RECORD OF DECISION

Onondaga Lake Bottom Subsite of the Onondaga Lake Superfund Site Towns of Geddes and Salina, Villages of Solvay and Liverpool, and City of Syracuse, Onondaga County, New York

NYSDEC

USEPA Region 2

JULY 2005

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION
ALBANY, NEW YORK

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 2
NEW YORK, NEW YORK

DECLARATION FOR THE RECORD OF DECISION

SITE NAME AND LOCATION

Onondaga Lake Bottom Subsite
Towns of Geddes and Salina, Villages of Solvay and Liverpool, and City of Syracuse, Onondaga County, New York

Superfund Site Identification Number: NYD986913580
Operable Unit 2

STATEMENT OF BASIS AND PURPOSE

This Record of Decision (ROD) documents the New York State Department of Environmental Conservation (NYSDEC) and US Environmental Protection Agency's (EPA's) selection of a remedy for the Onondaga Lake Bottom Subsite (site), which is chosen in accordance with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended (CERCLA), 42 US Code (USC.) §9601, et seq., and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 Code of Federal Regulations (CFR) Part 300. This decision document explains the factual and legal basis for selecting the remedy for the site. Appendix III, attached, is an index that identifies the items that comprise the Administrative Record upon which the selection of the remedy is based.

The New York State Department of Health (NYSDOH) was consulted on the planned remedy in accordance with CERCLA Section 121(f), 42 USC §9621(f), and it concurs with the selected remedy (see Appendix IV).

ASSESSMENT OF THE SITE

Actual or threatened releases of hazardous substances from the site, if not addressed by implementing the response action selected in this ROD, may present an imminent and substantial endangerment to public health, welfare, or the environment.

DESCRIPTION OF THE SELECTED REMEDY

The selected remedy addresses all areas of the lake where the surface sediments exceed a mean probable effect concentration quotient (PECQ) of 1 or a mercury PEC of 2.2 milligrams per kilogram (mg/kg).[1] The selected remedy will also attain a 0.8 mg/kg bioaccumulation-based sediment quality value (BSQV) for mercury on an area-wide basis for the lake and for other applicable areas of the lake to be determined during the remedial design. The selected remedy is also intended to achieve lakewide fish tissue mercury concentrations ranging from 0.14 mg/kg, which is for protection of ecological receptors, to 0.3 mg/kg, which is based on EPA's

---

[1] These cleanup criteria were developed to address acute toxicity to the sediment-dwelling (benthic) community in Onondaga Lake.

methylmercury National Recommended Water Quality criterion for the protection of human health for the consumption of organisms. The major components of the selected remedy include:

- Dredging of as much as an estimated 2,653,000 cubic yards (cy) of contaminated sediment/waste from the littoral zone[2] in Sediment Management Units (SMUs)[3] 1 through 7 to a depth that will prevent the loss of lake surface area, ensure cap effectiveness, remove non-aqueous-phase liquids (NAPLs), reduce contaminant mass, allow for erosion protection, and reestablish the littoral zone habitat. Most of the dredging will be performed in the in-lake waste deposit (ILWD) (which largely exists in SMU 1) and in SMU 2.

- Dredging, as needed, in the ILWD to remove materials within areas of hot spots (to improve cap effectiveness) and to ensure stability of the cap.

- Placement of an isolation cap over an estimated 425 acres of SMUs 1 through 7.

- Construction/operation of a hydraulic control system along the SMU 7 shoreline to maintain cap effectiveness. In addition, the remedy for SMUs 1 and 2 will rely upon the proper operation of the hydraulic control system, which is being designed under IRMs presently underway at the Semet Residue Ponds, Willis Avenue, and Wastebed B/Harbor Brook subsites to control the migration of contamination to the lake via groundwater from the adjacent upland areas.

- Placement of a thin-layer cap over an estimated 154 acres of the profundal zone.[4]

- Treatment and/or off-site disposal of the most highly contaminated materials (e.g., pure phase chemicals segregated during the dredging/handling process). The balance of the dredged sediment will be placed in one or more Sediment Consolidation Areas (SCAs), which will be constructed on one or more of Honeywell's Solvay wastebeds that historically received process wastes from Honeywell's former operations. The containment area will include, at a minimum, the installation of a liner, a cap, and a leachate collection and treatment system.

- Treatment of water generated by the dredging and sediment handling processes to meet NYSDEC discharge limits.

- Completion of a comprehensive lakewide habitat restoration plan.

---

[2] The littoral zone is the portion of the lake in which water depths range from 0 to 9 meters (m) (30 feet [ft]).

[3] For investigation and remediation purposes, the site has been divided into eight SMUs based on water depth, sources of water entering the lake, physical and ecological characteristics, and chemical risk drivers. SMUs 1 through 7 cover the littoral zone and SMU 8 covers the profundal zone.

[4] The profundal zone is the portion of the lake in which water depths exceed 9 m (30 ft) within SMU 8.

- Habitat reestablishment will be performed consistent with the lakewide habitat restoration plan in areas of dredging/capping.[5]

- A pilot study will be performed to evaluate the potential effectiveness of oxygenation at reducing the formation of methylmercury in the water column, while preserving the normal cycle of stratification within the lake. An additional factor which will be considered during the design of the pilot study will be the effectiveness of oxygenation at reducing fish tissue methylmercury concentrations. If supported by the pilot study results, the pilot study will be followed by full-scale implementation of oxygenation in SMU 8. Furthermore, potential impacts of oxygenation on the lake system will be evaluated during the pilot study and/or the remedial design of the full-scale oxygenation system.

- Monitored natural recovery (MNR) in SMU 8 to achieve the mercury PEC of 2.2 mg/kg in the profundal zone and to achieve the BSQV of 0.8 mg/kg on an area-wide basis within 10 years following the remediation of upland sources, littoral sediments, and initial thin-layer capping in the profundal zone. An investigation will be conducted to refine the application of an MNR model and determine any additional remedial measures (e.g., additional thin-layer capping) needed in the profundal zone.

- Investigation to determine the appropriate area-wide basis for the application of the BSQV of 0.8 mg/kg. During remedy implementation, additional remedial measures may be needed (e.g., thin-layer capping) to meet the BSQV on an area-wide basis.

- Implementation of institutional controls including the notification of appropriate government agencies with authority for permitting potential future activities which could impact the implementation and effectiveness of the remedy.

- Implementation of a long-term operation, maintenance, and monitoring (OM&M) program to monitor and maintain the effectiveness of the remedy.

It will be certified on an annual basis that the institutional controls are in place and that remedy-related OM&M is being performed.

A Phase 1A Cultural Resource Assessment for various areas including Onondaga Lake is currently underway. If, based upon the results of this Cultural Resource Assessment, a Phase 1B Cultural Resource Assessment (to locate culturally sensitive areas) is determined to be necessary, it would be performed during the remedial design phase.

The selected remedy also includes habitat enhancement, which is an improvement of habitat conditions in areas where CERCLA contaminants do not occur at levels that warrant active remediation, but where habitat impairment due to stressors has been identified as a concern. Habitat enhancement will be performed along an estimated 1.5 mi (2.4 km) of shoreline (SMU 3) and over approximately 23 acres (SMU 5). Habitat enhancement will be performed consistent with

---

[5] The design and construction of the remedy must meet the substantive requirements for permits associated with disturbance to state and federal regulated wetlands (e.g., 6 New York Code of Rules and Regulations [NYCRR] Part 663, Freshwater Wetlands Permit Requirements) and navigable waters (e.g., 6 NYCRR Part 608, Use and Protection of Waters).

the lakewide habitat restoration plan. This component of the remedy is not intended to satisfy the requirements of CERCLA or the NCP, but is included in order to address requirements of state law.

DECLARATION OF STATUTORY DETERMINATIONS

The selected remedy meets the requirements for remedial actions set forth in CERCLA Section 121, 42 USC §9621, because it: 1) is protective of human health and the environment; 2) meets a level or standard of control of the hazardous substances, pollutants, and contaminants, which attains the legally applicable or relevant and appropriate requirements under federal and state laws (with the possible exception of the most stringent surface water standard for dissolved mercury); 3) is cost effective; and 4) utilizes permanent solutions and alternative treatment (or resource recovery) technologies to the maximum extent practicable. In keeping with the statutory preference for treatment that reduces toxicity, mobility, or volume of contaminated media as a principal element of the remedy, NAPLs will be treated and/or disposed of at an off-site permitted facility.

Because this remedy will result in contaminants remaining on-site above levels that would allow for unlimited use and unrestricted exposure to site media, CERCLA requires that the site be reviewed at least once every five years. If justified by the review, additional remedial actions may be implemented to remove, treat, or contain the contaminated sediments.

ROD DATA CERTIFICATION CHECKLIST

The ROD contains the remedy selection information noted below. More details may be found in the Administrative Record file for this site.

- Contaminants of concern and their respective concentrations (see ROD, pages 16 – 21).

- Baseline risk represented by the contaminants of concern (see ROD, pages 27 – 33).

- Cleanup levels established for contaminants of concern and the basis for these levels (see ROD text boxes "Development of Sediment Effect Concentrations/Probable Effect Concentrations," [page 34]; "Development and Use of the Mean PEC Quotient," [page 37]; and "Application of the Mean PEC Quotient for Determining Remedial Areas/Volumes," [page 38]).

- Manner of addressing source materials constituting principal threats (see ROD, page 71).

- Current and reasonably anticipated future land use assumptions and current and potential future beneficial uses of surface water used in the baseline risk assessment and ROD (see ROD, page 27).

- Potential land and surface water use that will be available at the site as a result of the selected remedy (see ROD, page 27).

- Estimated capital, annual operation and maintenance, and present-worth costs; discount rate; and the number of years over which the remedy cost estimates are projected (see ROD, pages 56 and 81).

- Key factors used in selecting the remedy (e.g., how the selected remedy provides the best balance of tradeoffs with respect to the balancing and modifying criteria, highlighting criteria key to the decision) (see ROD, pages 72 – 73).

AUTHORIZING SIGNATURES

Denise M. Sheehan //ss//	7/1/05
Denise M. Sheehan Acting Commissioner NYSDEC	Date
Kathleen C. Callahan //ss//	7/1/05
Kathleen C. Callahan Acting Regional Administrator EPA, Region 2	Date

THIS PAGE INTENTIONALLY LEFT BLANK.

RECORD OF DECISION FACT SHEET
EPA REGION 2

<u>Site</u>

Site name:	Onondaga Lake Bottom Site
Site location:	Towns of Geddes and Salina; Villages of Solvay and Liverpool; and City of Syracuse, Onondaga County, New York
HRS score:	50
Listed on the NPL:	December 16, 1994

<u>Record of Decision</u>

Date signed:	July 1, 2005
Selected remedy:	Dredging and capping of contaminated sediments/wastes, oxygenation, and monitored natural recovery
Capital cost:	$414,000,000
Operation and maintenance cost:	$3,000,000 per year
Present-worth cost:	$451,000,000

<u>Lead</u>	NYSDEC
Primary Contact:	Timothy Larson, PE, Project Manager, NYSDEC (518) 402-9767
Secondary Contact:	Donald Hesler, Section Chief, NYSDEC (518) 402-9767

<u>Main PRP</u>	Honeywell International, Inc.

<u>Waste</u>

Waste type:	Volatile and semivolatile organic compounds; polychlorinated biphenyls; metals; and principal threat waste
Waste origin:	Discharges from upland sites to the lake
Contaminated media:	Sediment, surface water, and biota

THIS PAGE INTENTIONALLY LEFT BLANK.

DECISION SUMMARY

Onondaga Lake Bottom Subsite
of the Onondaga Lake Superfund Site
Towns of Geddes and Salina; Villages of Solvay and Liverpool; and City of Syracuse, Onondaga County, New York

JULY 2005

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION
ALBANY, NEW YORK

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 2
NEW YORK, NEW YORK

THIS PAGE INTENTIONALLY LEFT BLANK.

TABLE OF CONTENTS

VOLUME 1 OF 2

TABLE OF CONTENTS, continued

List of Figures (Appendix I)

List of Tables (Appendix II)

LIST OF ACRONYMS AND ABBREVIATIONS USED IN ROD AND RESPONSIVENESS SUMMARY

ARAR	applicable or relevant and appropriate requirement
ARCS	assessment and remediation of contaminated sediments
ASLF	Atlantic States Legal Foundation
BERA	baseline ecological risk assessment
BSQV	bioaccumulation-based sediment quality value
BTEX	benzene, toluene, ethylbenzene, and xylenes
C&D	construction and demolition
CAC	Citizens Advisory Committee
CAMP	Community Air Monitoring Plan
CCE	Citizens Campaign for the Environment
CEH	Council on Environmental Health [Onondaga County]
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980
CFR	Code of Federal Regulations
CHASP	Community Health and Safety Plan
cm	centimeter
CNY	Central New York
COC	chemical (or contaminant) of concern
CPOI	chemical parameter of interest
CT	central tendency
CTV	cap threshold value
cy	cubic yard
DNAPL	dense non-aqueous-phase liquid
DO	dissolved oxygen
EIS	environmental impact statement
EPA	Environmental Protection Agency
ER-L	effects range-low
ER-M	effects range-median
ESCSWCS	Empire State Chapter Soil and Water Conservation Society
ESF	Environmental Science and Forestry (SUNY)
FOCUS	Forging Our Community's United Strength
FS	feasibility study
ft	feet/foot
FWCA	Fish and Wildlife Coordination Act
FWIA	fish and wildlife impact analysis
g	gram
GSCC	Greater Syracuse Chamber of Commerce
HASP	health and safety plan
HHRA	human health risk assessment
HSRC	Hazardous Substance Research Center

ILWD	in-lake waste deposit
IRM	interim remedial measure
kg	kilogram
km	kilometer
lb	pound
LCP	Linden Chemicals and Plastics
m	meter
M	million
MANOVA	Multiple Analysis of Variance
Metro	Metropolitan Syracuse Sewage Treatment Plant
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mi	mile
mm	millimeter
MNR	monitored natural recovery
NAPL	non-aqueous-phase liquid
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
ng/L	nanograms per liter
NHPA	National Historic Preservation Act
NLSA	no loss of lake surface area
NOAA	National Oceanographic and Atmospheric Administration
NPL	National Priorities List
NRD	Natural Resource Damage
NRRB	National Remedy Review Board
NYCRR	New York Code of Rules and Regulations
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
NYSDOL	New York State Department of Law
OLP	Onondaga Lake Partnership
OM&M	operation, maintenance, and monitoring
ORD	Office of Research and Development (USEPA)
OSHA	Occupational Safety and Health Administration
OSRTI	Office of Superfund Remediation and Technology Innovation (USEPA)
OSWER	Office of Solid Waste and Emergency Response
OU	operable unit
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCDD/PCDF	polychlorinated dibenzo-p-dioxin/polychlorinated dibenzofuran
PEC	probable effect concentration
PECQ	probable effect concentration quotient
ppm	parts per million
PRG	preliminary remediation goal
PRP	potentially responsible party
PSA	preliminary site assessment

QAPP	quality assurance project plan
RA	remedial action
RAGS	Risk Assessment Guidance for Superfund
RAO	remedial action objective
RD	remedial design
RI	remedial investigation
RME	reasonable maximum exposure
ROD	Record of Decision
RS	responsiveness summary
SCA	sediment consolidation area
SEC	sediment effect concentration
SEL	sediment effect level
SLRIDT	St. Louis River/Interlake/Duluth Tar Site
SMU	sediment management unit
SPDES	State Pollutant Discharge Elimination System
SQG	sediment quality guideline
SUNY	State University of New York
SVOC	semivolatile organic compound
SWAC	surface-weighted average concentration
SYW	Syracuse West (from US Geological Survey quadrant sheet; used to identify New York State wetlands)
TAG	Technical Assistance Grant
TSS	total suspended solids
TWA	time-weighted average
UCL	upper confidence limit
UFI	Upstate Freshwater Institute
μg/kg	micrograms per kilogram
μg/L	micrograms per liter
USACE	US Army Corps of Engineers
USC	US Code
USEPA	US Environmental Protection Agency
USFDA	US Food and Drug Administration
USFWS	US Fish and Wildlife Service
USGS	US Geological Survey
VOC	volatile organic compound
yr	year

SITE NAME, LOCATION, AND DESCRIPTION

On June 23, 1989, Onondaga Lake was added to the New York State Registry of Inactive Hazardous Waste disposal sites. On December 16, 1994, Onondaga Lake and areas upland that contribute or have contributed contamination to the lake system were added to the U.S. Environmental Protection Agency's (EPA's) National Priorities List (NPL). This NPL listing means that the lake system is among the nation's highest priorities for remedial evaluation and response under the federal Superfund law for sites where there has been a release of hazardous substances, pollutants, or contaminants.

