Table D-1
Advantages and Disadvantages of Remediation Technologies for Contaminated Sediments

Remedial Technology	General Description	Typical Process Options	Specific Parameters to Consider	Potential Benefits	Potential Limitations	Precedent
In-Place Containment Technologies						
Engineered Capping	Controlled placement of various materials (e.g., sand, fill, gravel/cobbles, geotextile material) to physically isolate sediments from the overlying water column	Multimedia Sand cap AquaBlock ™ Revetments	Cost/location of capping material source Sediment surface topography Flooding characteristics Groundwater flow Benthic activity Water depths Water velocity Navigational traffic Constraints on access Erosion potential Sensitive/protected biological environment	Reduction of COC bioavailability Reduction of water-column COC concentrations Facilitation of conditions conducive to natural degradation processes Minimization of downstream contaminated sediment migration	COCs remain in place Resuspension and/or mixing of COC-containing material during placement COC release in the water-column during placement Benthic community alteration Long-term diffusion/advection of COCs through cap material Long-term erosion Cap surface recontamination Alteration of river hydraulics Disruption to recreational and commercial in-river and near-shore activities Placement may be challenging in deeper waters, areas with wave action, boat traffic or large targeted surface area Navigational dredging requirements AquaBlok™ creates an effective low permeability area, but is more prone to erosion Sand/gravel cap may improve fish habitat areas, but may need to be supplemented with revetments in higher velocities Multimedia cap (w/geotextile) provides the greatest integrity in erosion prone areas	Convair Lagoon (CA) Duwamish Waterway (WA) Puget Sound (WA) Hamilton Harbour (Ontario) St. Lawrence River (NY) Sheboygan River and Harbor (WI) Central Long Island Sound Disposal Site (NY) Mud Dump Site (NY)

Remedial Technology	General Description	Typical Process Options	Specific Parameters to Consider	Potential Benefits	Potential Limitations	Precedent
Particle Broadcasting	Placement of a thin layer (generally several inches) of clean material (e.g., clean sediment, sand, topsoil, or mixture thereof) to mitigate chemical flux to the water column and enhance natural attenuation processes	None	Water depth Water velocity Sediment type Navigational traffic Flood frequency Groundwater flow Constraints on access Sediment surface topography Erosion potential Placement technique Cap material availability	Retardation of dissolved chemical flux to water column Translocation of bioturbation zone upward and out of contaminated sediment Acceleration of COC reduction in sediment, biota, and water column Limited effect on benthic community Less intrusive to the environment	COCs remain in place Limited precedent for use Installation of the appropriate thickness required Accurate placement of cap material Cap erosion Navigational dredging requirements Resuspension and/or mixing of existing sediments during installation Challenging to implement in deep water and/or over a large surface area Requires greater volume of material to achieve nominal depth	None
Hydraulic Modifications	Physical alteration of existing water body to help control the movement/release of tainted sediments and/or promote deposition of clean sediments	Rechannelization (construction of a "new" channel and diversion of the present channel) Damming Construction of sedimentation basins Subsurface diversion structures (control the movement/ release of COC-containing sediment and promotes sediment deposition)	Areal extent of contaminated sediments Extent of development in surrounding area Physical configuration of river Space/access constraints Navigational traffic Available property Extent to which water levels would be raised Resident fish movement within the river (for damming technology) Areal extent of targeted sediment Water velocity Navigational traffic Flood capacity Erosion potential	COC-containing sediment physically separated from new channel Reduction of bioavailability Reduction of water-column and biota COC concentrations May enhance navigability Containment of COC-containing sediments within a smaller areal extent Controls contaminated sediment migration Promotes sediment deposition in the river	Alteration/modification of ecological habitat and surrounding area Available property Future use of old channel Flooding/hydraulic effects Alteration of benthic community and fish habitat Alteration of river hydraulics Topography Establishment of a habitat type that favors different aquatic species Resuspension of sediments during high flow events Upstream flooding considerations Available construction space Alteration of river hydraulics Sediment accumulation behind dam/sedimentation basin may require periodic removal High relative cost Limits movement of resident fish	Moss American Triana/Tennessee River Mississippi River

