TABLE 3.1
POTENTIAL REMEDIAL TECHNOLOGIES ORGANIZED BY GENERAL RESPONSE ACTION

General Response Actions			
Institutional Controls	**Monitored Natural Recovery**	**Sediment Containment**	**Sediment Removal**
Governmental Controls - Permit requirements - Restriction on shoreline or water usage Property Controls - Deed restrictions - Fencing and posting Enforcement and Permit Tools - Administrative orders Informational Devices - Fish consumption advisories - Listing on registry of contaminated sites - Swimming restrictions	Monitored Natural Recovery (MNR)	Capping - Engineered sediment cap and erosion controls as needed - Engineered capping with reactive materials - Thin-layer cap Vertical Containment - Deep soil mixing - Slurry wall - Sheetpiling	Dredging with BMPs as needed - Mechanical dredging - Hydraulic dredging - Combination/hybrid mechanical/ hydraulic - Pneumatic dredging "In-The-Dry" (Mechanical) Excavation Transport/Dewatering as Needed - Mechanical transport - Hydraulic transport - Passive dewatering - Active dewatering - Rehandling steps

TABLE 3.1 (CONTINUED)
POTENTIAL REMEDIAL TECHNOLOGIES ORGANIZED BY GENERAL RESPONSE ACTION

General Response Actions				
Sediment Consolidation and Disposal	***In Situ* Treatment**	***Ex Situ* Treatment**	**Hypolimnetic Oxygenation**	**Habitat Enhancement**
On-Site - Sediment consolidation area - Confined disposal facility Off-Site - Solid waste landfill - Hazardous waste landfill Water Management/Treatment as Needed Beneficial Sediment Reuse (after *Ex Situ* Treatment)	Chemical/Biological Phytoremediation Solidification/Stabilization Electrokinetic Chemical Treatment of Profundal Sediments	Thermal Desorption Incineration/Vitrification Dechlorination Chemical Extraction/Leaching Sediment Washing/ Separation Solidification/Stabilization Biological Treatment Land Farming, Composting, Biopile	Hypolimnetic Oxygenation	Habitat Enhancement – Rip-rap for stabilization – Shoreline vegetation – Large woody debris – Spawning gravels – Stabilization of oncolites and macrophyte establishment

TABLE 3.2

POTENTIAL OFF-SITE DISPOSAL FACILITIES

Disposal Facility	Location	Approximate Distance from Onondaga Lake	Transportation Options	Comments
High Acres	Fairport, New York	80 miles	Truck	Nonhazardous only
BFI Landfill (Pine Avenue Landfill)	Niagara Falls, New York	165 miles	Direct Rail or Truck	Nonhazardous only
Model City	Model City, New York (near Buffalo)	170 miles	Truck	Hazardous and Nonhazardous
Environmental Quality	Belleville, Michigan	445 miles	Direct Rail or Truck	Hazardous and Nonhazardous
Clean Harbors	Grassy Mountain, Utah	2150 miles	Indirect Rail (rail within 10 miles of facility) or Truck	Hazardous and Nonhazardous

Note:

1. Available capacity to be determined once schedule and volumes have been established.

TABLE 3.3

EX SITU TREATMENT METHODS

Method Name	Description	Advantages/Limitations
Thermal Desorption	Sediment heated directly or indirectly in kilns, heated screw conveyors, externally heated distillation chambers, or fluidized beds. Water, organics, and volatile metals are vaporized, captured, and/or destroyed.	Typically removes over 99 percent of VOC concentrations and over 90 percent of SVOCs. Solids content should be at least 85 percent; pH over 5 and less than 11 preferred. High clay concentrations may clump and interfere with process, while silt and clay can result in high fugitive dust emissions. Volatile metals must be captured. Residuals may include oversized media, condensed contaminants and water, emission gas dust, clean off gas, and spent carbon. Feed and material handling may present problems. Technology is high cost, and emissions resulting from mercury contamination would be problematic.
Incineration	Sediments fed into rotary kiln heated between 540 and 1040 degrees Celsius. Organic contaminants are oxidized, volatilized, burned, and/or destroyed, leaving simpler combustion products.	Over 99 percent removal of organics typical. Large volumes can be processed. Off gases treated by air pollution control equipment; may not be capable of treating all byproducts. May increase leachability of metals in treated solids. Heavy metals may show up in ash or be volatilized and released in flue gas. Flue gas treated by scrubber system. Favorable feed characteristics are low moisture content, absence of volatile metals, and low fines content. Technology is high cost, and emissions resulting from mercury contamination would be problematic.