Onondaga Lake itself is a 4.6-square-mile (sq. mi) (12-square-kilometer [sq. km]), 3,000-acre lake, approximately 4.5 mi (7.2 km) long and 1 mi (1.6 km) wide, with an average water depth of 36 ft (11 m). The lake has two deep basins, a northern basin and a southern basin, that have maximum water depths of approximately 62 and 65 ft (19 and 20 m), respectively. The basins are separated by a saddle region at a water depth of approximately 56 ft (17 m). Most of the lake has a broad nearshore shelf in water depths of less than 12 ft (3.7 m). This nearshore shelf is bordered by a steep offshore slope in water depths of 12 to 24 ft (3.7 to 7.3 m).

During the summer months, the upper water of Onondaga Lake warms to a greater degree than the deeper water. This causes the water in the lake to stratify (separate) into two layers of water: the epilimnion, which is the warmer, less dense upper layer and is about 30 ft (9 m) thick, and the hypolimnion, which is the colder, denser, bottom layer. During the summer, the hypolimnion becomes anoxic (runs out of oxygen), which has numerous implications for the lake's chemistry and biota (e.g., fish and insect life).

For the purposes of the remedial investigation and feasibility study (RI/FS) and this Record of Decision (ROD), the sediments in the lake are divided into two regions based on these two layers of water: the littoral zone, which includes sediments along the shoreline in less than 30 ft (9 m) of water and which are in contact with the epilimnion, and the profundal zone, which includes sediments in the deep basins in more than 30 ft (9 m) of water, which are in contact with the hypolimnion.

The two largest tributaries to Onondaga Lake, namely Ninemile Creek and Onondaga Creek, contribute 30.4 and 31.4 percent, respectively, of the total water flow to the lake. Other tributaries, in a clockwise direction from the southeast section of the lake, include Ley Creek, Harbor Brook, the East Flume, Tributary 5A, Sawmill Creek, and Bloody Brook (see Figure 1 in the Figures section of this ROD [Appendix I]). In addition to the tributary streams, the treated effluent from the Onondaga County Metropolitan Wastewater Treatment Plant (Metro), located between Onondaga Creek and Harbor Brook, provides a significant portion (approximately 19 percent) of the water entering the lake.

Various local entities have discharged wastewater directly to these tributary streams and/or have waste sites that have, or potentially have, impacted these tributaries and the lake itself.

In general, the eastern shore of Onondaga Lake is urban and residential, and the northern shore is dominated by parkland, wooded areas, and wetlands. There are approximately 320 acres of state-regulated wetlands and numerous smaller wetlands directly connected to Onondaga Lake or within its floodplains.

The northwest upland areas in Liverpool and Lakeland are mainly residential, with interspersed urban structures and several undeveloped areas. Much of the western and southern lakeshore is covered by wastebeds that received wastes generated from Honeywell's former Solvay operations and, to a lesser extent, dredge spoils from the lake. Many of these wastebeds have been abandoned and recolonized by vegetation. Urban centers and industrial zones in Syracuse and Solvay dominate the landscape surrounding the southern and eastern shores of Onondaga Lake from approximately the New York State Fairgrounds to Ley Creek.

The area around Onondaga Lake is the most urban in central New York State. The region experienced significant growth in the twentieth century, and in 2000, Onondaga County was the tenth most populous county in the state. The city of Syracuse is located at the southern end of Onondaga Lake, and numerous towns, villages, and major roadways surround the lake (see Figure 1).

Historically, Onondaga Lake supported a cold-water fishery. Common species found in the lake included Atlantic salmon (*Salmo salar*), cisco (*Coregonus artedii*), American eel (*Anguilla rostrata*), and burbot (*Lota lota*). Today, Onondaga Lake supports a warm-water fish community that is dominated by gizzard shad (*Dorosoma cepedianum*), freshwater drum (*Aplodinotus grunniens*), carp (*Cyprinus carpio*), and white perch (*Morone americana*). Sunfish are abundant in the littoral zone.

Several important sportfish are found in the lake, including channel catfish (*Ictalurus punctatus*), largemouth bass (*Micropterus salmonides*), smallmouth bass (*Micropterus dolomieui*), and walleye (*Stizostedion vitreum*). The shores of Onondaga Lake provide habitat for various mammal species. Woodchuck (*Marmota monax*), muskrat (*Ondatra zibethicus*), and squirrels (e.g., *Sciurus carolinensis*) are regularly observed on the shores of Onondaga Lake. These and other small-mammal species support predators such as mink (*Mustela vison*), fox (*Vulpes fulva* and *Urocyon cinereoargenteus*), and coyote (*Canis latrans*). The less-disturbed shoreline of the northwest section of the lake provides habitat for more reclusive or larger species, such as beaver (*Castor canadensis*) and deer (*Odocoileus virginianus*). Typically, large bodies of water in urban areas provide important habitat to migrating bird species which use the lakeshore as a resting area during migration. Seasonal and resident bird species around the lake include waterfowl, gulls, shorebirds, songbirds, and raptors.

SITE HISTORY AND ENFORCEMENT ACTIVITIES

Onondaga Lake has been the recipient of industrial and municipal sewage discharges for over 100 years. Honeywell has been a major contributor; however, other industries in the area have contributed contamination as well. Other contaminant sources to the lake include the Metro facility, industrial facilities and landfills along Ley Creek, the Crucible Materials Corporation (via Tributary 5A), and the former Oil City.

Honeywell International, Inc., and its predecessor companies operated manufacturing facilities in Solvay, New York, from 1881 until 1986. When Honeywell merged with its predecessor companies on December 1, 1999 (see the text box below [page 3]), it became liable for the contamination those companies introduced into the environment. For clarity, "Honeywell" is used throughout this ROD to refer to Honeywell International, Inc. and its predecessor companies. Honeywell, as a major contributor of contamination to the lake, has been named a potentially responsible party (PRP).

In the late 1800s and early 1900s, Onondaga Lake supported a thriving resort industry based upon the recreational utilization of the lake, including swimming and recreational fishing. The lake also had a plentiful cold-water fishery, which supported a commercial fishing industry until the late 1800s. However, from the late 1800s to the present, Onondaga Lake has been a receptacle for both industrial and municipal wastes.

Salt springs in the vicinity of Onondaga Lake supported a major salt recovery industry throughout the 1800s and were associated with the development of railroads and the Erie Canal in the region. This infrastructure supported the growth of additional industries, including former Honeywell operations (described in greater detail below), petroleum product storage (once known as "Oil City") adjacent to the southeastern shore of Onondaga Lake, fertilizer production, a steel foundry, a vehicle accessory manufacturing facility, pottery and china manufacturing, manufactured gas plants, and many other industries in the Syracuse area. These and other sites are more fully described in the RI/FS. An evolving municipal wastewater management system (initially with the development of a sewer system and later wastewater treatment facilities), now known as Metro, has been in existence since around 1896.

Honeywell International's Predecessor Companies

Honeywell International, Inc. predecessor companies include:

Allied Chemical and Dye Corp. (incorporated December 17, 1920)
General Chemical
Barrett Company
National Aniline and Chemical Company
Solvay Process Company
Semet Solvay Company
⇓
Allied Chemical Corporation (April 28, 1958)
⇓
Allied Corporation (April 27, 1981)
⇓
AlliedSignal, Inc. (September 18, 1985)
⇓
Honeywell International (Present)

Former Honeywell Operations: Production History and Releases

Honeywell's manufacturing processes were based on four major product lines collectively known as the Syracuse Works (see the text box below entitled "Product Lines and Periods of Production at the Syracuse Works"[page 4]). These processes resulted in releases of primarily mercury, organic contaminants, and calcite-related compounds (see the text box below entitled "What Contaminants are in Onondaga Lake?"[page 5]), as described below:

- Soda ash (sodium carbonate) and related products such as baking soda (sodium bicarbonate), sodium nitrite, sodium sesquicarbonate, ammonium bicarbonate, ammonium chloride, calcium chloride, and caustic soda (sodium hydroxide) were produced by a non-electrolytic cell process. The primary dissolved waste/contaminant associated with this process was ionic constituents (calcium, sodium, and chloride ions [Ca^{2+}, Na^{+}, and Cl^{-}, respectively]), and the primary solid component was Solvay waste, which is a white, chalky, calcite-related material.

- Benzene, toluene, xylene, naphthalene, and tar products from the recovery of coal distillation (coking) byproducts. The primary wastes/contaminants associated with this product line were benzene, toluene, ethylbenzene, and xylenes (BTEX), chlorinated benzenes, and polycyclic aromatic hydrocarbons (PAHs), especially naphthalene.

Product Lines and Periods of Production at the Syracuse Works

Facility	Product Line	Period of Production	Primary Contaminant Releases
Main Plant	Soda ash and related products Benzene, toluene, xylenes, naphthalene	1881 – 1986 1917 – 1970	Ionic waste constituents (Ca^{2+}, Na^{+}, and Cl^{-}), Solvay waste, BTEX, chlorinated benzenes, PAHs (especially naphthalene), and PCBs
Willis Avenue Plant	Chlorinated benzenes, hydrochloric acid, and chlor-alkali products	1918 – 1977	Mercury, BTEX, chlorinated benzenes, PAHs (especially naphthalene), PCBs, and dioxins/furans
Bridge Street Plant	Chlor-alkali products Hydrogen peroxide	1953 – 1979 1956 – 1969	Mercury, PCBs, and xylenes

Note: The Bridge Street Plant was sold to Linden Chemicals and Plastics (LCP) in 1979. LCP operated the plant until it closed in 1988.

- Chlorinated benzenes and byproduct hydrochloric acid from the chlorination of benzene. The primary wastes/contaminants associated with this product line were BTEX, chlorinated benzenes, and PAHs, especially naphthalene.

- Chlor-alkali products, including chlorine, caustic potash (potassium hydroxide), caustic soda (sodium hydroxide) produced by an electrolytic cell process, and related products such as potassium carbonate, hydrogen gas, and hydrogen peroxide produced by further reacting chlor-alkali byproducts with other chemicals. The primary wastes/contaminants associated with this product line were mercury, polychlorinated biphenyls (PCBs), and polychlorinated dibenzo-*p*-dioxin/polychlorinated dibenzofurans (PCDD/PCDFs).

Soda ash production at the Main Plant relied on local supplies of sodium chloride brine and limestone. Benzene, toluene, xylene, and naphthalene production at the Main Plant were based on fractional distillation of light oil, a byproduct that was produced by the coke ovens at the Syracuse Works until 1924, after which it was shipped to Syracuse from other locations. Benzene produced at the Main Plant served as the raw material for production of chlorinated benzenes at the Willis Avenue Plant, while xylene and other imported chemicals were used to produce hydrogen peroxide at the Bridge Street Plant.

Chlor-alkali production at both the Willis Avenue Plant and the Bridge Street Plant used mercury cells and diaphragm cells. Both types of cells are used in electrolytic processes for the production of chlorine, sodium hydroxide, and potassium hydroxide from purified sodium chloride and potassium chloride brine.

What Contaminants are in Onondaga Lake?

Honeywell released several of the major organic contaminants found at the Onondaga Lake subsite (e.g., low molecular weight PAHs [LPAHs], chlorinated benzenes, and BTEX) from at least as early as 1918, and began using PCBs and mercury as of the 1940s or possibly the late 1930s.

Benzene, Toluene, Ethylbenzene, and Xylenes: BTEX compounds are used by a number of manufacturers in industrial processes including the manufacture of other chemicals, some rubbers, paints, paint thinners, lubricants, pesticides, and fuel oil, and as cleaning solvents. Benzene, toluene, and xylenes compounds were produced at the benzol facility located at the Honeywell Main Plant and used at the Honeywell Willis Avenue Plant in the production of chlorinated benzenes. Benzene, toluene, and xylenes which were also part of Honeywell's waste streams, were released to the environment by Honeywell, and are each hazardous substances. In animals, benzene is not highly acutely toxic, but chronic exposure can result in central nervous system depression, immunosuppression, bone marrow depression, degenerative lesions of the gonads, fetal growth retardation, damage to genetic material, and solid tumors in several organs. Chronic exposure in humans can result in bone marrow depression, anemia, and leukemia. Breathing benzene can cause drowsiness, dizziness, and unconsciousness. Benzene is considered to be carcinogenic.

Chlorinated Benzenes: Chlorinated benzenes are a group of 12 cyclic aromatic compounds in which one to six hydrogen atoms of a benzene ring have been replaced by up to six chlorine substituents, including monochlorobenzene, dichlorobenzenes, trichlorobenzenes, tetrachlorobenzenes, pentachlorobenzene, and hexachlorobenzene. Chlorinated benzenes were produced by Honeywell's Willis Avenue Plant, which was in operation from 1918 until 1977. Chlorinated benzenes were also part of Honeywell's waste streams, were released to the environment by Honeywell, and are hazardous substances. Chlorinated benzenes are resistant to chemical and biological degradation and tend to accumulate in lipid- (fat-) containing tissues of animals and humans. Chlorinated benzenes have been shown to cause adverse reproductive effects in invertebrates and fish. Chlorinated benzenes can bioaccumulate in humans, and cause adverse health effects (e.g., hexachlorobenzene may cause liver damage).

Mercury: Honeywell used mercury in the production of chlorine and caustic soda at the mercury-cell chlor-alkali plants. Most of the mercury in water, sediments, or plants and animals is in the form of inorganic mercury salts and organic forms of mercury (e.g., methylmercury). Methylation of mercury is a key step in the entrance of mercury into food chains. The biotransformation of inorganic mercury to methylated organic forms in water bodies can occur in the sediment and the water column. Mercury is a known human and ecological toxicant. Methylmercury-induced neurotoxicity is the effect of greatest concern when exposure occurs to the developing fetus. Other adverse effects of mercury include reduced reproductive success, impaired growth and development, and behavioral abnormalities.

Polycyclic Aromatic Hydrocarbons: PAHs is the general term applied to a group of compounds, including naphthalene, comprised of several hundred organic substances with two or more benzene rings. They are released to the environment mainly as a result of incomplete combustion of organic matter and are major constituents of petroleum and its derivatives. Naphthalene and other PAHs were produced by Honeywell in conjunction with the benzene, toluene, and xylenes product line and other industrial activities. PAHs, in particular naphthalene, were also part of Honeywell's waste streams, were released to the environment by Honeywell, and are hazardous substances. While some PAHs are known to be carcinogenic, others display little or no carcinogenic, mutagenic, or teratogenic activity. Several PAHs exhibit low levels of toxicity to terrestrial life forms, yet are highly toxic to aquatic organisms.

Polychlorinated Biphenyls: PCBs are mixtures of up to 209 different compounds (referred to as "congeners") that include a biphenyl and from one to ten chlorine atoms. They have been used commercially since 1930 as dielectric and heat-exchange fluids and in a variety of other applications. PCBs have been used at and released to the environment from the Honeywell facilities. They are persistent and accumulate in food webs. PCBs bioaccumulate in the fatty tissues of humans and other animals. PCBs are considered probable human carcinogens and are linked to other adverse health effects such as developmental effects, reduced birth weights, and reduced ability to fight infection.