Remedial Technology	General Description	Typical Process Options	Specific Parameters to Consider	Potential Benefits	Potential Limitations	Precedent
Removal Technologies						
Dredging	Excavation of sediment from a water way; removed sediment will require subsequent management	Hydraulic (e.g., cutterhead, horizontal auger, dust pan, match box, plain suction) Mechanical (e.g., clamshell bucket, backhoe, bucket ladder, dipper, dragline) Specialty (e.g., PNEUMA® Pump, Dry Dredge™, SoliFlo)	Desired solids concentration Desired production rate Dredging accuracy Sediment/dredging depth Ability to handle debris Water depth Water velocity Navigational traffic Access constraints Presence of boulders/debris Bottom conditions Disposal requirements	Permanently removes contaminated sediment	Residual sediment due to mixing of COC-containing material with underlying material or surrounding sediment during dredging Areas missed by dredge Sediment resuspension/downstream migration Elevated COC levels in residual sediments Long- or short-term increases in COC bioavailability Alteration or destruction of benthic community Achieving low COC cleanup levels unlikely Presence of boulders/debris	Sheboygan River and Harbor (WI) Grasse River (NY) St. Lawrence River (NY) New Bedford Harbor (MA) Manistique River and Harbor (MI) Marathon Battery (NY) Shiawassee River (MI) Williamette River (OR) Duwamish Waterway (WA) Waukegan Harbor (IL) River Raisin (MI) Monguagon Creek (MI) Willow Run Creek (MI) Lake Jarnsjon (Sweden)
Dry Excavation	Removal of sediment following significant dewatering of the water body; removed sediment will require subsequent management	Area dewatering achieved via sheeting, coffer dam, water-filled structures, soil dams, by-pass pumping	Water depth Water flow/velocity Groundwater flow/infiltration Navigational traffic Access constraints Volume of water to be removed/contained Location, configuration, and extent of targeted sediment	Permanent removal of contaminated sediments	Residual sediment may contain elevated COC levels Long- or short-term increases in COC bioavailability Suspension and downstream transport of residual sediment Alteration or destruction of benthic community Inability to remove all sediment due to the presence of an impenetrable surface Inability to maintain "dry" conditions Excessive disruption to in-shore near-water recreational activity	Ruck Pond (WI) Unnamed Tributary (OH) Rouge River-Evans Product Ditch (MI) Town Branch Creek (KY)

Remedial Technology	General Description	Typical Process Options	Specific Parameters to Consider	Potential Benefits	Potential Limitations	Precedent
Management Technologies						
Treatment	Management of removed sediments prior to disposal	Dewatering (e.g., filter press hydrocyclone) Stabilization (typically used to meet disposal requirements)	Sediment/COC type Available space Water content of removed sediments COC concentration Management of water generated from dredge spoils Ultimate disposal location Location of treatment facility	Dewatering reduces wet volume (and potentially weight) of sediment for disposal Stabilization increases volume of sediment May decrease mobility of sediment	Obtaining necessary space requirements usually slows down removal operation	Typically utilized at most removal sites
Disposal	The final disposition for sediments that are removed/treated	In-water/upland confined disposal facilities (CDF) On-site/off-site landfills beneficial reuse	Volume of sediment COC concentration Access/space requirements Navigational traffic	Mitigation of potential risks associated with removed sediment	Necessary space requirements Interference with boat traffic Location of disposal facility Availability and capacity Increased risk of exposure and transportation accidents	CDF: New Bedford Harbor (MA) Landfills: most other removal sites

FACT SHEET:

Engineered Capping

Description:

Controlled placement of various materials (e.g., sand, fill, gravel/cobbles, geotextile material, etc.) to physically isolate sediments from the overlying water column. Typical process options include: multi-media cap, sand cap, AquaBlok™, and revetments. Typical cap thicknesses range from 0.5-3 feet.