TABLE 3.3 (CONTINUED)

EX SITU TREATMENT METHODS

Method Name	Description	Advantages/Limitations
Dechlorination	Sediment fed into batch reactor, where reagent is mixed with sediment and heated. When heated, the slurry's halogenated contaminants decompose into less toxic compounds.	Proven effective at dehalogenating PCB and other aromatic halides. May form harmful byproducts, such as dioxins and furans. Reaction time dependant on contaminant type, initial concentration, water content, humic clay content, and the presence of other reactive materials. Process would be retarded by the presence of aliphatic organics and inorganics.
Chemical Extraction/ Leaching	Hazardous contaminants are separated from sediment through the addition of a solvent or other leaching fluid. This process is followed by recovery and treatment of the leaching fluid.	Multiple extraction cycles are required to achieve high removal efficiencies. Three waste streams generated: concentrated contaminants, separated solvent/water, and treated sediment. Feed may require dewatering or screening.
Sediment Washing/ Separation	Physical separation method used to separate heavily contaminated fine fractions from less contaminated coarse fractions of sediments and soils.	Potential for removal of metals and organics. Most effective on sand and gravel. Not effective on uniform fine-grained material. Wastewater may be difficult to treat.
Solidification/ Stabilization	Sediments are treated with a reagent to bind or vaporize free water (solidification) or to alter the chemical form of the contaminant (stabilization), to reduce its mobility, and to improve handling and compressive strength. Solidifying agents include cements, fly ash, lime, and silicates. Stabilizing agents include polymers such as urea formaldehyde.	Can typically achieve over 95 percent reduction of contaminant mobility in stabilized/solidified soils. Most successful with inorganics. Stabilizing agent formulation is specialized. Volume may increase up to two times original volume, depending on reagent addition. May be difficult to immobilize PAHs, as they interfere with bonding. Not possible to make visual verification that all waste material has been treated.

TABLE 3.3 (CONTINUED)

EX SITU TREATMENT METHODS

Method Name	Description	Advantages/Limitations
Biological Treatment	Biological treatment in a slurry of sediment and water at 15 to 50 percent solids content, which is mechanically agitated to maximize oxygen transfer and contact between contaminant and microorganisms. Oxygen may also be supplied via aeration. Treatment can be anaerobic as well; nutrients and pH adjustments are usually made to optimize environmental conditions for microbes. Following treatment, slurry is dewatered and treated solids are disposed.	Potential to treat wide range of organic contaminants. Best for fine-grained particles; sizing and homogenization of sediment is required. Loading rates can be slow. PAHs are difficult to degrade. Heavy metals may inhibit microorganisms. Temperature, oxygen, and nutrient levels must be maintained. VOC emissions, monitoring, and controls may be required. Dewatering can be expensive. Not effective at treating mercury.
Landfarming, Composting, Biopile	Contaminated material is mixed with bulking agent (woodchips, straw, sawdust) and piled three to six feet high and placed over a drainage system and liner. A confined disposal facility can be engineered to serve as a treatment facility for the bioremediation of sediments. Bulking agent is required to absorb moisture, increase porosity, and provide a carbon source. Aeration from mechanically tilling (landfarming or composting) or forced aeration (biopile). Pile is irrigated, and fertilized can be covered or enclosed.	Over 90 percent reduction in organic contaminants. Technology is one of the oldest and most widely used methods for treating hazardous waste. May produce material for beneficial use, but chemical/toxicological characterization is essential. Large area required. Volatilization may occur. Long time required to degrade recalcitrant compounds such as PAHs. Desorption from sediment typically rate-limiting step. Metals do not degrade, may accumulate to levels toxic to hydrocarbon-degrading microbes. Low pH and excessive precipitation may cause problems. Not effective at treating mercury.