Polychlorinated dibenzo-*p*-dioxins/polychlorinated dibenzofurans: PCDD/PCDFs are composed of a triple-ring structure consisting of two benzene rings connected to each other by either two (dioxins) or one (furans) oxygen atoms. Dioxins and furans are byproducts of chemical manufacturing or the result of incomplete combustion of materials containing chlorine atoms and organic compounds. Based on evidence collected by Honeywell from their sites, PCDD/PCDFs were apparently generated as the result of a fire in the chlorination building at the Willis Avenue Plant in the 1930s and as trace contaminants during the various manufacturing operations and thus were released into the environment. PCDD/PCDFs tend to be very insoluble in water; adsorb strongly onto soils, sediments, and airborne particulates; and bioaccumulate in biological tissues. These substances have been associated with a wide variety of toxic effects in animals, including acute toxicity, enzyme activation, tissue damage, developmental abnormalities, and cancer.

In addition to the four major product lines, Honeywell facilities produced coke and producer gas (i.e., a mixture of carbon monoxide, nitrogen, hydrogen, methane, carbon dioxide, and oxygen). Other products were produced for short periods of time as pilot plant or developmental laboratory activity or as start-up operations that were later relocated. These products included:

- Nitric and picric acids.
- Salicylic acid and methylsalicylate.
- Benzyl chloride, benzoic acid, benzaldehyde, and phthalic anhydride.
- Phenol.
- Ammonia (via nitrogen fixation at the Bridge Street Plant).

Although not generally considered part of the Syracuse Works, the Barrett Division of the Semet-Solvay Chemical Company (one of Honeywell's predecessor companies) operated a paving material production facility from 1919 to 1983 at a location that is now part of the Wastebed B/Harbor Brook subsite. This part of the Wastebed B/Harbor Brook subsite consists of several buildings, aboveground storage tanks, and a gravel parking lot.

Former Honeywell Operations: Waste Management and Disposal

Waste was generated by most manufacturing processes at the Syracuse Works. Waste streams for disposal were discharged from the three plants to at least four different destinations: the Semet Residue Ponds (coke byproduct recovery only), Geddes Brook and Ninemile Creek (via the West Flume), the Solvay wastebeds, and directly to the lake (via the East Flume). The Solvay wastebeds are located in the towns of Camillus and Geddes, and in the city of Syracuse (see Figure 2). From approximately 1881 to 1986, these wastebeds were the primary means of disposal for the wastes produced by the Solvay operations. Initial Solvay waste disposal practices consisted of filling low-lying land adjacent to Onondaga Lake. Later, unlined wastebeds designed specifically for Solvay waste disposal were built using containment dikes constructed of native soils, Solvay waste, and cinders, or by using bulkheads made with timber along the lakeshore. The Syracuse Works also had a landfill in the center of Solvay Wastebed 15.

The discharge of Honeywell waste through the East Flume caused the formation of a large ILWD. The ILWD extends approximately 2,000 ft (610 m) into the lake, approximately 4,000 ft (1,219 m) along the lakeshore, and contains waste up to 45 ft (13.7 m) thick. The majority of the ILWD is within the boundaries of SMU[1] (see Figure 4), although some of the ILWD extends into the adjoining SMUs 2 and 7. The ILWD contains waste from all of Honeywell's product lines. The discharges of waste to Geddes Brook and Ninemile Creek through the West Flume, as well as the overflow from Solvay Wastebeds 9 to 15, also caused the formation of deposits of Honeywell wastes and resulted in the development of the deposits in the Ninemile Creek delta in the lake in SMU 4. The seeps overflow from Solvay Wastebeds 1 to 8 contributed to the formation of Honeywell wastes in the lake itself.

Two additional sites (the Mathews Avenue Landfill and the Willis Avenue Ballfield site) were used for disposal of industrial wastes and construction and demolition (C&D) debris from the Syracuse Works. A site known as the dredge spoils area located on the lakeshore northwest of the mouth

---

[1] For investigation and remediation purposes, the site has been divided into eight SMUs based on water depth, sources of water entering the lake, physical and ecological characteristics, and chemical risk drivers. SMUs 1 through 7 cover the littoral zone and SMU 8 covers the profundal zone. See Figure 3 and the section below entitled "Sediment Management Units."

of Ninemile Creek was used for disposal of dredged material from the Ninemile Creek delta and nearshore areas north of Ninemile Creek. Additional information on these Honeywell sites, including a location map, can be found in Chapter 4 of the Onondaga Lake RI report.

In 1970, the Syracuse Works' Main Plant ceased production of benzene, toluene, xylenes, and naphthalene. In addition, releases of mercury from the Willis Avenue Plant and the Bridge Street Plant were reduced. In 1977, when the Willis Avenue Plant closed, the production of chlorinated benzenes and chlor-alkali products at the plant ceased. In 1979, the Bridge Street Plant was sold to Linden Chemicals and Plastics (LCP), which operated the plant until it closed in 1988. In 1986, the Main Plant ceased production of soda ash and related products, marking the end of manufacturing by Honeywell at the Syracuse Works. A time line of a summary of activities since 1986 is provided below.

Time Line of Activities at the Onondaga Lake Bottom Site Since Cessation of Honeywell Production in 1986

Date	Activity
June 23, 1989	Onondaga Lake was added to the New York State Registry of Inactive Hazardous Waste disposal sites.
	⇓
Consent Decree dated March 16, 1992	Honeywell consented to investigate the lake pursuant to the terms of a New York district court ("Consent Decree" – 89-CV-815).
	⇓
December 16, 1994	Onondaga Lake and areas upland of the lake that contribute or have contributed contamination to the lake system were added to EPA's NPL.
	⇓
1992 to 2000	An RI was conducted by Honeywell.
	⇓
2001	Additional investigation conducted by NYSDEC.
	⇓
December 2002	NYSDEC rewrote the RI report and issued it in December of 2002.
	⇓
November 2004	Honeywell completed the FS report. NYSDEC issued the Proposed Plan for public comment.

Satisfaction of all ROD requirements does not represent a settlement with the State of all statutory claims under the State and federal Superfund laws (e.g., State and federal claims for Natural Resource Damages under the Superfund laws are not resolved by satisfaction of all ROD requirements) or of statutory claims under other State and federal environmental laws or of claims under common law.

HIGHLIGHTS OF COMMUNITY PARTICIPATION

The RI and FS reports describe the nature and extent of the contamination at and emanating from the site and evaluate remedial alternatives to address this contamination. The November 2004 Proposed Plan identifies NYSDEC's preferred remedy[2] and the basis for that preference. These documents were made available to the public in both the Administrative Record and information repositories maintained at the NYSDEC Region 7 Office, 615 Erie Boulevard West, Syracuse, New York; NYSDEC Central Office, 625 Broadway, Albany, New York; Onondaga County Public Library Syracuse Branch at the Galleries, 447 South Salina Street, Syracuse, New York; and Atlantic States Legal Foundation, 658 West Onondaga Street, Syracuse, New York. NYSDEC later added three new repositories at libraries in Camillus, Liverpool, and the State University of New York (SUNY) College of Environmental Science and Forestry (ESF) (see Appendix VI, Responsiveness Summary).

NYSDEC conducted a public availability session in February 2003 to present the findings of the RI report to the public.

A notice of the commencement of the public comment period related to NYSDEC's preferred remedy, the public meeting dates, contact information, and the availability of the above-referenced documents was published in the *Syracuse Post-Standard* on November 29, 2004. The public comment period opened on November 29, 2004. NYSDEC held informal availability sessions on January 6, 2005 from 7:00 to 9:00 P.M. and on January 12 and February 16, 2005 from 3:00 to 5:00 P.M., and held formal public meetings on January 12 and February 16, 2005 at 7:00 P.M. at the Martha Eddy Room in the Art and Home Center of the New York State Fairgrounds to present the findings of the RI/FS and Proposed Plan and to answer questions from the public about the site and the remedial alternatives under consideration. Approximately 200 and 100 people, including residents, environmental groups, local businesspeople, and state and local government officials attended the January 12 and February 16 public meetings, respectively. The public comment period was closed on March 1, 2005.

A notice of the commencement of a subsequent public comment period was published in the *Syracuse Post-Standard* on April 1, 2005. The purpose of the subsequent public comment period was to solicit public comments on the Proposed Plan as approved by EPA on March 25, 2005, on the NRRB's recommendations related to its review of the Proposed Plan, and on NYSDEC and EPA's New York regional office's responses to these recommendations. Responses to the written comments received during the public comment periods and to comments received at the public meetings are included in the Responsiveness Summary (see Appendix VI).

In addition, NYSDEC has performed an extensive outreach program relative to the Proposed Plan. NYSDEC met with local stakeholders including the Onondaga Nation (five meetings), Onondaga County Legislature's Environmental Committee, Onondaga County's Department of the

---

[2] EPA abstained from concurring with the Proposed Plan prior to its release to the public in November 2004 since it was not subject to prior review by EPA's National Remedy Review Board (NRRB). The NRRB is an EPA peer review group that reviews all proposed Superfund cleanup decisions that meet certain cost-based or other review criteria to ensure that these proposed decisions are consistent with Superfund law, regulations, and guidance. Subsequent to the issuance of the Onondaga Lake Proposed Plan the NYSDEC met with the NRRB, the NRRB commented on the Proposed Plan and EPA and NYSDEC responded to the NRRB comments. EPA subsequently issued a letter on March 25, 2005 which stated that EPA concurred with NYSDEC's preferred remedy.

Environment, Onondaga Lake Partnership (which consists of federal, state, local, public, and private interests that are involved in managing the environmental issues of Onondaga Lake and the Onondaga Lake watershed), Atlantic States Legal Foundation (Technical Assistance Grant recipient), various local scientists associated with Upstate Freshwater Institute, professors from the State University of New York Syracuse College of Environmental Science and Forestry, and officials and residents of the Town of Camillus (the town in which a sediment consolidation area may be constructed) to discuss the Proposed Plan. NYSDEC also met with environmental organizations, including the Sierra Club, Citizens Campaign for the Environment, and the Central New York Air and Waste Management Association.

SCOPE AND ROLE OF OPERABLE UNIT

The NCP, 40 CFR Part 300, defines an operable unit (OU) as a discrete action that comprises an incremental step toward comprehensively addressing site problems. This discrete portion of a remedial response manages migration or eliminates or mitigates a release, threat of a release, or pathway of exposure. The cleanup of a site can be divided into a number of OUs, depending on the complexity of the problems associated with the site. OUs may address geographical portions of a site, specific site problems, or an initial phase of an action, or may consist of any set of actions performed over time or any actions that are concurrent but located in different parts of a site.

NYSDEC and EPA have, to date, organized the work for the Onondaga Lake NPL site into eight subsites. These subsites, which are shown in Figure 5, are also considered by EPA to be OUs of the NPL site. The Onondaga Lake subsite is one of the OUs at the Onondaga Lake NPL site.

This ROD focuses only on the Onondaga Lake subsite of the Superfund NPL site. The primary objective of this action (the fourth OU for which a ROD has been issued) is to remediate the contamination within Onondaga Lake sediments such that any existing and potential future health and environmental impacts are eliminated or reduced, to the extent practicable.

The status of the other subsites is discussed below. Interim remedial measures (IRMs) are mentioned below to the extent that they address migration of contamination to the lake. The control of contamination migrating from these upland subsites to Onondaga Lake is an integral part of the overall remediation of Onondaga Lake.

Status of Other Onondaga Lake NPL Site Operable Units

The General Motors Ley Creek PCB Dredgings subsite includes areas along the banks of Ley Creek where PCB-contaminated dredge spoils removed from the creek were placed. A ROD was issued by NYSDEC in March 1997. The remediation of a 4,000-ft (1,219-m) stretch of the stream bank containing the dredge spoils (excavation and off-site disposal of PCB-contaminated sediments exceeding 50 parts per million [ppm] and site capping) was completed in August 2001.

In September 2000, NYSDEC issued a ROD for the LCP Bridge Street subsite. In March 2002, Honeywell entered into an administrative consent order with NYSDEC whereby it committed to implement the remedy at the site. The remedial design was approved in September 2004. Remedial construction activities, which include removal of impacted sediments from the West Flume, on-site ditches, and wetlands; restoration of wetlands; installation of a low-permeability cutoff wall around the site; installation of a low-permeability cap; and pumping of groundwater inside the cutoff wall is currently underway. Remediation of the LCP Bridge Street subsite will control discharges of mercury and other contaminants to the West Flume, some of which ultimately migrate to Onondaga Lake through Geddes Brook and Ninemile Creek. It is anticipated that the bulk of the construction will be completed in 2005.

An RI/FS for the Geddes Brook/Ninemile Creek site is underway pursuant to the terms of the Consent Decree referenced in the "Site History" section, above. The RI/FS includes an evaluation of alternatives for remediating channel sediments in lower Ninemile Creek and floodplain soils/sediments along both lower Geddes Brook and lower Ninemile Creek. The remediation of both streams and associated floodplains, in conjunction with remediation of the LCP Bridge Street subsite, is expected to result in a significant reduction of loadings of mercury and other contaminants to Onondaga Lake. In July 2002, Honeywell entered into an administrative consent order with NYSDEC whereby it committed to perform an IRM for Geddes Brook. The IRM will include the removal of all sediments down to the underlying clay layer in the reach of the brook from the West Flume to the confluence with Ninemile Creek. Impacted soils and sediments within the floodplain along lower Geddes Brook will also be remediated. The IRM design is currently underway.

In March 2002, NYSDEC and EPA issued a ROD for the Semet Residue Ponds subsite. The selected remedy includes the excavation of the residue from the Semet Ponds and on-site processing of the residue into benzene, light oil, and a soft tar product to be used in manufacture of driveway sealer. It also includes groundwater collection and on-site treatment. In December 2003, NYSDEC and EPA determined that a potential modification of the remedy, which would allow for the residue to be utilized as an alternative fuel, may be evaluated by way of a focused FS/remedial design/remedial action Consent Order. The Consent Order was executed by NYSDEC and Honeywell in January 2004. A draft focused FS report is currently under review. The remedial design related to the groundwater component of the remedy is currently underway.

The Town of Salina Landfill subsite, which borders Ley Creek, received domestic, commercial, and industrial wastes from the 1950s to the 1970s. A Proposed Plan identifying a preferred remedy for the Salina Town Landfill subsite was released for public comment in January 2003. The proposed remedy included the construction of a 6 NYCRR Part 360 multilayer cap over the landfill areas north and south of the creek and construction of a groundwater and leachate collection trench north and south of the creek.

An RI/FS is presently underway for the Willis Avenue subsite. In March 2002, Honeywell entered into an administrative consent order with NYSDEC whereby it committed to implement an IRM for the lakeshore area downgradient of the Willis Avenue and Semet Residue Ponds subsites. The IRM consists of the design, construction, and operation of a hydraulic containment system. This IRM is planned to eliminate, to the extent practicable, the discharge of groundwater and NAPLs containing contaminants such as chlorinated benzenes, BTEX, naphthalene and other PAHs, and mercury to Onondaga Lake.

Actions will be taken by Honeywell to address wastes to be collected by the hydraulic containment systems for the Willis Avenue and Semet Residue Ponds subsites pursuant to CERCLA. Contaminated groundwater, once collected, will be treated at a wastewater treatment plant that will be constructed on the Willis Avenue subsite. The containment systems will also be designed to collect NAPLs, which will be treated and/or disposed of at an off-site permitted facility. Since these NAPL materials are highly mobile, have high concentrations of toxic compounds, and present a significant risk to human health and the environment should exposure occur, they are characterized as principal threat wastes.

The Willis/Semet IRM is also intended to eliminate, to the extent practicable, direct point-source discharges to the lake through stormwater conveyances (stormwater piping and outfalls associated with I-690), and to eliminate, to the extent practicable, potential impacts to fish and wildlife resources associated with ongoing discharges from the Willis Avenue and Semet Residue Ponds subsites. The design of the IRM is currently underway. Remedial efforts for Tributary 5A are being evaluated by Honeywell as part of the RI/FS for the Willis Avenue subsite.