Scale of Implementation:

Full-Scale

Precedence (full-scale):

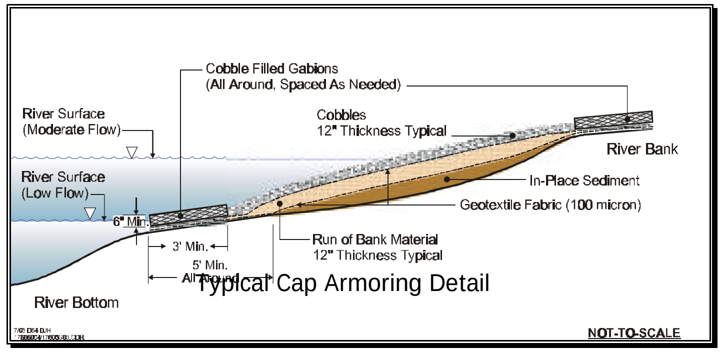
- ✓ Convair Lagoon (CA)
- ✓ Duwamish Waterway (WA)
- ✓ Puget Sound (WA)
- ✓ Hamilton Harbour (Ontario, Canada)
- ✓ St. Lawrence River (NY)
- ✓ Sheboygan River and Harbor (WI)
- ✓ Central Long Island Sound Disposal Site (NY)
- ✓ Mud Dump Site (NY)

Documented Effectiveness Toward Risk Reduction:

- ✓ reduces chemical bioavailability
- ✓ reduces water-column chemical concentrations
- ✓ can facilitate conditions conducive to natural degradation processes
- ✓ minimizes downstream migration of contaminated sediment
- ✓ can improve fish habitat areas

<u>For More Information:</u>

- ✓ USEPA ARCS Program: *Guidance for In-Situ Subaqueous Capping of Contaminated Sediments*. EPA 905-B96-004. September 1998.
- ✓ Hazardous Substance Research Center and USEPA Great Lakes National Program Office. "Proceedings from: In-Situ Capping of Contaminated Sediments – A Seminar for Decision Makers." Chicago, IL. November 20-21, 1996.



Typical Cap Armoring Detail

Critical Engineering Design Issues Influencing Effectiveness:

- ✓ cost/location of capping material source
- ✓ sediment surface topography
- ✓ flooding characteristics
- ✓ ground-water flow
- ✓ benthic activity
- ✓ water depths/velocity
- ✓ navigational traffic
- ✓ access constraints
- ✓ erosion potential
- ✓ sensitive/protective biologic environment

Short-/Long-Term Issues:

- ✓ chemical remains in-place
- ✓ resuspension and/or mixing of contaminants during placement
- ✓ chemical release in water column during placement
- ✓ benthic community alteration
- ✓ long-term diffusion/advection of chemicals through cap material
- ✓ long-term erosion
- ✓ cap surface recontamination
- ✓ alteration of river hydraulics
- ✓ disruption to recreational and commercial in-shore and near-shore activities
- ✓ placement may be challenging in deeper waters, areas with wave action, boat traffic or large targeted surface area
- ✓ navigational dredging requirements
- ✓ gas generation (sediment decomposition)

FACT SHEET:

Particle Broadcasting

Description:

Placement of a thin layer (generally several inches) of clean material (e.g., clean sediment, sand, topsoil, or mixture thereof) to mitigate chemical flux to the water column and enhance natural attenuation processes.

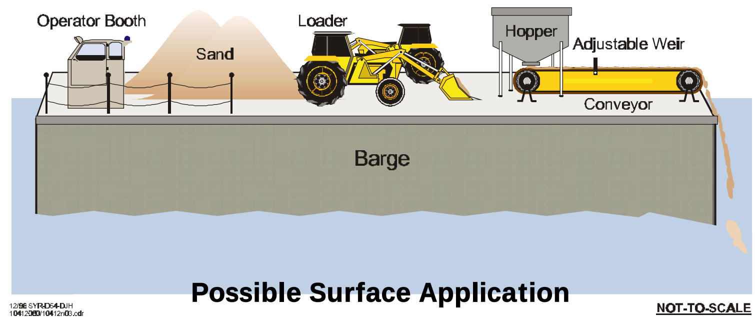
Can be placed via surface or subsurface application.

Scale of Implementation:

Proposed as a remedial option at Ward Cove (AK). Limited precedence for use as defined above; however, similar application techniques used full scale at several engineered capping sites including Hamilton Harbor (Ontario, Canada), Eagle Harbor (WA), and Pier 64 (WA).