TABLE 3.4
SCREENING OF REMEDIAL TECHNOLOGIES ASSOCIATED WITH LAKE REMEDIATION

General Response Action (GRA)	Remedial Technology	Variations	Effectiveness	Implementability	Overall Screening Conclusion*
No Action	None	None	Would not be effective in meeting RAOs.	Readily implementable. Not likely to be acceptable to public or regulatory agencies.	Should be retained for comparative purposes only
Institutional Controls	Government Controls	Includes controls imposed by federal, state, or local governments, such as restrictions on dredging, surface water usage, etc.	Potentially effective in reducing exposure to impacted media.	Readily implementable. Not likely to be acceptable to public or regulatory agencies except when more active forms of remediation cannot feasibly provide complete remediation.	Retained
	Property Controls	Includes deed restrictions. Could limit shore modifications by lakeshore property owners.	Potentially effective in reducing exposure to impacted media.	Readily implementable. Not likely to be acceptable to public or regulatory agencies except when more active forms of remediation cannot feasibly provide complete remediation.	Retained
	Enforcement Tools	Includes actions such as administrative orders preventing dredging.	Potentially effective in reducing exposure to impacted media.	Readily implementable. Not likely to be acceptable to public or regulatory agencies except when more active forms of remediation cannot feasibly provide complete remediation.	Retained
	Informational Devices	Includes activities such as health advisories on fish consumption, listing on registry of contaminated sites, and swimming bans.	Potentially effective in reducing exposure to impacted media.	Readily implementable. Not likely to be acceptable to public or regulatory agencies except when more active forms of remediation cannot feasibly provide complete remediation.	Retained

TABLE 3.4 (CONTINUED)

SCREENING OF REMEDIAL TECHNOLOGIES ASSOCIATED WITH LAKE REMEDIATION

General Response Action (GRA)	Remedial Technology	Variations	Effectiveness	Implementability	Overall Screening Conclusion*
Natural Recovery	Monitored Natural Recovery	Always should include a monitoring plan and contingency plan	In appropriate systems, can be effective at reducing chemical concentraitions and risks in physical and biological media. Allows ongoing short-term risks while remedy is achieved over a specified time period.	Implementable. Monitoring program and contingency plan required.	Retained
Containment	Capping	Engineered sediment cap with erosion controls as needed	Effective at physical and chemical isolation of sediments to reduce potential exposure of aquatic organisms and people in appropriate system. May be ineffective in some systems (e.g., high groundwater advection rates).	Implementable. Generally more easily placed in shallower areas. Caps along exposed shorelines may need aggressive erosion and stabilization controls such as rip-rap. Difficult to implement on steep slopes.	Retained
		Engineered capping with reactive materials	Innovative technology; may be effective for physical isolation and treatment, reducing potential exposure to aquatic organisms. Provides alternate approach to standard capping for systems where standard capping may be ineffective.	Potentially implementable, depending on results of bench and pilot studies. Design issues similar to cap alternative. May require extensive maintenance to replace reactive materials in some designs.	Not retained because relatively unproven compared to standard capping, which appears to be effective (see Appendix H).
		Thin-layer capping	Potentially effective in some systems. May not invovle complete isolation, so effectiveness can be less than standard capping.	Implementable. Thin layers can be placed by a variety of methods. Shoreline/slope design issues similar to standard capping.	Retained
	Vertical Barrier Containment	Deep soil mixing	Effective as a hydraulic barrier to reduce contaminant flux to lake. Potential short-term impacts due to resuspension of contaminants.	Implementable in nearshore, difficult in deeper waters. Less prone to corrosion and may have more strength than sheetpiling.	Retained for upland and nearshore use

TABLE 3.4 (CONTINUED)