An amendment to the Willis Avenue RI/FS administrative consent order was signed in 1996 for the performance of an IRM to address the discharge of site-related contaminants from the I-690 storm drain system. As part of the IRM, the system was cleaned and surveyed using video equipment. This work indicated that contaminated groundwater was entering the system through open pipe joints. Remedial work, including the testing and sealing of the open pipe joints, began in 1998 and was completed in 1999. A program for monitoring the effectiveness of the IRM indicated that residual contaminant concentrations were reduced but not eliminated. Due to this residual contamination, a pilot study was initiated in 2002 pursuant to an administrative consent order with NYSDEC to study the isolation of the underdrain (groundwater) flow from the stormwater (from I-690) within the eastern portion of the system. This pilot study is ongoing.

Honeywell is conducting an RI/FS for the Wastebed B/Harbor Brook subsite, which includes the East Flume. In November 2003, Honeywell entered into an administrative consent order with the NYSDEC whereby it committed to implement an IRM for the Wastebed B/Harbor Brook subsite. The IRM consists of the design, construction, and operation of a hydraulic containment system at the Wastebed B/Harbor Brook subsite along the shoreline from the Willis Avenue subsite to Harbor Brook and along the lower portion of Harbor Brook. The IRM is intended to isolate and collect contaminants including mercury, chlorinated benzenes, BTEX, naphthalene and other PAHs, and NAPLs from groundwater before they enter Onondaga Lake and Harbor Brook. Contaminated groundwater, once collected, will be treated at a wastewater treatment plant that is being constructed on Honeywell's Willis Avenue subsite.

The Wastebed B/Harbor Brook subsite IRM design will address collection of NAPLs, which will be treated and/or disposed of at an off-site permitted facility. This IRM will be designed so that it can be integrated with the Willis/Semet IRM (discussed above), resulting in a continuous hydraulic containment system along the entire lakeshore of SMUs 1 and 2 from Tributary 5A to Harbor Brook as well as upstream along the west bank of lower Harbor Brook. Since this IRM involves treatment of source materials constituting principal threat wastes, this IRM also addresses the statutory preference for treatment as a principal element. Pre-design sampling associated with the IRM is underway.

In March 2002, Honeywell entered into an administrative consent order with NYSDEC whereby it committed to implement an IRM for the East Flume. As documented in the Onondaga Lake RI report, the East Flume was historically one of the major discharge locations for mercury and other waste materials to the lake. The IRM for the East Flume includes the excavation of approximately 19,000 cubic yards (cy) (14,500 cubic meters [m^3]) of sediment from within the upper and lower East Flume, the abandonment of an existing 72-inch (183-cm) concrete pipe that discharges to the upper East Flume, and the extension of an existing 60-inch (152-cm) concrete pipe into Onondaga Lake.

An RI/FS is underway at the General Motors former Inland Fisher Guide (IFG) facility subsite. Three significant IRMs have been performed to prevent the migration of PCBs off of the site and into Ley Creek, a tributary to Onondaga Lake. An on-site industrial landfill that contained chromium-and PCB-contaminated material has been capped. The purpose of this IRM was to prevent these contaminants from leaching into the groundwater. A second IRM involved the removal of highly contaminated soil from a former discharge swale. This swale was used, in the 1950s and 1960s, as a conduit for the discharge of liquid process waste to Ley Creek. The swale was subsequently filled in, but the contaminated soil remained until the performance of this IRM. Over 26,000 tons of soil containing hazardous waste levels of PCBs have been removed from the site. The third significant IRM was the construction of a treatment pond and associated water treatment system. This pond collects all water that accumulates on site in any of the storm sewers or abandoned process sewers. The pond water is then sent through the treatment plant in order to meet permitted discharge limits, prior to discharge to Ley Creek. The purpose of this IRM was to stop the intermittent discharge of PCBs and other contaminants that occur during storm events. Construction activities associated with these IRMs have been completed.

SUMMARY OF SITE CHARACTERISTICS

Onondaga Lake is a 4.6-square mile (sq mi) (12-square kilometer [sq km]), 3,000-acre lake, approximately 4.5 mi (7.2 km) long and 1 mi (1.6 km) wide, with an average water depth of 36 ft (11 m). The lake has two deep basins, a northern basin and a southern basin, that have maximum water depths of approximately 62 and 65 ft (19 and 20 m), respectively. The basins are separated by a saddle region at a water depth of approximately 56 ft (17 m). Most of the lake has a broad nearshore shelf in water depths of less than 12 ft (3.7 m). This nearshore shelf is bordered by a steep offshore slope in water depths of 12 to 24 ft (3.7 to 7.3 m).

Site Geology/Hydrogeology

The bedrock geology beneath the lake consists of 500 to 600 ft (150 to 180 m) of sedimentary rocks of the Vernon Shale Formation, which are comprised of soft and erodible mudstones with some localized, discontinuous gypsum seams. The Syracuse Formation overlies the Vernon Formation to the south of Onondaga Lake to an elevation of 300 to 380 ft (90 to 120 m) above mean sea level. The Syracuse Formation is approximately 600 ft (180 m) thick and is comprised of shales, dolostones, and salts. In this formation, groundwater flowing upward to the north toward Onondaga Lake is the source of brines in the area that contribute to the background salinity levels in the lake.

Onondaga Lake is underlain by a thick layer of soft, unconsolidated sediments ranging from approximately 80 ft (24 m) to over 300 ft (90 m) thick beneath the mouth of Onondaga Creek at the south end of the lake.

Two primary hydrogeologic units exist at the lake: unconsolidated deposits and underlying bedrock shale. The unconsolidated deposits were formed by the combination of glacial processes, post-glacial (lacustrine) processes, and human activities. These unconsolidated deposits consist (from top to bottom) of layers of fill, marl, silt and clay, silt and fine sand, sand and gravel, and till overlying the shale bedrock.

Groundwater in the unconsolidated deposits, which overlies the silt and clay layer, comprises an unconfined groundwater zone that provides most of the discharge of groundwater to the lake. There is limited groundwater discharge from the deeper unconsolidated units to the lake. Groundwater from the bedrock discharges to the lower portion of the overlying unconsolidated deposits west of the lake. Total quantities of groundwater discharged to the lake are small compared to discharges of surface water to the lake.

A major influence on groundwater density is salinity (measured by total dissolved solids concentrations). The range in total dissolved solids concentrations in the area of the lake (400 milligrams per liter [mg/L] to almost 194,000 mg/L) is caused by the presence of Honeywell's Solvay wastes and naturally occurring salt brines.

Surface Water Hydrology

Onondaga Lake receives surface runoff from a drainage basin of 285 sq mi (738 sq km). Surface water flows primarily from the south and southeast into the lake through six tributaries: Ninemile Creek, Onondaga Creek, Ley Creek, Harbor Brook, Bloody Brook, and Sawmill Creek. In addition, lesser amounts of surface water are contributed to the lake through two industrial conveyances: the East Flume and Tributary 5A. Ninemile Creek and Onondaga Creek are the largest sources of water flow to the lake and together accounted for approximately 62 percent of the inflow into the lake from surface sources for the period from 1971 to 1989. Discharge from the Metro Plant accounted for approximately 19 percent of the total inflow during the same period. Ley Creek and Harbor Brook accounted for an estimated 8 and 2 percent of the total inflow, respectively. Contributions from all other tributaries, including Bloody Brook, the East Flume, Tributary 5A, and Sawmill Creek were minor in comparison and together accounted for the remaining 9 percent. The highest inflows of water and suspended solids from tributaries occur during the spring due to snowmelt and springtime rain events, peaking in March and April.

Water also enters the lake through an intermittent bidirectional flow from the Seneca River at the outlet of the lake. This bidirectional flow is possible because Onondaga Lake is part of the New York State Barge Canal System, and the elevation of the lake is controlled by a dam on the Oswego River at Phoenix, New York, downstream of the site. Flow from the outlet is sensitive to the rate of tributary inflow, wind speed and direction, water surface elevations in the river and lake, seiche (variation in the lake surface) activity in the lake, elevated salinity, and other factors. Due to the shallowness of the outlet channel, it is likely that only epilimnetic surface water flows out of the lake into the river. The annual contribution of the Seneca River to the lake has not been quantified but is believed to be less than 10 percent of the total flow to the lake on an annual basis.

The lake elevation can influence the characteristics of the nearshore sediments, including wetlands and parts of the littoral sediments that are subject to wave and ice disturbance. The lake is generally at its highest elevation in the early spring due to increased tributary flows and at its lowest elevation during the summer months. For the 30-year period from 1971 to 2000, maximum annual variations in lake levels ranged from 1.6 ft (0.5 m) in 1988 to 7.2 ft (2.2 m) in 1993, with an overall mean of 4.1 ft (1.25 m).

Based on the United States Geological Survey (USGS) data, the following observations have been made:

- The average lake elevation is 362.82 ft (110.59 m) above mean sea level.
- The highest lake level was 369.18 ft (112.53 m) above mean sea level.
- The lowest level was 361 ft (110 m) above mean sea level.

Onondaga Lake is stratified during summer, more weakly stratified in winter, and is vertically mixed in the spring and fall. Summer stratification is most pronounced from May through September due to temperature effects on water density. During summer stratification, the colder (and therefore denser) hypolimnion is unable to mix with the overlying warmer (and therefore less dense) epilimnion. The boundary between the epilimnion and the hypolimnion is called the thermocline and is the region in the water column where the temperature changes most rapidly with depth. In Onondaga Lake, the thermocline is located at approximately 30 ft (9 m) below the water surface. The epilimnetic waters continue to be mixed by wind and wave action, while the hypolimnion is isolated beneath the thermocline.

The hypolimnion receives organic and inorganic solids that settle by gravity from the epilimnion toward the lake bottom. As the summer progresses, biodegradation of the organic solids deplete the oxygen in the hypolimnion, creating anoxic conditions. The presence of an anoxic hypolimnion is not uncommon in stratified lakes. However, oxygen depletion in the hypolimnion of Onondaga Lake is exacerbated by loading of phosphorus to the lake from the Metro Plant discharge, and to a lesser degree from tributaries. Phosphorus is the limiting nutrient that, when it is increased, promotes the growth or productivity of phytoplankton, which in turn increases the organic loading of settling solids to the hypolimnion. Increased phytoplankton productivity also leads to decreased water clarity (due to the high mass of phytoplankton in surface water). In addition to anoxia, elevated concentrations of sulfides and ammonia found in the hypolimnion are considered evidence of advanced cultural eutrophication.

Waters within Onondaga Lake are more saline than in most inland lakes. Solvay Wastebeds 1 through 15 as well as Solvay waste that was disposed of directly in the lake and at other locations along and near the lakeshore are known to contribute calcium, sodium, and chloride to Ninemile Creek and/or the lake. In addition, naturally occurring salt brine, which was collected and evaporated in the vicinity of Onondaga Lake for many years, affects both groundwater and nearby surface water quality. Natural salt springs present near the lake result in saline wetlands. The USGS recently documented a saline spring in Onondaga Creek between Kirkpatrick and Spencer Streets; however, the daily load (on the order of 10 tons [9,000 kilograms {kg}]) is a minor contribution to the salt budget of the lake. The Geddes Brook/Ninemile Creek RI report estimated that the daily total dissolved solids load from Solvay Wastebeds 9 through 15 to Ninemile Creek is on the order of 440 tons (400,000 kg) based on two base-flow sampling events in 1998.

Most solids that enter the lake from tributary inflows settle to the lake bottom and are not transported out of the lake through the outlet. Suspended solids from the tributaries initially settle in nearshore sediment, where the water depth is less then 15 ft (4.5 m). With the exception of deltas formed at the mouth of some tributaries (e.g., Ninemile Creek, East Flume, and Ley Creek), nearshore sediment generally does not accumulate because it is frequently resuspended by wind and waves. Over time, sediment is carried to deeper waters by lake circulation and ultimately settles to the bottom in deeper parts of the lake.

Sediment Characteristics

Based on the depth of the thermocline during stratification, the Onondaga Lake RI report defined sediment located above the thermocline (i.e., 30 ft [9 m]) as littoral sediment and sediment located below the thermocline as profundal sediment. The intent of these designations was to distinguish between the different biological, physical, and chemical processes of the epilimnion and hypolimnion.

Littoral Sediment

Much of the sediment in water depths of less than 15 ft (4.5 m) consists generally of fine silts and clays, sand, and shell fragments.

High concentrations of calcite exist within the littoral sediments throughout most of the lake, due to disposal of Solvay waste during operation of the former Honeywell Main Plant from 1881 to 1986 and past and present input of naturally calcitic sediments from the tributaries. Available data indicate that external calcium loading to the lake decreased by 70 percent between 1983 to 1985 and 1987 to 1989, reflecting the cessation of Honeywell's activities at its Main Plant in 1986. Calcium carbonate deposition also decreased by 64 percent over the 1985 to 1989 time frame.

Oncolites are another form of calcite in littoral sediments of Onondaga Lake. Oncolites are small, oval or irregularly rounded, calcareous concretions that resemble elongated pebbles. Made up of calcium carbonate and a small fraction of organic material, they are found throughout the littoral sediments of the lake, especially along the northeast, north, and northwest shorelines. Oncolites are of relatively low mass and therefore are readily moved by waves and currents. Eventually, oncolites may become stationary if they grow to a sufficient size. In Onondaga Lake, oncolite formation is closely associated with discharges of calcium-laden wastes to the lake by Honeywell.

While much of the littoral zone is considered non-depositional due to wind and wave action, discrete areas at the mouths of the tributaries are depositional. These areas, called deltas, are created when the tributary enters the lake, the flow rate drops sharply, and suspended solids settle to the lake bottom. Sediment in these areas accumulates and reflects the composition of the suspended solids that were transported by the tributary into the lake. The delta at the mouth of Ninemile Creek was dredged in the 1960s to remove material that had accumulated over time.

Another historically depositional area within the littoral zone in the southern corner of Onondaga Lake is the area referred to as the ILWD. This area was formed primarily through the precipitation of calcite (calcium carbonate) and other Honeywell wastes from the overflow of dikes around Wastebed B and discharges via the East Flume.

Profundal Sediment

Profundal sediment (i.e., sediment in water depths greater than 30 ft [9 m]) is characterized by small particle size and relatively high moisture content and relatively high concentrations of phosphorus, nitrogen, and organic carbon, when compared to littoral zone sediments. This sediment is comprised of two units. The first unit extends to approximately 35 inches (90 centimeters [cm]) below the sediment surface and is composed of black clay with distinct layers or laminations. The clay has a sulfide smell and gas bubbles (presumably methane) are present. The second unit extends from approximately 35 inches (90 cm) to at least 16 ft (500 cm) below the sediment surface and is composed of dark gray clay with occasional wood fragments and snail shells. This unit also contains laminations, though they are less distinct than in the first unit. The laminations are attributed to deposition of calcite, clays, and diatoms (silica) associated with erosion of the watershed, productivity cycles within the lake, and other annual events.

Areas of Archaeological or Historical Importance

The Onondaga Nation has asserted that Onondaga Lake lies within its aboriginal territory and that Onondaga villages were located on the shores of the Lake. The Nation asserts it relied heavily on the Lake and its tributaries in the past for fishing, gathering of plants for medicinal and nutritional needs, and for recreation. Later, in the late 1800s and early 1900s, Onondaga Lake supported a thriving resort industry based upon the recreational utilization of the lake, including swimming and recreational fishing. The lake also had a plentiful cold-water fishery, which supported a commercial fishing industry until the late 1800s. However, from the late 1800s to the present, Onondaga Lake has been a receptacle for both industrial and municipal wastes.

A draft Phase 1A Cultural Resource Assessment for the project area was produced in October 2004; this report noted the likelihood that the proposed project might encounter both recorded and unrecorded prehistoric and historic resources. Consequently, it is likely that once the area of remedial impact becomes established, additional cultural resource investigations will be required before the remedy is implemented.

