Technical Guidelines for In Situ Sediment Remediation

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Federal Remediation Technologies Roundtable
Reston, Virginia
11 May 2016

U.S.ARMY

US Army Corps of Engineers

ERDC
Engineer Research and Development Center

Objectives

- Supplement Contaminated Sediment Guidance (2005) with Technical Guidelines for Remediation Technologies (Monitored Natural Recovery, In Situ Capping and Removal)
- Provide technical guidelines for evaluating, designing, implementing and monitoring in situ remediation at contaminated sediment sites

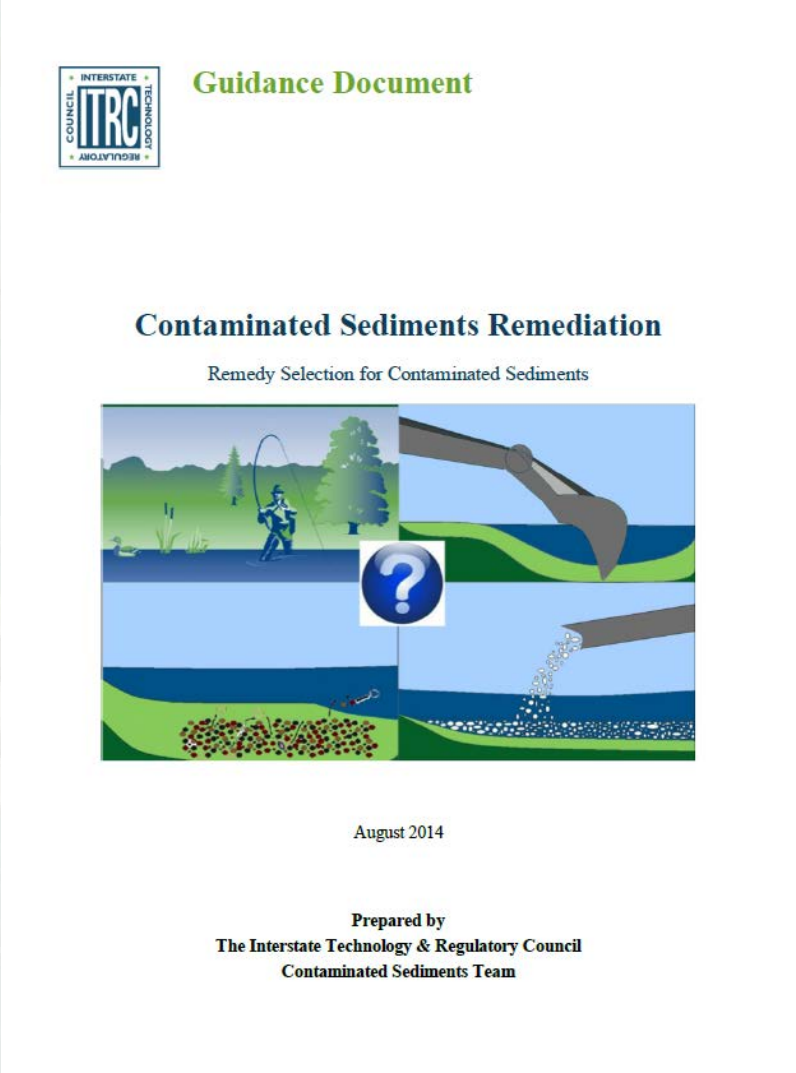
Contaminated Sediment Remediation Guidance for Hazardous Waste Sites

Purpose

- Provide guidance for evaluation, design and implementation of contaminant exposure reduction technologies as components of contaminated sediment remediation projects
- Primarily intended for federal and state remedial project managers and remediation practitioners evaluating and designing remedial response actions or non-time-critical removal actions
- Focus is primarily on items that need consideration during design and implementation
- Also identifies data needs, provides screening considerations and assists comparisons among in situ remediation technologies based on effectiveness and implementability under existing site conditions