Documented Effectiveness Toward Risk Reduction:

- ✓ accelerated reduction of chemical concentration in sediment, biota and water column
- ✓ limits negative effects on benthic community
- ✓ less intrusive to the environment
- ✓ retardation of dissolved chemical flux to water column
- ✓ translocation of bioturbation zone upward and out of contaminated sediment



Possible Surface Application

Critical Engineering Design Issues Influencing Effectiveness:

- ✓ water depth
- ✓ water velocity
- ✓ sediment type
- ✓ navigational traffic
- ✓ flood frequency
- ✓ ground-water flow
- ✓ constraints on access
- ✓ sediment surface topography
- ✓ erosion potential
- ✓ placement technique
- ✓ cap material availability

Short-/Long-Term Issues:

- ✓ chemical remains in-place
- ✓ limited precedence for use
- ✓ accurate placement of cap material
- ✓ cap erosion
- ✓ navigational dredging requirements
- ✓ resuspension and/or mixing of existing sediments during installation
- ✓ challenging to implement in deep water and/or over a large surface area
- ✓ will require greater volume of material to achieve nominal depth

For More Information:

- ✓ Hazardous Substance Research Center and USEPA Great Lakes National Program Office. "Proceedings from: In-Situ Capping of Contaminated Sediments – A Seminar for Decision Makers." Chicago, IL. November 20 – 21, 1996
- ✓ Hazardous Substance Research Center. "Capping Contaminated Sediment In-Situ." CENTERPOINT, Vol. 2 No. 2, 1995.

FACT SHEET:

Hydraulic Modifications

Description:

Physical alteration of existing water body to help control the movement/release of tainted sediments and/or promote deposition of clean sediments. Typical process options include rechannelization, damming, sedimentation basins, and subsurface structures.

Scale of Implementation:

Full-Scale

Precedence (full-scale):

- ✓ Mississippi River (subsurface structures)
- ✓ Moss American (rechannelization)
- ✓ Triana/Tennessee River (rechannelization)

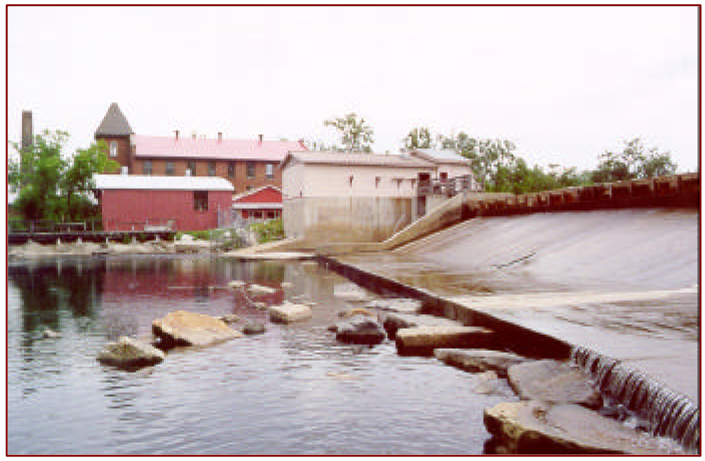
Documented Effectiveness Toward Risk Reduction:

Damming, Sedimentation Basins, Subsurface Structures

- ✓ containment of constituent-containing sediments within a smaller areal extent
- ✓ controls the migration of contaminated sediments
- ✓ promotes sediment deposition in the aquatic environment

Rechannelization

- ✓ constituent-containing sediment physically separated from new channel
- ✓ reduction of bioavailability
- ✓ reduction of water-column and biota chemical concentrations
- ✓ may enhance navigability



River Dam

Critical Engineering Design Issues Influencing Effectiveness:

- ✓ extent to which water levels would be raised
- ✓ need for resident fish movement within the river
- ✓ areal extent of targeted sediment
- ✓ water velocity, depth, etc.
- ✓ navigational traffic
- ✓ flood capacity
- ✓ erosion potential
- ✓ extent of development in surrounding area (rechannelization)
- ✓ physical configuration of river (rechannelization)
- ✓ available property/space/access constraints

Short-/Long-Term Issues:

- ✓ alteration and/or modification of existing ecological habitat and surrounding area
- ✓ establishment of a habitat type that favors different aquatic species (sedimentation basin)
- ✓ resuspension of sediments during high flow events
- ✓ upstream flooding considerations
- ✓ available property/construction space
- ✓ alteration of river hydraulics
- ✓ sediment accumulation behind dam/sedimentation basin may require periodic removal
- ✓ limits movement of resident fish (damming)
- ✓ future use of old channel (rechannelization)
- ✓ topography (rechannelization)

