles

- Use realistic time frames for remedy design, implementation and completion, and incorporate risks associated with remedy implementation when comparing on-going risks
- The effectiveness of in-situ (capping & MNR) and ex-situ (dredging) alternatives should be evaluated under conditions present at the site
- There should not be a presumption that removal of contaminated sediments from a water body will be more effective or permanent than MNR or capping

Adapted from U.S. EPA 2005

Key Remedy Selection Principles

- Contaminants that are deeply buried, have no significant migration pathway to the surface, and are unlikely to be exposed in the future may not need removal because they do not necessarily contribute to site risks
- No remedy is perfect
- A combination of sediment management options may be the most effective way to manage risk
- Developing accurate cost estimates is an essential part of evaluating alternatives
- An important risk management function is to compare and contrast the cost and benefits of various remedies

Adapted from U.S. EPA 2005

For Further Info ...

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