Sediment Remediation Technologies

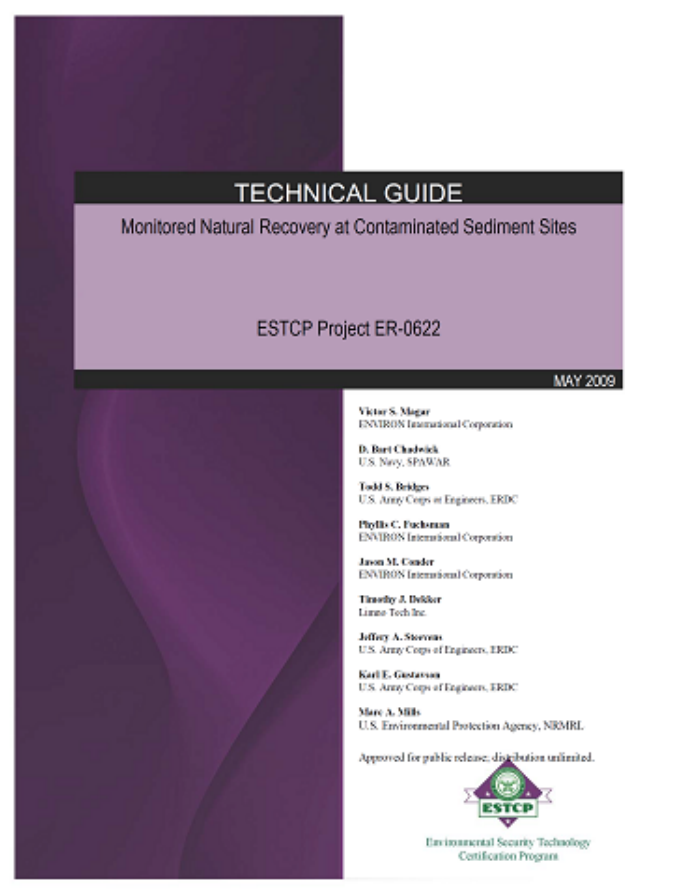
- Technologies have been adapting and morphing into additional options, moving from the laboratory to demos and full-scale implementation
- Current set of technologies
  - Monitored Natural Recovery (MNR)
  - Enhanced Monitored Natural Recovery (Thin Layer Capping w/ or w/o Amendments)
  - In Situ Treatment
  - Amended Capping
  - Isolation Capping
  - Environmental Dredging/Removal



Existing Technical Guidelines

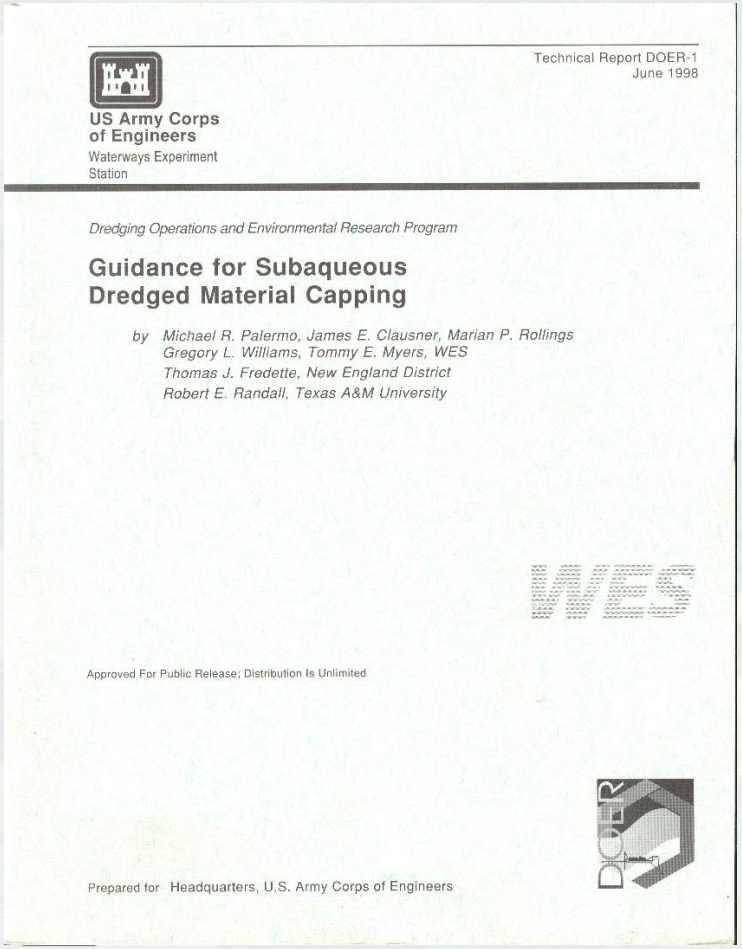
- Environmental Dredging (Sept 2008)

- Monitored Natural Recovery (May 2009)



Existing Technical Guidelines

- In Situ Isolation Capping (June 1998 and Sept 1998)