Results of the Remedial Investigation

To determine the nature and extent of contamination and assess risks to humans and the environment, as part of the RI, more than 6,000 samples were collected and analyzed for contaminants including metals, volatile organic compounds (VOCs), and semivolatile organic compounds (SVOCs). A human health risk assessment (HHRA) and baseline ecological risk assessment (BERA) were completed as part of the RI process. These risk assessments are discussed in the "Summary of Site Risks" section of this ROD. The RI, HHRA, and BERA reports were finalized by NYSDEC in December 2002. NYSDEC conducted a public availability session in February 2003 to present the findings of these documents to the public.

As a result of the RI studies and risk assessments, numerous contaminants were identified as chemical parameters of interest (CPOIs) (see the text box entitled "What are Chemical Parameters of Interest?"[page 17]). The RI report presents information on site history, field and laboratory investigations, physical characteristics of the site, sources of contamination, nature and extent of contamination, and fate and transport of contaminants. The results of the RI are summarized below.

Sediments

- Mercury contamination is found throughout the lake, with the most elevated concentrations detected in sediments in the Ninemile Creek delta and in the ILWD, which extends along the southern shoreline from near Tributary 5A to beyond Harbor Brook.

- Mercury contamination is widespread in the upper 6.5 ft (2 m) of the sediments in the lake, and it is even deeper in sediment in the Ninemile Creek delta and the ILWD. At the Ninemile Creek delta, mercury contamination extends to a depth of at least 16.4 ft (5 m) into the sediments. Mercury contamination extends to a depth of about 26.2 ft (8 m) and possibly greater into the sediment/waste in the ILWD.

- The organic contaminants (e.g., BTEX, chlorinated benzenes, low molecular weight PAHs [LPAHs], PCBs, and PCDD/PCDFs) are primarily found in the ILWD and the shoreline area of the Honeywell sites, with concentrations of these CPOIs in the waste several orders of magnitude higher than in most of the lake. At the ILWD, elevated concentrations of these CPOIs extend to a depth of at least 26.2 ft (8 m). High molecular weight PAHs (HPAHs) are concentrated in the sediments throughout much of the southern basin of the lake, with the highest concentrations occurring off the former Oil City shoreline region and the shoreline areas near the Honeywell sites.

- Elevated contaminant concentrations and visual evidence (e.g., liquids, droplets, sheens) indicate that NAPL (e.g., chlorinated benzenes, which were manufactured and released as a waste by Honeywell) exists throughout the ILWD and in an area off the Honeywell causeway. Based on data collected during the RI/FS, it was determined that the NAPLs and highly contaminated waste materials in these areas of the lake are highly mobile, at least when disturbed, have high concentrations of toxic compounds, and present a significant risk to human health and the environment should exposure occur; therefore, they are characterized as principal threat wastes. In the areas of the ILWD that are far from shore (approximately 660 to 980 ft [200 to 300 m]), it is most likely that these NAPLs were disposed of directly into the lake with the other wastes.

As discussed in the "Description of Lakewide Alternatives" section of this ROD, the volume of materials (contaminated sediments/wastes) in the littoral zone that exceed the cleanup criteria range from about 12 million cy to more than 20 million cy.

What are Chemical Parameters of Interest?

The **chemical parameters of interest**, or **CPOIs**, for the Onondaga Lake RI/FS are defined as those elements or compounds that were selected as **contaminants of potential concern (COPCs)**, **chemicals of concern (COCs)**, or **stressors of concern (SOCs)**. The major classes of CPOIs include mercury and other metals, BTEX, chlorinated benzenes, PAHs, PCBs, PCDD/PCDFs, and calcite.

COPCs: COPCs are used in human health risk assessments (HHRAs) to determine contaminants that may be harmful to humans. An HHRA for the Onondaga Lake subsite was performed as part of the RI. COPCs were developed using available contaminant concentration data for lake fish (fillets only; limited to species likely to be consumed by humans), and for water and sediments in the northern and southern basins of the lake. A total of 62 COPCs were identified in the HHRA that fall into the classes identified above plus pesticides and additional VOCs and SVOCs (see Table 1).

COCs: COCs are used in baseline ecological risk assessments (BERAs) to determine chemicals that may be harmful to the environment. A BERA for the Onondaga Lake subsite was performed as part of the RI. COCs were developed using toxicity values to establish conservative thresholds for adverse effects to ecology (water, surface sediment, surface soil, plants, fish, and wildlife). As presented in the BERA, numerous toxic chemicals were detected at elevated concentrations in various lake media. A total of 38 COCs were identified in the BERA that fall into the classes identified above plus pesticides and additional SVOCs (see Table 2).

SOCs: SOCs are used in BERAs to determine those chemical contaminants which may not be addressed as hazardous wastes or hazardous substances, but which may cause effects or conditions that are harmful to the environment. The SOCs identified in the BERA include calcite and oncolites in sediments and calcium, chloride, salinity, ammonia, nitrite, phosphorus, and sulfide in water, as well as depleted dissolved oxygen and reduced water transparency (see Table 2).

Surface Water

- Concentrations of total mercury in lake water are highest in the nearshore areas around both Ninemile Creek and the ILWD. In the deep basins, water column total mercury concentrations increase significantly in the hypolimnion during summer stratification, with a high fraction of this hypolimnetic total mercury occurring in the dissolved phase.

- Concentrations of benzene, chlorobenzene, and dichlorobenzenes in lake water are highest near the Honeywell source areas in the vicinity of the East Flume and Harbor Brook.

Biota

- Mercury, PCBs, hexachlorobenzene, and PCDD/PCDFs have bioaccumulated in Onondaga Lake fish, and mercury has been found at elevated levels in benthic macroinvertebrates. It is likely that these contaminants have bioaccumulated in other biota (e.g., birds, mammals) as well; however, there are insufficient data to quantitatively assess the extent of bioaccumulation in these other biota. Consumption of fish drives the potential cancer risks and non-cancer hazards for humans (see the "Summary of Site Risks" section of this ROD).

- As discussed in the HHRA report, concentrations of mercury (as methylmercury) in tissue of edible-size fish collected from the lake since 1992 range from less than 0.1 to 5.1 milligrams per kilogram (mg/kg) (or ppm), with the average concentration of 1.1 mg/kg exceeding the US Food and Drug Administration limit of 1 mg/kg.

Impacts to Fish and Wildlife Resources

The contamination in the media described above has contributed to negative effects on the fish and wildlife resources around Onondaga Lake in a number of ways, including:

- Oncolite formation.
- Spring and fall turnover, which were not regular occurrences in the lake during the period of ionic waste discharges.
- Chloride loadings to Onondaga Lake from Solvay waste.
- Reduced species richness and a standing crop of macrophytes in the nearshore zone.
- Reduced species richness of zooplankton communities.
- Increased dominance of benthic macroinvertebrate communities by pollution-tolerant taxa.
- Reduced reproduction in the lake by numerous fish species.
- Elimination of cold-water fishery.
- Mercury, PCB, and PCDD/PCDF contamination of fish.
- Lack of amphibian reproduction in wetlands that are directly connected to lake water.
- Reduced species richness of amphibians and reptiles.

A detailed evaluation of the nature and extent of contamination, including contaminant distribution maps and concentration ranges of CPOIs in site media, can be found in Chapter 5 of the RI report.

Fate and Transport of Contaminants

Some of the key findings of the CPOI fate and transport analyses include:

<u>General</u>

- The lake is a sink for essentially all contaminants. For every CPOI examined, the estimated loads of contaminants entering the lake are at least five times greater than the loads leaving the lake.

- Several important contaminant source areas or mechanisms have been identified. These transport routes serve to deliver multiple contaminants to the lake. Among the routes and mechanisms are the following:

  – Ninemile Creek: This tributary has been and continues to be the single largest external source for total mercury. It has also been a source of PCDD/PCDFs, PCBs, lead, and chromium to the lake.

  – Harbor Brook: This tributary has been and continues to be a major source of LPAHs, particularly naphthalene, to the lake.

  – Ley and Onondaga Creeks: These tributaries appear to be ongoing sources of PCBs, and possibly PCDD/PCDFs, and are among the largest sources of lead to the lake.

  – East Flume: This tributary has been a long-term and important conduit for mercury, chlorinated benzenes, PAHs, and PCDD/PCDFs to the lake.

  – Honeywell lakeshore area groundwater: Transport of contaminants to the lake via groundwater represents the most important loading route for several CPOIs, including LPAHs such as naphthalene (from the Wastebed B/Harbor Brook site), chlorobenzene and dichlorobenzenes (from the Willis Avenue site), and all four BTEX compounds(from the Willis Avenue, Semet Residue Ponds, and Wastebed B/Harbor Brook sites). The NAPL plumes, which lie beneath the Willis Avenue and Wastebed B/Harbor Brook sites, contribute to the groundwater contamination and may also be contributing NAPL directly to the lake.

  – ILWD: Resuspension of these materials presents a significant source of mercury to the lake, perhaps representing the largest internal source to the water column. It is also a potentially important source of PCDD/PCDFs, BTEX, chlorinated benzenes, PCBs, PAHs, and other non-mercury CPOIs. Surface concentrations of several CPOIs are highly elevated in this waste area relative to the rest of the lake.

  – Profundal sediments: These sediments appear to be responsible for the increase in the hypolimnetic mercury inventory during summer stratification. This increase is believed to be a major source of mercury in the lake.

Mercury

- The lake sediments contain a huge reservoir of mercury. Both profundal and littoral sediments have high mercury inventories.

- Internal loads of mercury, generated via sediment resuspension and other mechanisms, probably yield a net load to the water column similar in magnitude to the externally derived loads, at least during the period of summer stratification.

- The primary removal mechanism for mercury in the water column of Onondaga Lake is particle settling. Deposition to the profundal sediments is the ultimate fate of most of the mercury in the lake, although data indicate that this mercury is not entirely sequestered from the environment.

- Internal sources of total mercury include the resuspension and transfer of materials from the ILWD and the transfer of dissolved and particulate mercury from the profundal sediments. Resuspension and transfer of materials from the ILWD contributes a significant flux to the epilimnion mercury budget, while the transfer of materials from profundal sediments is an additional source of total mercury to the hypolimnion.

- Wind-driven resuspension (i.e., resuspension of lake sediments during windy conditions) is a major mechanism for the release of contaminants from the ILWD and possibly other littoral zone sediments. Groundwater advection through these materials may also transport significant quantities of mercury, as well as other CPOIs, to the lake.

- Particle resuspension and increased diffusion associated with methane gas ebullition in the anoxic sediments (i.e., disturbance of the lake bottom sediments by escaping methane bubbles) are the likely mechanisms for the release of mercury from profundal sediments to the hypolimnetic water column.

- The primary source of methylmercury to the water column is the methylation of total mercury in the hypolimnetic water column during the recurring anoxic stratified period. Diffusion of methylmercury across the thermocline provides the majority of the methylmercury budget to the epilimnion during the summer stratified period. The methylmercury produced in the hypolimnion during stratification escapes to the oxic waters of the lake during the process of fall turnover, resulting in a substantial increase in the epilimnetic concentrations.

Chemical Parameters of Interest Other than Mercury

- The lake sediments represent a huge reservoir of contaminant mass for many other CPOIs. Significant contamination other than mercury exists in the littoral zone near the Honeywell lakeshore area, extending along the shore as far as Ley Creek for some compounds. This inventory of contamination cannot be considered sequestered as it is in an area subject to wind-driven waves. The ILWD is located in this region, representing a clear source of contamination to the water column of the lake.

- Low molecular weight organics, such as BTEX, chlorinated benzenes, and LPAHs, tend to be found in sediments offshore of Honeywell's former facilities. An apparent combination of rapid deposition and rapid biodegradation, as well as groundwater-based releases, has resulted in a sediment inventory that is primarily located near the source area.

- High molecular weight organics, such as HPAHs, PCDD/PCDFs, and PCBs, are present at elevated levels throughout the lake bottom sediments, reflecting their resistance to biodegradation as well as the extended period of discharge to the lake by Honeywell and possibly other sources.

- The likely sources of the current loads of BTEX, chlorinated benzenes, and LPAHs include groundwater and NAPL from the various Honeywell upland sites and the ILWD area.

- The largest sources of PCBs to the lake are likely the ILWD and Ley Creek.

- The largest sources of PCDD/PCDFs to the lake are likely Ninemile Creek (octachlorodibenzodioxin- and tetrachlorodibenzofuran-dominant), the East Flume (tetrachlorodibenzofuran-dominant), and Ley Creek (octachlorodibenzodioxin-dominant).

- Elevated levels of cadmium, chromium, copper, lead, nickel, and zinc are found in the lake sediments. The pattern of contamination suggests sources other than, or in addition to, Honeywell for many of these metals. In part because of their longevity in the environment, these metals can be found at levels above background throughout the sediments of the lake bottom.

<u>Calcite Precipitation and Ionic Wastes</u>

- The rate of calcite formation has diminished by at least half since the closure of Honeywell's Main Plant. Current sedimentation rates are about half of the pre-1986 sedimentation rates.

- Currently, ionic concentrations remain elevated with respect to other nearby water bodies, even though, overall, ionic concentrations in the lake water have been significantly reduced from conditions in the 1980s and earlier.

- Oncolites are found throughout the littoral zone along most of the northern part of the lake and may have had a significant effect on the ecological structure of the lake by creating an unstable substrate for macrophyte (aquatic plant) colonization, thus limiting macrophyte distribution.

A detailed evaluation of the fate and transport of CPOIs can be found in Chapter 6 of the RI report.

See Tables 3, 4, and 5 (in the Tables section of this ROD [Appendix II]) for summaries of sediment data from all depths, Table 6 for surface water data from all depths, and Table 7 for fish data.

Sediment Management Units

For investigation and remediation purposes, the site has been divided into eight SMUs based on water depth, sources of water entering the lake, and physical, ecological, and chemical characteristics (see Figure 3). The division of the site into SMUs allowed the development and evaluation of remedial alternatives appropriate to each area. The remedial alternatives evaluated for each SMU were then used in combination to develop comprehensive, lakewide remedial alternatives which would reduce site risks to humans and the environment. SMUs 1 through 7 are located in the littoral zone of the lake (i.e., water depths of 0 to 30 ft [0 to 9 m]), and SMU 8 covers the profundal zone (i.e., water depths of greater than 30 ft [9 m]).

SMU 1

SMU 1 is located at the southern end of Onondaga Lake and encompasses the majority of the ILWD. The ILWD was formed primarily through the deposition of calcium carbonate and other wastes from the overflow of dikes around Wastebed B and through discharges via the East Flume. These discharges into the lake are believed to have included a combination of cooling water, sanitary waste, Solvay waste, mercury wastes, and organic chemical wastes, which settled out and formed a large delta that is at a higher elevation than surrounding areas of the lake bottom. This waste material is typically described as very soft to soft, although there are some harder crusts. This softness, along with geophysical evidence of historical failures (i.e., underwater slumping or "landslides" associated with the ILWD), causes concern as to whether the wastes in their current configuration are sufficiently stable to prevent a portion of the ILWD from slumping in the future.

SMU 1 is located directly offshore of Wastebed B, and the East Flume and Harbor Brook enter Onondaga Lake here. SMU 1 extends approximately 3,850 ft (1,170 m) west from the mouth of Harbor Brook, encompassing a surface area of approximately 84 acres. At its widest point, SMU 1 extends approximately 2,200 ft (671 m) into the lake. Lake bathymetry indicates that the nearshore shelf (at water depths less than 13 ft [4 m]) is relatively broad and is bordered by a steeper offshore slope at water depths from 13 to 30 ft (4 to 9 m).

A portion of the SMU 1 shoreline is contiguous with the state-regulated wetland SYW-19 (see Figure 6), which is dominated by Phragmites while the rest of the shoreline is partially forested. Nearshore sediments are dominated by Solvay waste (e.g., calcium carbonate deposits). Macrophyte beds are lacking, fish reproduction appears low, and there is a severely impaired benthic community.