For More Information:

- ✓ USEPA. Superfund at Work: Success in Brief: EPA and Olin Clean Up Triana Site: “A Major Victory for the Environment.” EPA 520-F-93-001.1993

FACT SHEET:

Dredging

Description:

Excavation of sediment from a waterway. Removed sediment will require subsequent management. Typical process options include hydraulic (e.g., cutterhead, horizontal auger, dust pan, matchbox, plain suction); mechanical (e.g., clamshell bucket, backhoe, bucket ladder, dipper, dragline); and specialty (e.g. PNEUMA® Pump, Dry Dredge™, SoliFlo℠ **).**

Scale of Implementation:

Full-Scale

Precedence (full-scale):

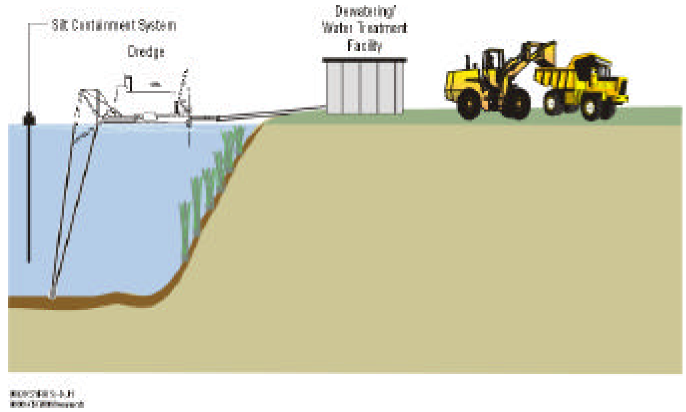
- ✓ Sheboygan River and Harbor (WI)
- ✓ Grasse River (NY)
- ✓ St. Lawrence River (NY)
- ✓ New Bedford Harbor (MA)
- ✓ Manistique River and Harbor (MI)
- ✓ Marathon Battery (NY)
- ✓ Shiawassee River (MI)
- ✓ Williamette River (OR)
- ✓ Duwamish Waterway (WA)
- ✓ Waukegan Harbor (IL)
- ✓ River Raisin (MI)
- ✓ Monguagon Creek (MI)
- ✓ Willow Run Creek (MI)
- ✓ Lake Jarnsjon (Sweden)

Documented Effectiveness Toward Risk Reduction:

- ✓ permanently removes sediment from aquatic environment

For More Information:

- ✓ National Research Council. *Contaminated Sediments in Ports and Waterways: Cleanup Strategies and Technologies.* National Academy of Sciences. 1997
- ✓ USEPA ARCS Program. *Remediation Guidance Document.* EPA-905-R94-003. October 1994.
- ✓ Herbich, J.B. *Handbook of Dredging Engineering*. McGraw Hill, Inc. 1992



Typical Dredging Components

Critical Engineering Design Issues Influencing Effectiveness:

- ✓ desired solids concentration
- ✓ desired production rate
- ✓ dredging accuracy
- ✓ sediment/dredging depth
- ✓ ability to handle debris
- ✓ water depth
- ✓ water velocity
- ✓ navigational traffic
- ✓ access constraints
- ✓ the presence of boulders/debris
- ✓ bottom conditions
- ✓ disposal requirements
- ✓ weather
- ✓ location, configuration, and extent of targeted sediment

Short-/Long-Term Issues:

- ✓ residual sediment due to mixing of constituent-containing material with underlying material or surrounding sediment during dredging
- ✓ areas missed by dredge
- ✓ sediment resuspension/downstream migration
- ✓ elevated chemical levels in residual sediments
- ✓ long- or short-term increases in chemical bioavailability
- ✓ alteration or destruction of benthic community
- ✓ achieving low chemical cleanup levels unlikely
- ✓ presence of boulders/debris
- ✓ exposure of more highly contaminated sediments
- ✓ cannot achieve 100% removal; remaining residuals available for future exposure

FACT SHEET:

Dry Excavation

Description:

Removal of sediment following significant dewatering of the water body. Removed sediment will require subsequent management. Typical process options include area dewatering achieved via sheeting, coffer dam, water filled structures, soil dams, and by-pass pumping/siphoning.