Technical Report DOER-1
June 1998

US Army Corps of Engineers
Waterways Experiment Station

Dredging Operations and Environmental Research Program

Guidance for Subaqueous Dredged Material Capping

by Michael R. Palermo, James E. Clausner, Marian P. Rollings
Gregory L. Williams, Tommy E. Myers, WES
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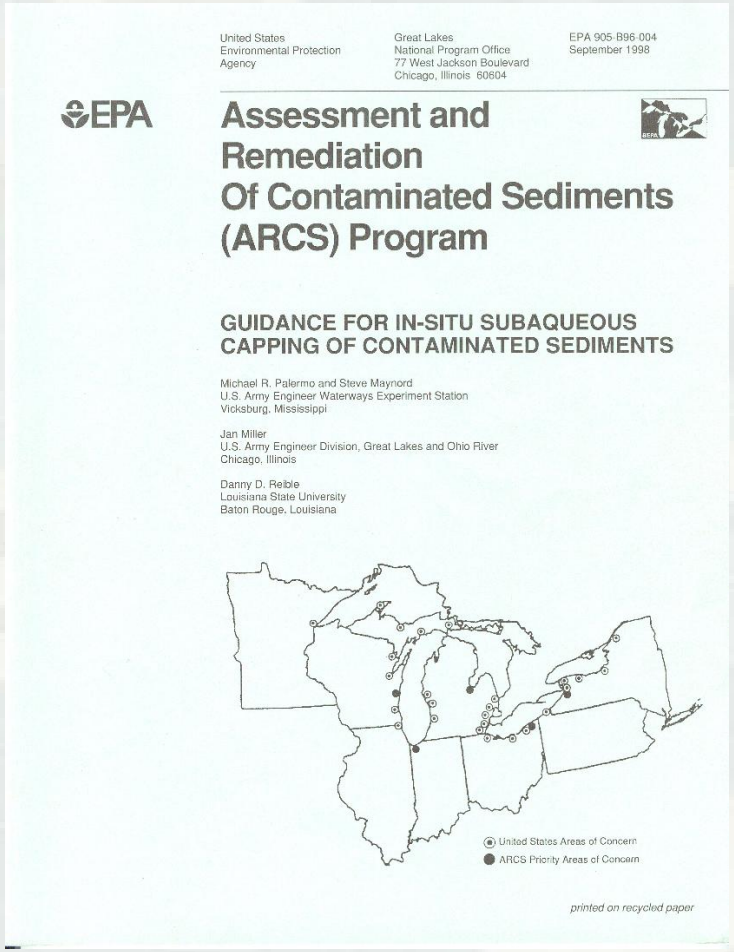
WES

Approved For Public Release; Distribution Is Unlimited

DOER

Prepared for Headquarters, U.S. Army Corps of Engineers



United States Environmental Protection Agency
Great Lakes National Program Office
77 West Jackson Boulevard
Chicago, Illinois 60604

EPA 905-B96-004
September 1998

EPA

Assessment and Remediation Of Contaminated Sediments (ARCS) Program

GUIDANCE FOR IN-SITU SUBAQUEOUS CAPPING OF CONTAMINATED SEDIMENTS

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United States Areas of Concern
ARCS Priority Areas of Concern

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Needs

Technical Guidelines for Active In Situ Technologies:

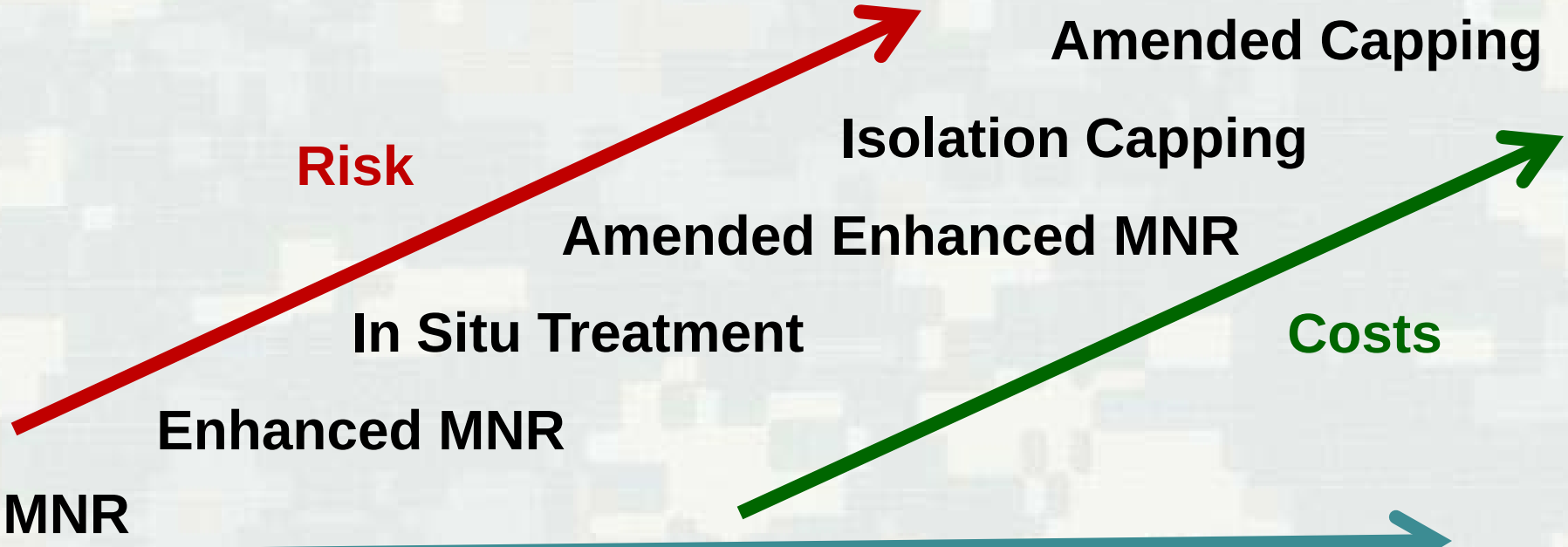
- Enhanced Monitored Natural Recovery (Thin Layer Capping w/ or w/o amendments)
- In Situ Treatment
- Amended Capping
- Update of Isolation Capping based on past 20 years of applications

Goals

- Provide technical guidelines for evaluating, designing, implementing and monitoring active in situ remediation at contaminated sediment sites
- Fill the gaps in the existing set of technical guidelines
- Update capping guidance, existing guidance limited to isolation capping
  - Address thin-layer capping and capping dredging residuals
  - Address new materials and methods including amended (reactive) caps
  - Address cap maintenance and rehabilitation
  - Consider natural recovery and recontamination
- Extend guidance to include enhanced monitored natural recovery (thin-layer capping) and in situ treatment using risk-based principles
- Apply risk-based principles; evaluate reduction in total exposure
  - Reduce concentration
  - Reduce bioavailability
  - Provide isolation

In Situ Sediment Remediation

- Represents a continuum of technologies of progressively greater action and cost to address less favorable site conditions and greater risk



Technical Guidelines

- Overview of Risk Reduction Performance and Components
- Favorable and unfavorable conditions
- Data needs
  - Physical Characteristics
  - Sediment Characteristics
  - Contaminant Characteristics
  - Site Use
- Design and evaluation protocols
  - Lab testing
  - Modeling
  - Materials
  - Quantities
- Implementation and Equipment
- Monitoring

Site Characteristics

- Site characteristics are key to assessing net risk reduction, implementability, permanence, cost-effectiveness and compatibility with site use.
  - Physical Characteristics
  - Sediment Characteristics
  - Contaminant Characteristics
  - Land and Waterway Use Characteristics

Physical Characteristics

Physical Characteristics	*EMNR*	*In Situ Treatment*	*Capping*
Sediment stability	H	H	M
Deposition rate	H	M	M
In-water & shoreline infrastructure	L	M	M
Presence of hard bottom	L	L	L
Presence of debris	L	M	M
Hydrodynamics	H	H	H
Conveyance	L	L	H
Bathymetry and slope	M	H	H
Groundwater advection	H	H	H
Ebullition	M	M	H
Bioturbation depth/intensity	H	M	M

H = critical M = contributing L = unimportant

Sediment Characteristics

Sediment Characteristics	*EMNR*	*In Situ Treatment*	*Capping*
Geotechnical properties	M	M	H
Slope stability	M	H	H
Potential for liquefaction	L	M	H
Erodibility	H	H	M
Potential for resuspension, release and residuals	L	M	M

Contaminant Characteristics

Contaminant Characteristics	*EMNR*	*In Situ Treatment*	*Capping*
Contaminant type (bioaccumulative or toxic)	H	H	M
Contaminant mobility and bioavailability	H	H	H
Contaminant fate and transport	H	H	M
Risk reduction required	H	H	L
Extent of contamination	H	H	H
On-going source impacts	M	M	H
Source materials (e.g., NAPL)	M	H	H
Exposure pathways and risk estimates	H	H	M

Land and Water Use Characteristics

Site Use Characteristics	*EMNR*	*In Situ Treatment*	*Capping*
Cultural and archeological issues	L	M	M
Site accessibility	L	M	H
Current and future waterway use	M	H	H
Current and future land use	L	L	M
Presence of sensitive species or habitat	L	H	H