Multiple external sources for most of the CPOIs present in the lake have been identified in the vicinity of SMU 1, including the Wastebed B/Harbor Brook and the Willis Avenue subsites.

NAPL is present within layers of the ILWD and is typically found in small brown nodules. The NAPL does not appear to be present in continuous layers. Sheens were also noted on the lake surface at every location in this area during intrusive activities. There is evidence of mobility of the NAPL residual in the lake during intrusive activities such as well placement, sediment coring and sample collection, and likely during sediment resuspension caused by wind-driven waves. Since these NAPLs and other highly contaminated materials in the lake in this area are highly mobile, have high concentrations of toxic compounds, and present a significant risk to human health and the environment should exposure occur, they are characterized as principal threat wastes.

Risk concerns and associated CPOIs and stressors in SMU 1 include sediment toxicity to benthic macroinvertebrates (mercury, ethylbenzene, xylenes, chlorobenzene, dichlorobenzenes, trichlorobenzenes, PAHs, total PCBs); exposure of humans to sediments by wading (arsenic, PAHs, PCDD/PCDFs, hexachlorobenzene); exposure of fish to mercury and other CPOIs and subsequent human and wildlife consumption of fish; benthic macroinvertebrate/insect consumption by wildlife (PAHs, barium, chromium, mercury, methylmercury, selenium); a moderately to severely impaired benthic community (sediment toxicity); and impaired habitat conditions (limited macrophyte cover).

SMU 2

SMU 2 is located in the southern portion of the lake offshore from the causeway formerly used by Honeywell for loading and unloading materials. The SMU extends approximately 3,000 ft (914 m) along the southern shore of the lake, from the border with SMU 1 toward Tributary 5A. At its widest point, SMU 2 extends approximately 550 ft (170 m) into the lake. Lake bathymetry indicates that the nearshore shelf is relatively broad, except near the mouth of Tributary 5A, where it becomes steeper (*i.e.*, greater than 15 percent slope). Storm drains associated with I-690 discharge into this SMU.

Natural shoreline features, including vegetation, are lacking in SMU 2. The littoral zone sediments are dominated by calcium carbonate deposits. Macrophyte beds are lacking, there is a moderately impaired to severely impaired benthic community, and evidence of fish reproduction in the area is low to none.

Multiple external sources for most of the CPOIs present in the lake were identified in the vicinity of SMU 2, including the Semet Residue Ponds and the Willis Avenue subsites.

Stained fill material was observed at one location within SMU 2. The 0 to 10.5 ft (0 to 3.2 m) depth interval at this location contained black impacted fill material that was granular in nature (slag, brick, wood, etc.) and was, according to Honeywell, likely placed during the construction of the causeway in the 1970s. The staining of the fill material may be a result of NAPL in this area. The source of the contamination at this location is likely related to the NAPL (chlorinated benzenes) plume from the Willis Avenue site or from the I-690 storm drains in the area, which intercept a portion of the contaminated groundwater from the Honeywell site. The NAPLs and other highly contaminated materials in the lake in this area are also characterized as principal threat wastes.

Risk concerns and associated CPOIs and stressors in SMU 2 include sediment toxicity to benthic macroinvertebrates (mercury, ethylbenzene, xylenes, chlorobenzene, dichlorobenzenes, trichlorobenzenes, PAHs, total PCBs); exposure of humans to sediments by wading (arsenic, PAHs, PCDD/PCDFs, hexachlorobenzene); exposure of fish to mercury and other CPOIs and subsequent human and wildlife consumption of fish; benthic macroinvertebrate/insect consumption by wildlife (PAHs, barium, chromium, mercury, methylmercury, selenium); a moderately to severely impaired benthic community (sediment toxicity); and impaired habitat conditions (limited macrophyte cover and oncolites).

SMU 3

SMU 3 is located offshore of Honeywell's inactive Solvay Wastebeds 1 through 8, which were used to dispose of wastes from the manufacturing of soda ash via the Solvay process. SMU 3 extends approximately 8,000 ft (2,440 m) west from SMU 2. At its widest point, it extends approximately 825 ft (250 m) into the lake. Lake bathymetry indicates that the shelf is relatively steep in the southern part of SMU 3, becoming broader to the north.

The sediments are dominated by calcium wastes including oncolites. Macrophyte beds are generally sparse, but increase at the border with SMU 4. The immediate shoreline is erosional, but vegetation on the Solvay wastebeds supports terrestrial wildlife. Evidence suggests that fish reproduction is low. The benthic community impacts vary widely from slightly to severely impacted.

Risk concerns and associated CPOIs and stressors in SMU 3 include sediment toxicity to benthic macroinvertebrates in some areas (mercury, ethylbenzene, xylenes, dichlorobenzenes, total PCBs); impaired habitat conditions (calcitic sediments, unstable shoreline, limited macrophyte cover [except at the border of SMUs 3 and 4]); a slightly to moderately impaired benthic community (sediment toxicity in some areas); and impaired habitat conditions (limited macrophyte cover and oncolites).

SMU 4

SMU 4 is located along the shore of Onondaga Lake west of SMU 3 and includes the delta where Ninemile Creek discharges into the lake. SMU 4 extends approximately 3,300 ft (1,006 m) along the shore of the lake. At its widest point, it extends approximately 1,375 ft (420 m) into the lake. Lake bathymetry indicates that the shelf is relatively steep in the northern part of SMU 4, becoming broader to the south. The sediment load at the mouth of Ninemile Creek drives the depositional processes along the central portion of this SMU by discharging fine- and coarse-grained material to the lake. The sediment load from the creek influences the bathymetry and water depth in the central portion of this SMU.

SMU 4 is contiguous with state-regulated wetland SYW-10 (see Figure 6), which is a floodplain forest. Macrophyte beds are prevalent in the depositional areas of Ninemile Creek. During low water events in late summer, exposed sediments attract shorebirds. Evidence suggests significant fish reproduction in the area. Some sediments of the SMU include eroded Solvay wastebed materials and oncolites. The benthic community is moderately impacted.

Multiple external sources were identified in the vicinity of SMU 4, including the LCP Bridge Street site, West Flume, Geddes Brook and Ninemile Creek, and Honeywell's Solvay Wastebeds 1 through 15. The LCP Bridge Street site is located along the West Flume and consists of 20 acres of land used by Honeywell for chlor-alkali production. The West Flume discharges into Geddes Brook, which discharges into Ninemile Creek.

Risk concerns and associated CPOIs and stressors in SMU 4 include moderately impaired benthic community; habitat conditions (limited macrophyte cover in some areas); and exposure of fish to mercury and other CPOIs and subsequent human and wildlife consumption of fish.

SMU 5

SMU 5 includes the littoral zone along the northern and western shores of the lake. Sawmill Creek and Bloody Brook discharge into SMU 5. The Seneca River, the main discharge point for Onondaga Lake, is also located within SMU 5 at the northwestern end of the lake. SMU 5 extends approximately 30,000 ft (9,144 m) from the Ninemile Creek delta to the Ley Creek delta. At its widest point, it extends approximately 1,375 ft (420 m) into the lake. Lake bathymetry indicates that the nearshore shelf (at water depths less than 13 ft [4 m]) is relatively broad and is bordered by a steep offshore slope at water depths from 13 to 30 ft (4 to 9 m).

Habitat conditions vary significantly across SMU 5. The northwest section is contiguous with state-regulated wetland SYW-6 (see Figure 6), which includes floodplain forest and emergent wetlands. There are large macrophyte beds and overhanging vegetation that encourage fish reproduction. The remainder of the shoreline is dominated by human uses, including the Onondaga Lake Park and roadways. Some shoreline vegetation is present. The sediments throughout the SMU are dominated by calcium carbonate and oncolites. Macrophytes and fish reproduction decrease along the northeast section of the SMU. The benthic community is slightly to moderately impacted.

External sources for some CPOIs present in the lake were identified within the vicinity of SMU 5 in the Bloody Brook area. Bloody Brook runs through an industrial complex, some suburbs, and some major transportation rights of way, discharging into the middle of the northern side of the lake.

Risk concerns and associated CPOIs and stressors in SMU 5 include slightly impaired habitat conditions in some areas (oncolites and limited macrophyte cover in some areas) and slightly to moderately impaired benthic communities and limited macrophyte cover in some areas.

SMU 6

SMU 6 extends approximately 5,000 ft (1,500 m) along the eastern end of Onondaga Lake from the mouth of Ley Creek to 700 ft (213 m) south of the mouth of Onondaga Creek, and includes where Ley Creek, Onondaga Creek, and Metro discharge into Onondaga Lake. At its widest point, it extends approximately 1,925 ft (590 m) north into the lake. Lake bathymetry indicates that the nearshore shelf is relatively broad.

The SMU 6 shoreline is contiguous with state-regulated wetland SYW-12 (see Figure 6), which includes floodplain forest and emergent wetlands. Sediments are less dominated by calcium carbonate deposits than some other SMUs and oncolites are not abundant. Macrophyte beds are present, especially at the mouth of Onondaga Creek. Fish reproduction appears low. The benthic community is moderately to severely impacted.

Multiple external sources and potential sources for some of the CPOIs present in the lake were identified in the vicinity of SMU 6, including Ley Creek, Onondaga Creek, and the former Oil City area. The Ley Creek area contains the GM – IFG site, the GM Ley Creek Dredgings site, the Town of Salina Landfill, and the GM Old Ley Creek Channel site. The Onondaga Creek area includes the Niagara Mohawk – Erie Boulevard Manufactured Gas Plant site, the Niagara Mohawk – Hiawatha Boulevard Manufactured Gas Plant site, the Roth Steel site, and the American Bag and Metal site. The former Oil City area was used as a bulk storage and transfer facility for numerous industries. These sites are discussed further in the Onondaga Lake RI report. Although the Honeywell sites and former facilities (and related discharge points) are not located adjacent to the shoreline of SMU 6, the effects of Honeywell's facilities and discharges are evident in the sediments of this SMU based on the presence of Honeywell CPOIs.

Risk concerns and associated CPOIs and stressors in SMU 6 include sediment toxicity to benthic macroinvertebrates (mercury, ethylbenzene, xylenes, dichlorobenzenes, PAHs, total PCBs); sediment exposure to humans by wading (arsenic, PAHs, PCDD/PCDFs, hexachlorobenzene); exposure of fish to mercury and other CPOIs and subsequent human and wildlife consumption of contaminated fish; benthic macroinvertebrate/insect consumption by wildlife (PAHs, barium, chromium, mercury, methylmercury, selenium); and impaired habitat conditions (limited macrophyte cover).

SMU 7

SMU 7 is located at the southern corner of Onondaga Lake and includes the littoral zone located between SMU 1 and SMU 6. SMU 7 is located between Harbor Brook to the west and the

Onondaga Creek delta to the east and extends approximately 1,375 ft (420 m) along the shore of the lake. At its widest point, it extends approximately 2,200 ft (670 m) into the lake. Lake bathymetry indicates that the shelf is relatively broad near the shore, becoming slightly steeper at a water depth greater than 13 ft (4 m).

A portion of SMU 7 is contiguous with part of state-regulated wetland SYW-19 (see Figure 6), which is dominated by Phragmites. The remainder of the shoreline is in close proximity to the railway. Macrophyte beds are present. Calcium carbonate deposits and associated oncolites are less dominant than in other SMUs. Fish reproduction appears low and the benthic community is severely impacted.

Multiple external sources for most of the CPOIs present in the lake were identified in the vicinity of SMU 7, including Harbor Brook, which flows adjacent to the Lakeshore Area and the Penn-Can property (both part of the Wastebed B/Harbor Brook subsite). NAPL was observed in one boring in SMU 7. In addition, sheen was consistently noted at the water surface during installation of borings, consistent with the observations at the ILWD. NAPL was also noted in a number of sediment samples collected from Harbor Brook, as well as in samples of the marl deposit collected from beneath the sediments of Harbor Brook. Based on historic photos and sampling, it can be seen that the ILWD extends into a portion of SMU 7.

Risk concerns and associated CPOIs and stressors in SMU 7 include sediment toxicity to benthic macroinvertebrates (mercury, ethylbenzene, xylenes, chlorobenzene, dichlorobenzenes, trichlorobenzenes, PAHs, total PCBs); sediment exposure to humans by wading (arsenic, PAHs, PCDD/PCDFs, hexachlorobenzene); exposure of fish to mercury and other CPOIs and subsequent human and wildlife consumption of contaminated fish; benthic macroinvertebrate/insect consumption by wildlife (PAHs, barium, chromium, mercury, methylmercury, selenium); and impaired habitat conditions (limited macrophyte cover).

SMU 8

SMU 8 includes the entire profundal zone of Onondaga Lake, where the water depth is greater than 30 ft (9 m). It is approximately 22,000 ft (6,710 m) long and approximately 5,225 ft (1,590 m) wide at its widest part. SMU 8 has two basins, northern and southern, which are separated by a slight ridge, or saddle, that is approximately 56 ft (17 m) deep. The maximum depths of the northern and southern basins are 62 ft (19 m) and 65 ft (20 m), respectively. Lake bathymetry indicates that the profundal nearshore shelf is relatively steep, becoming broader towards the center of the lake.

SMU 8 is dominated by anoxic conditions during the summer months that limit the use of the sediments by the benthic community. Anoxic conditions also prevent fish from using the deepwater habitat during the summer. The extent to which fish use the hypolimnion under oxic conditions is unknown.

The ultimate fate of most of the sediment entering Onondaga Lake is burial in the profundal sediment. Therefore, the sources contributing to the contamination within SMUs 1 through 7, as discussed above, are also sources of contamination to the profundal sediments in SMU 8.

Risk concerns and associated CPOIs and stressors in SMU 8 include habitat impairment, with exclusion of the benthic community during periods of anoxia and exposure of fish to mercury and other CPOIs (e.g., PCBs) in the epilimnion and in the hypolimnion during those times that oxygen is available and subsequent human and wildlife consumption of contaminated fish.

CURRENT AND POTENTIAL FUTURE SITE AND RESOURCE USES

The State of New York, Onondaga County, and the City of Syracuse have jointly sponsored the preparation of a land-use master plan to guide future development of the Onondaga Lake area (Reimann-Buechner Partnership, 1991). The primary objective of land-use planning efforts is to enhance the quality of the lake and lakeshore for recreational and commercial uses. Anticipated recreational uses of the lake include fishing without consumption restrictions and swimming. The Onondaga Nation similarly asserts it seeks to safely make greater use of lake.

Land Use

In general, the eastern shore of Onondaga Lake is mainly urban and residential, and the northern shore is dominated by parkland, wooded areas, and wetlands. The northwest upland is primarily residential, with interspersed urban structures and several undeveloped areas. Solvay wastebeds cover much of the western lakeshore. Urban centers and industrial zones dominate the landscape surrounding the south end of Onondaga Lake from approximately the New York State Fairgrounds to Ley Creek. Land around the southwest corner and southern portion of the lake is generally industrial and has been significantly modified as part of long-term development of the Syracuse area. Land around much of the lake is recreational, providing hiking and biking trails, picnicking, sports, and other recreational activities.

Surface Water Use

Approximately the northern two-thirds of Onondaga Lake is classified by the State of New York as Class B water (best usages defined as "primary and secondary contact recreation and fishing. These waters shall be suitable for fish propagation and survival" [6 NYCRR Part 701.7]). The southern third of Onondaga Lake and the area at the mouth of Ninemile Creek are classified as Class C water (best usage defined as "fishing. These waters shall be suitable for fish propagation and survival. The water quality shall be suitable for primary and secondary contact recreation, although other factors may limit the use for these purposes" [6 NYCRR Part 701. 8]). No permitted swimming beaches or sanctioned swimming areas exist at Onondaga Lake (NYSDOH, 1995).