SCREENING OF REMEDIAL TECHNOLOGIES ASSOCIATED WITH LAKE REMEDIATION

General Response Action (GRA)	Remedial Technology	Variations	Effectiveness	Implementability	Overall Screening Conclusion*
Containment (continued)	Vertical Barrier Containment (continued)	Slurry Wall	Effective as a hydraulic barrier to reduce contaminant flux to lake. Potential short-term impacts due to resuspension of contaminants.	Potentially implementable depending on water depth, wall depth, and soil being displaced.	Not retained for in-water use due to implementability issues and because upland walls should provide same function.
		Sheetpiling	Effective as a hydraulic barrier to reduce contaminant flux to lake.	Potentially implementable nearshore, although quality control may be difficult when installed through water, and depth may be an issue.	Not retained for in-water use because of implementability issues and because upland walls should provide same function.
Sediment Removal (includes potential BMPs, transport, and dewatering)	Dredging	Mechanical Dredging	Effective at removing risks related to chemicals from environment of concern. Elevated short-term risks from resuspensed sediments likely in highly contaminated sediments. Potential long-term impacts from residual sediment-related chemicals lost to wider areas.	Implementable, particularly in shallower areas. May require implementation of BMPs that can slow production. Rehandling and dewatering steps required in most cases. May need backfill or additional dredging for slope stability.	Retained
		Hydraulic Dredging	Effective at removing risks related to chemicals from environment of concern. Elevated short-term risks from resuspensed sediments (but often less than mechanical) and entrained water likely in highly contaminated sediments. Potential long-term impacts from residual sediment-related chemicals lost to wider areas. Potential impacts from discharge water.	Implementable, particularly in shallower areas. May require implementation of BMPs that can slow production. May need backfill or additional dredging for slope stability. May require specialized equipment. Water separation and water treatment would be required. Land requirements are high for entrained water and solids handling.	Retained

TABLE 3.4 (CONTINUED)

SCREENING OF REMEDIAL TECHNOLOGIES ASSOCIATED WITH LAKE REMEDIATION

General Response Action (GRA)	Remedial Technology	Variations	Effectiveness	Implementability	Overall Screening Conclusion*
Sediment Removal (includes potential BMPs, transport, and dewatering) (continued)	Dredging (continued)	Combination/ Hybrid Mechanical/ Hydraulic Dredging	Effective at removing risks related to chemicals from environment of concern. Elevated short-term risks from resuspensed sediments (often more so for mechanical) and entrained water likely in highly contaminated sediments. Potential long-term impacts from residual sediment-related chemicals lost to wider areas. Potential impacts from discharge water.	Implementable, particularly in shallower areas. May require implementation of BMPs that can slow production. May need backfill or additional dredging for slope stability. May require specialized equipment. Water separation and water treatment would be required. Land requirements are high for entrained water and solids handling.	Retained
		Pneumatic Dredging	Effective at removing risks related to chemicals from environment of concern. Elevated short-term risks from resuspensed sediments (but often less than mechanical) and entrained water likely in highly contaminated sediments. Potential long-term impacts from residual sediment-related chemicals lost to wider areas. Potential impacts from discharge water less due to higher slurry concentration.	Difficult implementability. Equipment not available on a commercial scale. Only feasible in soft, fine-grained material. Not feasible in water depths less than 7 ft deep.	Not retained because of implementability issues
	Dry Excavation	Mechanical Excavation	Effective at removing risks related to chemicals from environment of concern. Fewer short-term chemical impacts than dredging.	Implementable only in shallow (<12 ft water depth) nearshore areas. Requires extensive water diversion structures. Rehandling and dewatering steps required.	Not retained. Relatively infeasible as compared to dredging. Only implementable in very nearshore areas.

TABLE 3.4 (CONTINUED)
SCREENING OF REMEDIAL TECHNOLOGIES ASSOCIATED WITH LAKE REMEDIATION

General Response Action (GRA)	Remedial Technology	Variations	Effectiveness	Implementability	Overall Screening Conclusion*
Disposal	On-Site Consolidation	Solid waste or SDA.	Can be effective with proper design and construction, including liners, caps, and leachate control. Potential short-term impacts with rehandling steps.	Implementable. Design approaches proven. Existing suitable sites exist near lake. Regulatory and community acceptance status needs to be finalized with NYSDEC. Requires extensive long-term maintenance.	Retained
	Off-Site Disposal	Solid waste or hazardous waste landfill, including Canada	Can be effective when taken to a properly designed existing landfill. Potenital short-term impacts with rehandling/transport steps.	Implementable. Suitably permitted landfills exist. Requires transport of at least 8 to 170 miles. Requires extensive long-term maintenance.	Retained.
	Water Management/ Treatment		Potential impacts from discharge water with and without treatment.	Implementable. Proven technologies exist.	Retained
	Beneficial Reuse (after *ex situ* treatment)		Effective only with fully treated sediments.	Implementable where treatment is sufficient.	Not retained. Dependent on treatment technologies that were not retained (see below).
***In Situ* Treatment**	Chemical/Biological		Innovative technology potentially effective for reducing mobility or toxicity of contaminants in sediment and surface water.	Limited implementablity. Technology not widely proven on a large scale.	Not retained. Too many implementation issues as compared to more proven technologies.
	Phytoremediation		Innovative technology potentially effective degrading and removing organics and removing inorganics.	Limited implementablity. Technology not proven on a field scale. Difficult or impossible to implement on large amounts of sediments and in deep water areas of the lake. May requires maintenance through harvest and removal of plants.	Not retained. Too many implementation issues as compared to more proven technologies.