Enhanced Monitored Recovery

- Acceleration of a proven ongoing recovery process by engineering means, usually the addition of a thin layer of clean sediment to kick-start the burial process and reduce bioactive zone contamination levels, possibly sequestering components
- Placed as a uniform thin (a few inches) layer, or in berms or windrows that can be further distributed by natural sediment transport processes
- Flow control structures for the waterway may be designed and placed to encourage sedimentation

Favorable Conditions for MNR	
Characteristic	**Condition**
Deposition rate	Annual deposition >> annual erosion; net deposition rate > 1 cm/yr
Erodibility	Low shear stress environment under extreme conditions; less than 6 inches of erosion predicted in 100-year event
Horizontal and vertical distribution of contamination	Contaminant conc. increase with depth; depth of peak conc. is greater than 2 ft; surficial bioavailable concentrations are fairly uniform
Required risk reduction	Typically, no more than a factor of 30

MNR vs. EMNR

- Deposition: >1 cm/yr vs. 0.3 cm/yr to 1 cm/yr
- Risk Reduction: < factor of 10 vs. > factor of 20
- Natural Recovery Time: < 10 to 15 yr vs. > 20 yr
- Bioturbation: shallow (< 5 cm) vs. deep (> 10 cm)

In Situ Treatment

- In-place chemical, physical, or biological degradation or sequestration of contaminants in bottom sediments
- Reduce contaminant transfer up the food web by reducing uptake by benthic organisms, predominantly by sequestration
- Reduce direct contaminant flux to the water column
- Application of bentonite, clay polymers, and pozzolanic materials can bind contaminants and reduce permeability
- Enhance in situ contaminant degradation

Favorable Conditions for In Situ Treatment	
Characteristic	**Condition**
Deposition rate	Annual deposition ≥ annual erosion; net deposition rate > 1 cm/yr
Horizontal and vertical distribution of contamination	Contaminant conc. increase with depth; depth of peak conc. is greater than 2 ft; surficial bioavailable concentrations are fairly uniform
Slope	Slopes greater than 10% pose difficulties in placing and retaining amendments and slopes greater than 20% are not suitable for most placement and mixing options
Required risk reduction	Typically, no more than a factor of 100
Groundwater advection	Characteristic net upward velocity < 0.5 cm/day

Capping

- Physical isolation of the contaminated sediment from the benthic environment and water column
- Stabilization of contaminated sediments, preventing resuspension and transport to other sites
- Reduction of the flux of dissolved contaminants into the water column
- Capping materials may include clean sediments, sands, gravels, sand/silt/clay mixtures, or may involve a more complex design with geotextiles, liners, armor stone, reactive amendments and multiple layers.
- Conventional placement equipment and techniques are frequently used for a capping project, but these practices must be controlled more precisely than for conventional placement. Specialty equipment is often required for placing materials in complex capping designs.

Capping

Update includes:

- Integrated design instead of incremental design
  - How thick does it need to be?
- Assesses multi-functionality of materials and layers
- Cohesive cap materials
  - Do I need armoring?
- Contaminant sequestration
  - Do I need an amendment?
  - What type?
  - How much?
  - How long will it last?
- What is the potential for recontamination?
- How do I incorporate habitat?
  - Do I need to have extra material for habitat?

Favorable Conditions for Capping	
Characteristic	**Condition**
Slope	Slopes >15% pose difficulties in placing and retaining capping materials; >25% are not generally suitable
Geotechnical properties	Undrained shear strengths less than 0.5 kPA poses severe restrictions on placement
Contaminant mobility	Kd > 3,000 L/kg
Groundwater advection	Velocity << 1 cm/day unless amendment used; velocities greater than 1 mm/day promote contaminant flux
Required risk reduction	Not critical but generally > a factor of 100
Current and anticipated waterway use	Cap design and water depth must be compatible with waterway use and habitat

Physical Isolation vs. Amended Capping

- Groundwater: < 0.5 cm/day vs. > 1 cm/day
- Mobility: Kd > 10,000 L/kg vs. Kd < 3,000 L/kg
- NAPL: Below residual saturation vs. above
- Allowable thickness: thick vs. thin
- Risk reduction factor: <300 vs. >1000

Status

▪ Internal and Sponsor Review	Completed
▪ Peer Review Draft	Sep 2016
▪ External Peer Review	Nov 2016
▪ Final Draft	Feb 2017
▪ Publication	Mar 2017
▪ Distribution	Apr 2017