Fishing occurs, but the NYSDOH has a specific, restrictive advisory for Onondaga Lake which warns against eating walleye (*Stizostedion vitreum*), with consumption of all other species limited to no more than once per month (NYSDOH, 2005). The specific advisory also stipulates that infants, children under 15, and women of childbearing age should eat no fish from the lake. The more general, statewide advisory for the state's fresh waters advises that consumption be limited to no more than one meal per week. Onondaga Lake and the associated tributaries do not serve as potable-water sources (Syracuse Department of Water, 2000). The shoreline of the lake (especially in the park) is used for water-related recreation such as fishing and boating. In 1990, more than one million people used Onondaga Lake County Park, located along the northern half of the lake (Moore, pers. comm., 1991).

SUMMARY OF SITE RISKS

As part of the RI process, baseline risk assessments were conducted for the site to estimate the risks to human health and the environment. The baseline risk assessments, consisting of an HHRA, which evaluated risks to people, and a BERA, which evaluated risks to the environment, analyzed the potential for adverse effects both under current conditions and if no actions are taken to control or reduce exposure to hazardous substances at the Onondaga Lake subsite. As indicated below, based upon the results of the RI and the risk assessments, NYSDEC and EPA have determined that active remediation is necessary to protect public health or welfare and the environment from actual and threatened releases of hazardous substances into the environment.

Human Health Risk Assessment

A site-specific HHRA was performed to quantitatively evaluate both cancer risks and non-cancer health hazards associated with potential current and/or future exposures to chemicals present in Onondaga Lake surface water, sediments, and fish in the absence of any action to control or mitigate those chemicals. The HHRA was prepared to evaluate potential risks associated with exposure to elevated concentrations of mercury, benzene, chlorobenzene, and other COPCs in surface water; mercury, benzene, xylenes, chlorinated benzenes, PAHs, PCBs, PCDD/PCDFs, and other COPCs in sediments; and mercury, hexachlorobenzene, PCBs, PCDD/PCDFs, and other COPCs in fish.

Hazard Identification

In addition to mercury (including methylmercury), approximately 60 other chemicals were identified as COPCs in one or more site media using a screening process comparing measured concentrations to risk-based concentrations. Risks were calculated for these COPCs in the HHRA. The COPCs that are associated with unacceptable levels of cancer risk or non-cancer hazard are known as COCs.

Exposure Assessment

Recreational visitors to Onondaga Lake are the receptors or individuals with the greatest potential for exposure to COPCs. Cancer risks and non-cancer health hazards were evaluated for young children (less than 6 years old), older children (6 years to less than 18 years old), and adults (18 years and over). In addition, it was assumed that people eat fish caught in Onondaga Lake, even though NYSDOH currently advises that women of childbearing age, infants, and children under the age of 15 should not eat any fish from Onondaga Lake and all others should eat no more than one meal per month of any species, with no walleye to be eaten at all. Recreational visitors were assumed to include anglers who eat fish from Onondaga Lake; people who swim, wade, or boat in the lake; and people who play or walk along the shoreline of the lake. The exposure point concentrations for the COCs, along with detection frequencies for these contaminants, are presented in Table 8.

In addition to consumers of fish, the HHRA also evaluated exposure to those who may contact contaminated sediments and water; specifically, current and future recreational users of Onondaga Lake and future construction workers. A summary of the results of the risk estimates is provided below in the "Risk Characterization" section.

In order to allow risk managers to consider various options when evaluating remediation strategies, the HHRA estimated cancer risks and non-cancer hazards based on a range of potential exposures under both the reasonable maximum exposure (RME) scenario, which portrays the highest level of human exposure that could reasonably be expected to occur, and the central tendency (CT, or "typical") scenario. Cancer risks and non-cancer health hazards were assessed for recreational visitors to Onondaga Lake and future construction workers under both these scenarios.

Toxicity Assessment

Risk estimates for all COPCs were based on use of toxicity values, using carcinogenic slope factors (CSFs) to assess potential carcinogenic effects and reference doses (RfDs) to assess potential non-cancer effects. These measures were primarily derived and published by EPA. The three COCs (or COC groups) responsible for a majority of estimated site risks are methylmercury, PCBs, and PCDD/PCDFs.

- Methylmercury, which is the predominant form (95 percent or more) of total mercury in fish tissue, is a toxic chemical with which a number of adverse health effects have been associated in both human and animal studies. The critical health endpoint from exposure to methylmercury is developmental neurotoxicity.

- PCBs cause cancer in animals and probably cause cancer in humans. In addition, serious non-cancer health effects have been observed in animals exposed to PCBs. Studies of Rhesus monkeys exposed to PCBs indicate a reduced ability to fight infection and reduced birth weight in offspring exposed in utero.

- PCDD/PCDFs are probable human carcinogens, based on evidence in laboratory animals. They have also been associated with a wide variety of toxic effects in animals, including acute toxicity, enzyme activation, tissue damage, and developmental abnormalities.

A summary of the toxicity information for both non-cancer health effects as well as cancer endpoints is presented in Tables 9 and 10, respectively.

Risk Characterization

The HHRA shows that cancer risks and non-cancer health hazards associated with ingestion of chemicals in sport fish (e.g., largemouth bass) from Onondaga Lake are above levels of concern. Fish ingestion is the primary pathway for exposure to COCs and for potential adverse health effects. Cancer risks and non-cancer health hazards calculated for the consumption of Onondaga Lake fish exceeded the target risk level range, as follows:

- **Cancer risks:** The calculated RME cancer risks (ranging from 2.4×10^{-4} to 7.8×10^{-4}) exceeded the high end of the target risk range (10^{-4}), and exceeded the low end of the target cancer risk (10^{-6}) by more than two orders of magnitude.[3] The CT fish ingestion cancer risk (about 4.5×10^{-5} for all recreational receptors) was below the high end of the target range but above the low end of the range. The cancer risk estimates for the COCs for the RME scenario are presented in Table 11.

---

[3] In an HHRA, exposures are evaluated based on the potential risk of developing cancer and the potential for non-cancer health hazards. The likelihood of an individual developing cancer is expressed as a probability. For example, a 10^{-4} cancer risk means a "one-in-ten-thousand excess cancer risk," or one additional cancer may be seen in a population of 10,000 people as a result of exposure to site contaminants under the conditions explained in the Exposure Assessment of the HHRA. Current federal Superfund guidelines for acceptable exposures are "generally concentration levels that represent an excess upper bound cancer to an individual of between 10^{-4} to 10^{-6}" (40 CFR § 300.430[e][2][A][2]) (corresponding to a one-in-ten-thousand to a one-in-a-million excess cancer risk). The 10^{-6} risk is used as the point of departure for determining remediation goals.

- **Non-cancer health hazards:** The RME non-cancer hazard indices (ranging from about 18 to 28) exceeded the target hazard index (1) by more than an order of magnitude.[4] The calculated CT non-cancer hazard index (ranging from about 4.5 to 7) also exceeded the target. The non-cancer hazard quotients and indices for the COCs for the RME scenario are presented in Table 12.

RME cancer risks for most recreational exposure pathways (e.g., swimming, wading, boating) other than fish ingestion equaled or exceeded the low end of the target risk range of 1×10^{-6}, with the highest of these being about 3.5×10^{-5} for older child exposure to nearshore sediments from the southern basin of the lake. For the CT cancer risk calculations, the low end of the target range was equaled and slightly exceeded in one pathway other than fish ingestion, with a maximum CT risk of about 2×10^{-6} for young child exposure to nearshore sediments from the southern basin. RME cancer risks (3.7×10^{-6}) for exposure to south basin sediments for future construction workers exceeded the low end of the target risk range of 1×10^{-6}. All other RME and CT risks for future construction workers were less than the target range.

None of the calculated non-cancer hazards (for both RME and CT scenarios) associated with pathways other than fish ingestion exceeded the target threshold of 1, indicating that exposure to lake COPCs from all pathways except fish consumption are not predicted to result in adverse non-cancer effects. (Note that risks due to the sediments and soils in the wetlands around the lake and the dredge spoils area near Ninemile Creek were calculated in the Onondaga Lake risk assessments but are not presented in this ROD. These areas are now being addressed as part of investigations taking place at other upland sites; i.e., the Ninemile Creek Dredge Spoils Area for state-regulated wetland SYW-6 [see Figure 6], Geddes Brook/Ninemile Creek for state-regulated wetland SYW-10, and the Wastebed B/Harbor Brook site for state-regulated wetlands SYW-12 and SYW-19.)

Baseline Ecological Risk Assessment

The BERA evaluated the likelihood that adverse ecological effects are occurring or may occur as a result of exposure to one or more chemicals or stressors. The BERA was prepared to evaluate potential risks associated with exposure to elevated concentrations of mercury, chlorinated benzenes, and other COCs and stressors in surface water; mercury, BTEX, chlorinated benzenes, PAHs, PCBs, PCDD/PCDFs, and other COCs and stressors in sediments; and mercury, chlorinated benzenes, PAHs, PCBs, PCDD/PCDFs, and other COCs in fish and other wildlife. The framework used for assessing site-related ecological risks is similar to that used for HHRAs and consists of problem formulation, ecological exposure assessment, ecological effects assessment, and risk characterization.

Problem Formulation

Problem formulation identifies the major factors to be considered in a BERA, including COC and SOC (e.g., ionic waste) characteristics, ecosystems and/or species potentially at risk, and ecological effects to be evaluated. It establishes the goals, breadth, and focus of the assessment,

---

[4] For non-cancer health effects, a “hazard quotient” (HQ) is calculated for each contaminant. An HQ represents the ratio of the estimated exposure to the corresponding reference doses (RfDs). The sum of the HQs is termed the “hazard index” (HI). The key concept for a non-cancer HI is that a “threshold level” (measured as an HQ or HI of 1) exists, below which non-cancer health effects are not expected to occur.

develops a conceptual model, and selects assessment endpoints, which are explicit expressions of the environmental value that is to be protected. In an HHRA, only one species (humans) is evaluated and the cancer and non-cancer effects are the usual assessment endpoints. In contrast, a BERA involves multiple species that are likely to be exposed to differing degrees and respond differently to the same contaminant. Assessment endpoints focus the risk assessment on particular components of the ecosystem that could be adversely affected by contaminants from the site.

Assessment endpoints selected for Onondaga Lake are based on the sustainability of plant and animal communities and populations. "Sustainability" relates to survival, growth, and reproduction. The assessment endpoints include:

- Sustainability of an aquatic macrophyte community to provide food and shelter for aquatic organisms and wildlife.
- Sustainability of phytoplankton and zooplankton communities as a food source for aquatic organisms and wildlife.
- Sustainability of a terrestrial plant community to provide food and shelter to invertebrates and wildlife.
- Sustainability of a benthic invertebrate community to serve as a food source for local fish and wildlife.
- Sustainability of fish populations.
- Sustainability of amphibian and reptile populations.
- Sustainability of insectivorous, benthivorous, piscivorous (fish-eating), and carnivorous bird populations.
- Sustainability of insectivorous and piscivorous mammal populations.

Detailed quantitative assessment of sustainability of selected populations of fish and wildlife were conducted by selecting individual species representative of various feeding preferences, predatory levels, and habitats. Receptors selected to represent the Onondaga Lake ecological community for the BERA included eight species of fish, six species of birds, and four species of mammals. The remaining receptors (i.e., both aquatic and terrestrial plants, phytoplankton and zooplankton, amphibians, reptiles) were evaluated qualitatively.

Ecological Exposure Assessment

The assumptions and models used to predict the potential exposure of plants and animals to COCs associated with Onondaga Lake are addressed in this component. Exposure parameters (e.g., body weight, prey ingestion rate, home range) of wildlife species selected as representative receptors and site-specific fish, sediment, and water COC concentrations were used to calculate the exposure concentrations or dietary doses using food-web models.

Ecological Effects Assessment

Mercury and numerous other potentially toxic chemicals, including metals, PCBs, PAHs, BTEX, chlorinated benzenes, and PCDD/PCDFs, were detected at concentrations above ecological screening levels in various lake media.

Measures of toxicological effects were selected based on lowest-observed-adverse-effect levels (LOAELs) and no-observed-adverse-effect levels (NOAELs) from studies reported in the scientific literature. Reproductive effects (e.g., egg maturation, egg hatchability, and survival of juveniles) were generally the most sensitive endpoints.

Risk Characterization

Multiple lines of evidence, based on various measurement endpoints (measures of effect), were used to evaluate major components of the Onondaga Lake ecosystem to determine if contamination has adversely affected plants and animals in and around the lake. Almost all lines of evidence indicate that input of chemicals and ionic waste in Onondaga Lake has produced adverse ecological effects at all trophic levels (levels of the food chain) examined.

As discussed in the BERA, mercury and possibly other chemicals have bioaccumulated in most organisms serving as a food source for biota in the lake, resulting in risks to fish and wildlife above acceptable levels. Comparisons of measured tissue concentrations and modeled doses of chemicals to measures of toxicological effects show exceedances of hazard quotients for chemicals in the lake. Many of the chemicals in the lake are persistent (i.e., would remain in the same chemical state without breaking down); therefore, the risks associated with these chemicals are unlikely to decrease significantly unless remediation is performed.

Exceedances of site-specific sediment effects concentrations based on macroinvertebrate toxicity tests (see the text box entitled "Development of Sediment Effect Concentrations/Probable Effect Concentrations"[page 34]) suggest that adverse effects to benthic invertebrates due to contact with surface sediments will frequently occur in most areas of the lake. The greatest number of contaminants with exceedances and the greatest magnitude of those exceedances were found in areas in the southern portion of the lake (i.e., SMUs 1, 2, 6, and 7) and near Ninemile Creek (i.e., SMU 4).

This is confirmed by benthic community analysis, which indicates that these areas are moderately to severely impacted. As defined in the BERA, "moderately impacted" indicates that the macroinvertebrate community is altered to a large degree from the reference condition and "severely impacted" indicates that the macroinvertebrate community is limited to a few tolerant species, usually midges or worms, and often only one or two species are abundant. In addition, the aquatic macrophytes in the lake have been adversely affected by lake conditions, and the resulting loss of macrophyte habitat that formerly provided valuable feeding, spawning, and nursery areas has likely adversely affected the aquatic invertebrates and vertebrates living in Onondaga Lake.

Summary of Human Health and Ecological Risks

Key results of the HHRA include the finding that contamination in Onondaga Lake presents risks to human health that are above EPA guidelines. In addition, the primary sources of these cancer risks and non-cancer health hazards are due to mercury, PCBs, and PCDD/PCDFs as a result of the consumption of Onondaga Lake fish.

Key results of the BERA indicate that comparisons of measured tissue concentrations and modeled doses of chemicals to toxicity reference values show exceedances of hazard quotients for site-related chemicals throughout the range of the point estimates of risk. Site-specific sediment toxicity data indicate that sediments are toxic to benthic macroinvertebrates on both an acute (short-term) and chronic (long-term) basis. Many of the contaminants in the lake are persistent and, therefore, the risks associated with these contaminants are unlikely to decrease significantly in the absence of remediation. On the basis of these comparisons, it has been determined through the BERA that all receptors of concern are at risk. Contaminants and stressors in the lake have either impacted or potentially impacted every trophic level examined in the BERA.

Based upon the results of the RI and the risk assessments, NYSDEC and EPA have determined that active remediation is necessary to protect public health or welfare and the environment from actual and threatened releases of hazardous substances into the environment.

Basis for Action

Actual or threatened releases of hazardous substances from the site, if not addressed by implementing the response action selected in this ROD, may present an imminent and substantial endangerment to public health, welfare, or the environment.

The documents that form the basis of NYSDEC and EPA's selection of a remedy are included in the Administrative Record Index (see Appendix III) and include the final RI report, BERA, and HHRA (all dated December 2002), the final FS report (dated November 29, 2004), the Proposed Plan (dated November 29, 2004), the comments on the Proposed Plan and RI/FS received from the public during the comment period, the comments on the Proposed Plan issued by EPA's National Remedy Review Board (NRRB) (dated February 18, 2005), the responses of NYSDEC and EPA Region 2 to the NRRB's comments (dated March 25, 2005), and this ROD (which includes the Responsiveness Summary).