TABLE 3.4 (CONTINUED)
SCREENING OF REMEDIAL TECHNOLOGIES ASSOCIATED WITH LAKE REMEDIATION

General Response Action (GRA)	Remedial Technology	Variations	Effectiveness	Implementability	Overall Screening Conclusion*
***In Situ* Treatment (continued)**	Solidification/ stabilization		Innovative technology potentially effective at immobilizing and stabilizing heavy metals in a non-leachable matrix. Most effective for ponds, rivers or industrial lagoons where the treatment area can be isolated.	Applications to date identified significant issues associated with implementation. Technology not typically used within an inland lake setting. Inability to control mixing conditions and curing temperature has resulted in no successful applications. Significant sediment resuspension would likely occur.	Not retained. Too many implementation issues as compared to more proven technologies.
	Electrokinetic		Innovative technology potentially effective degrading organics and transforming metals to less toxic forms.	Limited implementablity. Technology not proven on a field scale.	Not retained. Too many implementation issues as compared to more proven technologies.
	Profundal Sediment Chemical Treatment		Unclear effectiveness at reducing releases of total and methylmercury in profundal sediments. Would need further evaluations to determine effectiveness. Potential for undesirable ancillary impacts.	Implementable using material spreading techniques used in eutrophic lakes.	Not retained. Effectiveness very unclear.
***Ex Situ* Treatment**	Thermal Desorption (including thermal retort)		Effective for removal/volatilization of organic constituents and mercury. Not effective for removal of most inorganic compounds, but it has been used to remove mercury. Potential short-term impacts with rehandling steps.	Implementable for some chemicals, but mercury vapor control is complex. USEPA recommends against thermal treatment of mercury due to difficulties in controlling off gas. Requires numerous rehandling steps.	Not retained. Numerous handling and logistical steps. Limited chemical applicability.

TABLE 3.4 (CONTINUED)
SCREENING OF REMEDIAL TECHNOLOGIES ASSOCIATED WITH LAKE REMEDIATION

General Response Action (GRA)	Remedial Technology	Variations	Effectiveness	Implementability	Overall Screening Conclusion*
***Ex Situ* Treatment (continued)**	Incineration/ Vitrification		Effective for destruction and/or removal of organic constituents. Not effective for destruction of inorganic compounds. Potential short-term impacts with rehandling steps.	Potentially implementable. On-site incineration typically meets significant public resistance. Control of mercury vapors is a severe problem	Not retained. Numerous handling and logistical steps. Limited chemical applicability.
	Dechlorination		Potentially effective in detoxifying specific types of aromatic organics, in particular dioxins and PCBs. Not effective for the majority of site sediment COCs. Potential short-term impacts with rehandling steps.	Very difficult to implement due to excessive amounts of reagent required for chlorinated compounds, lack of full-scale applications to date, and lack of commercial availability. Past applications have been in conjunction with thermal treatment.	Not retained. Numerous implementation issues and limited chemical applicability.
	Chemical Extraction		Potentially effective for extracting organics and metals, including chlorobenzenes and mercury. The extraction solution is then treated to remove and recover contaminants. Potential short-term impacts from chemicals and rehandling steps.	Can be difficult to implement due to complex treatment requirements for extraction fluid, lack of full-scale applications to date, and lack of commercial availability.	Not retained. Numerous implementation issues and limited chemical applicability.
	Sediment Washing		Potentially effective physical separation process for removing organics and metals through separation of fine fraction, where this fraction contains the majority of the contamination. Potential short-term impacts from rehandling steps.	Very difficult to implement due to complex treatment requirements for extraction fluid, lack of full-scale applications to date, and lack of commercial availability. The majority of the sediments are fine-grained, so unlikely to be implementable to lake sediments.	Not retained. Numerous implementation issues.