Scale of Implementation:

Full-Scale

Precedence (full-scale):

- ✓ Ruck Pond (WI)
- ✓ Unnamed Tributary (OH)
- ✓ Rouge River-Evans Product Ditch (MI)
- ✓ Town Branch Creek (KY)

Documented Effectiveness Toward Risk Reduction:

- ✓ permanently removes contaminated sediment from aquatic environment

Critical Engineering Design Issues Influencing Effectiveness:

- ✓ water depth
- ✓ water flow/velocity and variability
- ✓ ground-water flow/infiltration
- ✓ navigational traffic
- ✓ access constraints
- ✓ volume of water to be removed/contained
- ✓ location, configuration and extent of targeted sediment
- ✓ weather

Dry Excavation Activities

Short-/Long-Term Issues:

- ✓ residual sediment may contain elevated chemical levels
- ✓ long- or short-term increases in chemical bioavailability
- ✓ suspension and downstream transport of residual sediment
- ✓ alteration or destruction of benthic community
- ✓ inability to remove all sediment due to the presence of an impenetrable surface
- ✓ inability to maintain "dry" conditions
- ✓ excessive disruption to in-shore near-water recreational activity

For More Information:

- ✓ National Research Council. *Contaminated Sediments in Ports and Waterways: Cleanup Strategies and Technologies.* National Academy of Sciences. 1997
- ✓ Thomas H. Praeger, P.E., Stuart D. Messur and Richard P. DiFiore. "Remediation of PCB-Containing Sediments Using Surface Water Diversion "Dry Excavation": A Case Study." *Wat. Sci. Tech.* Vol. 33, No. 6, pp. 239-245, 1996.
- ✓ USEPA ARCS Program. *Remediation Guidance Document.* EPA-905-R94-003. October 1994.
- ✓ Herbich, J.B. *Handbook of Dredging Engineering*. McGraw Hill, Inc. 1992

FACT SHEET:

Management Technologies - Treatment/ Disposal

Description:

Treatment - Management of removed sediments prior to disposal. Typical process options include dewatering (e.g., filter press hydrocyclone), and stabilization (typically used to meet disposal requirements). High cost and limited marginal increased benefit typically precludes use of chemical removal/destruction treatment processes.

Disposal - The final disposition for sediments that are removed/treated. Typical process options include in-water/upland confined disposal facilities (CDF), on-site/off-site landfills, and beneficial reuse.

Scale of Implementation:

Full-Scale

Precedence (full-scale):

Treatment

- ✓ Dewatering and/or stabilization typically utilized at most removal sites

Disposal

- ✓ CDF: New Bedford Harbor (MA) and many navigational dredging sites
- ✓ Landfills: most other removal sites

Documented Effectiveness Toward Risk Reduction:

Treatment

- ✓ dewatering reduces wet volume (and potentially weight) of sediment for disposal
- ✓ stabilization increases volume of sediment
- ✓ may decrease mobility of sediment

Disposal

- ✓ mitigation of potential risks associated with removed sediment

Confined Disposal Facility

Critical Engineering Design Issues Influencing Effectiveness:

Treatment

- ✓ sediment/constituent type
- ✓ available space
- ✓ water content of removed sediments and final desired solids content
- ✓ constituent concentration
- ✓ management of water generated from dredge spoils
- ✓ ultimate disposal location
- ✓ location of treatment facility
- ✓ presence of oils

Disposal

- ✓ volume of sediment
- ✓ constituent concentration
- ✓ access/space requirements
- ✓ navigational traffic

Short-/Long-Term Issues:

Treatment

- ✓ obtaining necessary space requirements
- ✓ can limit removal operation rates

Disposal

- ✓ necessary space requirements
- ✓ interference with boat traffic
- ✓ location of disposal facility
- ✓ availability and capacity
- ✓ increased risk of exposure and transportation accidents
- ✓ permitting

For More Information:

- ✓ USEPA. *National Conference on Management and Treatment of Contaminated Sediments*. Proceedings Cincinnati, OH. May 13-14, 1997. EPA-625-R-98-001, August 1998.
- ✓ National Research Council. *Contaminated Sediments in Ports and Waterways: Cleanup Strategies and Technologies.* National Academy of Sciences. 1997
- ✓ USEPA ARCS Program. *Remediation Guidance Document.* EPA-905-R94-003. October 1994.