TABLE 3.4 (CONTINUED)

SCREENING OF REMEDIAL TECHNOLOGIES ASSOCIATED WITH LAKE REMEDIATION

General Response Action (GRA)	Remedial Technology	Variations	Effectiveness	Implementability	Overall Screening Conclusion*
***Ex Situ* Treatment (continued)**	Solidification/ Stabilization		Effective for improving material handling and for immobilizing and stabilizing heavy metals in a non-leachable matrix. Stabilizing mercury in soils and sediments, for example, has been tested based on sulfide precipitation. Potential short-term impacts from rehandling steps.	Difficult to implement. Addition of solidifying or stabilizing reagents may increase both volume and weight for disposal or containment.	Not retained. Too many implementation issues as compared to more proven technologies.
	Biological (includes landfarming and slurry phase bioremediation)		Effective at biodegradation of simple organic chemicals. Not effective with transformation of mercury. May release large volumes of volatile chemicals. Potential short-term impacts from rehandling steps.	Difficult to implenment on large scale.	Not retained. Too many implementation issues as compared to more proven technologies.
Aeration (oxygenation)	Aeration (oxygenation)		Potentially effective for reducing methylmercury production.	Implementable. Requires extensive operation and maintenance.	Retained
Habitat Enhancement	Rip-Rap Placement		Effective at stabilizing eroding shorelines.	Implementable. Conventional technology.	Retained
	Shoreline Woody Vegetation		Effective at stabilizing eroding shorelines.	Implementable. Relatively common technology that may require temporary maintenance.	Retained
	Large Woody Debris		Effective at providing habitat structure	Implementable. Conventional technology.	Retained
	Spawning Gravels		Effective at providing spawning habitat	Implementable. Conventional technology.	Retained
	Stabilization of Oncolites and Macrophyte Establishment		Potentially effective at stabilizing oncolites and establishing macrophytes	Potentially implementable. Would require pilot testing to verify effectiveness and most appropriate techniques.	Retained

* The overall screening conclusion considers whether the remedial technology should be “retained” for use in developing remedial alternatives in Section 4 (the next step of the evaluation process) or “not retained” for further evaluation. In addition, some technologies are retained with some provisions presented as presented in this column. For example, some technologies may be more appropriate for particular site conditions and/or SMUs, which is evaluated further in Section 3.11 and Table 3-4 below.

TABLE 3.5

SMU-BASED REMEDIAL TECHNOLOGY SCREENING MATRIX

Sediment Management Unit	No Action	Institutional Controls	Monitored Natural Recovery	Capping			Removal and Consolidation/Disposal			Treatment		In-Lake Barrier Wall	Aeration (Oxy-genation)	Habitat Enhance-ment
				Thin Capping	Engineered Capping	Reactive Capping	Dredging and On-site Consolidation	Dredging and Off-site Disposal	Dry Removal and Disposal	*In Situ* Treatment	*Ex Situ* Treatment and Disposal			
1	X[1]	X	X[2]	--	X	--	X	X	X	--	--	--	--	X
2	X[1]	X	X[2]	--	X	--	X	X	X	--	--	--	--	X
3	X[1]	X	X[2]	--	X	--	X	X	X	--	--	--	--	X
4	X[1]	X	X[2]	--	X	--	X	X	X	--	--	--	--	X
5	X[1]	X	X[2]	--	X	--	X	X	X	--	--	--	--	X
6	X[1]	X	X[2]	--	X	--	X	X	X	--	--	--	--	X
7	X[1]	X	X[2]	--	X	--	X	X	X	--	--	--	--	X
8	X[1]	X	X	X	X	--	X	X	X	--	--	--	X	--

-- Not sufficiently feasible

X - Sufficiently effective and implementable to carry forward to alternative development in Section 4.

1 - This option is retained for comparative purposes only and does not constitute an effective remedial technology.
2 - Based on the conclusions of the Monitored Natural Recovery White Paper (Appendix N), this technology appears to be feasible in the deeper littoral areas from 6 to 9 m deep, but this assumption would need to be further evaluated through design level analysis.