Development of Sediment Effect Concentrations/Probable Effect Concentrations

To evaluate sediment quality in Onondaga Lake, toxicity of the sediment to sediment-dwelling (benthic) invertebrates was tested. Laboratory tests involved exposing the midge *Chironomus tentans* and the amphipod *Hyalella azteca* to Onondaga Lake sediments and observing their growth and survival. Since the results for *Chironomus tentans* were found to be the more sensitive test, these acute toxicity data were then used to develop the following five site-specific SECs:

Effects Range-Low (ER-L) – The concentration that represents the lowest 10^{th} percentile of the concentrations at which toxic effects were observed. At concentrations below the ER-L, toxic effects are rarely expected.

Threshold Effect Level (TEL) – The geometric mean of the concentration that represents the lowest 15^{th} percentile of the concentrations at which toxic effects were observed and the 50^{th} percentile (median) of the concentrations at which no toxic effects were observed. At concentrations below the TEL, toxic effects are rarely expected.

Effects Range-Median (ER-M) – The concentration that represents the 50^{th} percentile (median) at which toxic effects were observed. At concentrations above the ER-M, toxic effects are likely to occur.

Probable Effect Level (PEL) – The geometric mean of the ER-M and the 85^{th} percentile of the concentration distribution for the no-effects data. At concentrations above the PEL, toxic effects are likely to occur.

Apparent Effect Threshold (AET) – The concentration of a chemical in sediment above which a particular toxic effect (e.g., increased mortality or decreased biomass) is always significant compared to reference concentrations. At concentrations above the AET, toxic effects are predicted to always occur.

The geometric mean of these five Onondaga Lake SECs was calculated to provide a single consensus-based probable effect concentration (PEC) for each contaminant. At concentrations above the PEC, adverse effects in sediments are expected to frequently occur. The derivation of these site-specific values is presented in the Onondaga Lake BERA. SECs and PECs were calculated for each of the CPOIs in the BERA. For mercury, the following SEC values were calculated: 0.51 mg/kg for ER-L, 0.99 mg/kg for TEL, 2.8 mg/kg for ER-M, 2.84 mg/kg for PEL, and 13 mg/kg for AET. Based on these five SECs, the PEC for mercury is 2.2 mg/kg. As discussed in the BERA, the SECs and PECs do not consider the potential effects that could occur throughout the food web as a result of bioaccumulation. However, bioaccumulation is considered in the development of PRGs for fish tissue and for a sediment quality value for mercury. See text boxes entitled, “Preliminary Remediation Goals for Fish Tissue” (page 40)and “Bioaccumulation-Based Sediment Quality Values (page 41).”

REMEDIAL ACTION OBJECTIVES

Remedial action objectives (RAOs) are specific goals to protect human health and the environment. These objectives are based on available information and standards, such as applicable or relevant and appropriate requirements (ARARs), to-be-considered (TBC) guidance, and site-specific risk-based levels. There are no federal or New York State sediment cleanup standards for mercury or the other CPOIs found in Onondaga Lake sediments. Although the sediments are the primary focus of the remediation, the degree of attainment of New York State’s surface water standards and guidance values and site-specific fish target concentrations were also evaluated.

The RAOs for Onondaga Lake were based on site-specific information, including the nature and extent of CPOIs, the transport and fate of mercury and other CPOIs, and the baseline human health and ecological risk assessments. The RAOs were developed in the RI report as goals for controlling CPOIs within the lake and protecting human health and the environment. The RAOs for Onondaga Lake are:

- **RAO 1**: To eliminate or reduce, to the extent practicable, methylation of mercury in the hypolimnion.
- **RAO 2**: To eliminate or reduce, to the extent practicable, releases of contaminants from the ILWD and other littoral areas around the lake.
- **RAO 3**: To eliminate or reduce, to the extent practicable, releases of mercury from profundal sediments.
- **RAO 4**: To be protective of fish and wildlife by eliminating or reducing, to the extent practicable, existing and potential future adverse ecological effects on fish and wildlife resources and to be protective of human health by eliminating or reducing, to the extent practicable, potential risks to humans.
- **RAO 5**: To achieve surface water quality standards, to the extent practicable, associated with CPOIs.

In order to achieve these RAOs, preliminary remediation goals (PRGs) were established to provide additional information/goals with which remedial alternatives can be developed and selected. Onondaga Lake contains three primary media that have been impacted by CPOIs: sediments, biological tissue, and surface water. The following three PRGs have been developed, each addressing one of the affected media:

- **PRG 1**: Achieve applicable and appropriate sediment effect concentrations (SECs) for CPOIs and the bioaccumulation-based sediment quality value (BSQV) of 0.8 mg/kg for mercury, to the extent practicable, by reducing, containing, or controlling CPOIs in profundal and littoral sediments.
- **PRG 2**: Achieve CPOI concentrations in fish tissue that are protective of humans and wildlife that consume fish. This includes a mercury concentration of 0.2 mg/kg in fish tissue (fillets) for protection of human health based on the reasonable maximum exposure scenario and EPA's methylmercury National Recommended Water Quality criterion for the protection of human health for the consumption of organisms of 0.3 mg/kg in fish tissue. This also includes a mercury concentration of 0.14 mg/kg in fish (whole body) for protection of ecological receptors. These values represent the range of fish tissue PRGs.
- **PRG 3**: Achieve surface water quality standards, to the extent practicable, associated with CPOIs.

PRG 1– Sediments

Toxicity

The sediment PRG (PRG 1) is based on five site-specific SECs and one consensus-based probable effect concentration (PEC) for the CPOIs evaluated in the RI and risk assessments (see the text box called "Development of Sediment Effect Concentrations/Probable Effect Concentrations"[page 34]). The SECs and PECs were calculated using data from acute sediment toxicity testing using benthic macroinvertebrates. Benthic macroinvertebrates live in and around the sediments for most of their lives, and therefore experience the highest direct exposure to contamination in the lake.

As part of the FS report, the PEC values were incorporated into a mean PEC quotient (PECQ) approach to provide a consistent method of comparing the overall acute toxicity risk from the mixture of contaminants at various locations of the lake (see the text boxes called "Development and Use of the Mean PEC Quotient" [page 37] and Table 13) and to select a level of remediation that would address the risk of direct acute toxicity to the benthic macroinvertebrate community from the contamination in the lake sediments. Although chronic toxicity tests were conducted as part of the RI, insufficient data were available to develop SECs based on results of chronic toxicity testing.

The mean PECQ can be used as a basis for delineating areas of the lake to be remediated. The areas of the lake in which CPOI concentrations in the littoral sediment exceed a mean PECQ of 1 (see the text box called "Application of the Mean PEC Quotient for Determining Remedial Areas/Volumes" [page 38]) generally coincide well with those areas where acute toxicity to benthic macroinvertebrates was observed in the sediment toxicity tests. Therefore, the mean PECQ of 1 was determined to be protective and selected as a remediation goal to address direct acute toxicity to benthic invertebrates. In addition, since mercury in the lake is a primary concern and elimination or reduction of mercury is part of all five RAOs, the mercury PEC of 2.2 mg/kg was also selected as a remediation goal.

Figure 7 presents the mean PECQ distribution and the exceedances of the mercury PEC.

For all but one of the lakewide alternatives evaluated in this ROD, the primary criteria for remediation of sediment toxicity are the mean PECQ of 1 and the mercury PEC. To assess the feasibility of a cleanup based on an SEC to achieve a lower level of residual contamination, one alternative was developed using the effects range-low (ER-L) as the sediment toxicity remediation goal rather than the mean PECQ of 1 and mercury PEC criteria. The ER-L is the concentration at which acute toxic effects are rarely expected, and is more likely to also protect the macroinvertebrate community from chronic effects. (See Figure 8 for exceedances of the ER-L.)

Development and Use of the Mean PEC Quotient

The Onondaga Lake SECs and PECs were used to identify sediments in the lake to be considered for remediation, due to the sediment's direct, acute toxicity to the benthic community. Because of the large number of CPOIs and the differences in sources, transport, and fate, a further refinement of the SEC/PEC approach was used to develop a single number, the mean PECQ, which takes into account the presence and the concentrations of multiple chemicals in the sediments. Similar approaches have been used in many different regions of the US and Canada by federal and state agencies, monitoring programs, and ecological risk assessors to focus remediation on areas that are likely to have the greatest overall toxicity.

Mean PECQs for sediment samples were calculated in the following four-step process:

- The CPOIs were divided into five groups based on chemical class (i.e., metals, aromatics, chlorinated benzenes, PAHs, and PCBs).
- Each detected chemical concentration in a sample was divided by its PEC, resulting in a quotient of the concentration of that chemical in the sample to its respective PEC (e.g., a mercury concentration of 4.4 mg/kg was divided by the mercury PEC of 2.2 mg/kg for a mercury PECQ of 2).
- For each chemical group, all the resulting PECQs for a particular sample were summed, and the sum of the individual PECQs is divided by the total number of CPOIs for the group in that sample.
- The mean PECQs for each chemical group were summed, and the sum was divided by the total number of groups in the sum.

A simplified hypothetical example of the calculation of the mean PECQ for a sediment sample would be where only five CPOIs are present in the sample, and PECQs of 1, 2, 3, 4, and 5 were calculated for the five CPOIs. The mean PECQ for the sample would be the sum of the five individual PECQs (1 + 2 + 3 + 4 + 5 = 15) divided by the total number of PECQs calculated in the sample (i.e., 5), resulting in a mean PECQ of 3 (15/5) for the sample.

One component of the evaluation was to determine which CPOIs appeared to exhibit the strongest influence on observed acute toxicity on a lakewide basis. This analysis resulted in 23 of the 46 CPOIs for which SECs and PECs were calculated being included in the calculation of the final mean PECQ (see Table 13). In the case of Onondaga Lake, the mean PECQ for a sample was calculated based on the PECQs for each of the five chemical groups, which were then averaged to produce the overall mean PECQ for that sample.

Bioaccumulation

The mercury in fish is derived from a combination of food sources such as benthic macroinvertebrates, uptake from the water column through skin or gills, and incidental intake of suspended particles in the water column. Together, these exposure pathways result in the bioaccumulation of mercury in fish. To address the risk to wildlife and humans from consumption of contaminated fish, a BSQV was developed for this contaminant in addition to the benthic toxicity-based PEC of 2.2 mg/kg (see discussion under PRG 2 and associated text box [page 40]). As calculated, the BSQV of 0.8 mg/kg represents a concentration in sediments that, if not exceeded, is predicted to result in mercury concentrations in fish below levels of concern for wildlife that consume fish. Since this ecological-based target level was less than that for protection of adults (i.e., is also protective of human health), it was selected as the target BSQV against which surface-weighted average sediment concentrations will be compared.

Concentrations of PCBs, hexachlorobenzene, and PCDD/PCDFs in fish tissue were also determined to be risk drivers for human health and wildlife. PCBs, hexachlorobenzene, and

PCDD/PCDFs are not widespread in sediments in the lake and are found primarily in a few specific areas of the lake (e.g., SMUs 1, 2, 6, and 7). The NYSDEC sediment screening criteria for protection of wildlife and humans from bioaccumulation were used as the comparison values for these three CPOIs. Therefore, site specific BSQVs were not developed for these CPOIs. The areas where these CPOIs are elevated are generally co-located with areas that exceed the cleanup criteria of the mean PECQ of 1 plus the mercury PEC and would be addressed under the remedial alternatives evaluated in this ROD.

Application of the Mean PEC Quotient for Determining Remedial Areas/Volumes

For Onondaga Lake, the mean PECQ for each sample is an indication of the relative risk of acute sediment toxicity posed by the suite of CPOIs at that location. Mean PECQs can be useful for ranking various stations with respect to relative risk and for prioritizing stations for remedial action. For example, if the mean PECQs at two stations are 20 and 1, the station with the higher quotient could be considered a higher priority for remediation.

The relationship of the mean PECQ to toxicity was evaluated by comparing the mean PECQ for each sediment station to the 1992 chironomid mortality data for that same station. There was a general trend showing that as the mean PECQs increased, mortality also increased. An analysis of this relationship suggested that there is an inflection point in the toxicity data around a mean PECQ value of 1 to 2, but the correlation coefficient for these data is rather small, and the data about this inflection point show a high degree of uncertainty. However, a mean PECQ value of 1 can be supported by the concept that if the concentration of a CPOI is equal to or greater than a corresponding acute toxicity threshold (i.e., the PEC for that CPOI), then toxicity would be anticipated to occur. The mean PECQ is simply the “average” quotient for the number of CPOIs detected in the sediments. A mean PECQ value of 1 suggests that on average, the concentrations of CPOIs do not exceed their corresponding PECs.

After evaluating the relationship of the mean PECQ to chironomid acute toxicity, along with the results for the 1992 amphipod acute mortality data, 2000 chironomid and amphipod chronic mortality data, and 2000 chironomid chronic non-emergence data, NYSDEC concluded that remediation of sediments in areas exceeding a mean PECQ of 1 would remediate those sediments where acute toxicity had been observed.

The use of the mean PECQ value of 1 (plus the PEC for mercury; see text) provides a measure of the areal limits of remediation of Onondaga Lake sediments that would protect the benthic community from acute toxicity resulting from direct exposure to CPOIs in the sediments. The mean PECQ methodology itself does not explicitly address chronic toxicity. However, the alternatives discussed in this ROD, other than the No Action Alternative, would result in a reduction of chronic toxicity to the benthic community in those areas of the lake where existing contaminated littoral sediments would be capped (assuming the cap is effective in keeping levels below the PECs) or where existing contaminated littoral sediments would be removed to the ER-L.

Applicability to RAOs

PRG 1 addresses RAOs 1 through 4 to various degrees, as follows.

- **RAO 1**: Methylation of mercury in the hypolimnion is influenced by two primary factors: anoxic conditions (meaning there is no oxygen) and the availability of mercury for methylation. By reducing mercury concentrations in the surface sediments to achieve a specific SEC value, PRG 1 reduces the amount of mercury that may be released into the hypolimnion. The reduction in the amount of mercury released from littoral and profundal sediments into the water column would, in turn, reduce methylation of mercury in the hypolimnion, thus addressing RAO 1.

- **RAO 2**: Reducing the concentration of CPOIs in the ILWD and other contaminated littoral sediments would limit the amount of CPOIs available for release, thus addressing RAO 2.

- **RAO 3**: Reducing, containing, or controlling mercury concentrations in profundal sediments would limit the amount of mercury available for release into the lake through methane gas ebullition or diffusion, thus addressing RAO 3.

- **RAO 4**: Remediating littoral and profundal sediment concentrations to achieve a specific SEC value would directly reduce adverse ecological effects to the benthic community. In addition, reductions of CPOI concentrations in sediment would reduce adverse effects associated with direct exposure of humans, fish, and wildlife to sediment, as well as adverse effects associated with bioaccumulation of CPOIs from sediment. Reductions of mercury concentrations in sediment would also reduce the amount of mercury released to the water column, thereby reducing mercury methylation in the hypolimnion. This, in turn, would make mercury less available for uptake by lake biota and would ultimately reduce potential risks to fish, wildlife, and humans, thus addressing RAO 4.

PRG 2 – Fish Tissue

The fish tissue PRG (PRG 2) primarily addresses RAO 4, which is to be protective of fish and wildlife by eliminating or reducing, to the extent practicable, existing and potential future adverse ecological effects on fish and wildlife resources and to be protective of human health by eliminating or reducing, to the extent practicable, potential risks to humans. A result of such a reduction could be that humans may consume fish in accordance with the state's general advisory for eating sport fish, which states that an individual eat no more than one meal (one-half pound) per week. The current fish consumption advisory in Onondaga Lake (see "Current and Potential Future Site and Resource Uses" section) is much more restrictive than this state-wide general advisory.

Quantitative target concentration ranges for protection of wildlife and humans consuming mercury-contaminated fish from Onondaga Lake were developed (see the text box on "Preliminary Remediation Goals for Fish Tissue" [page 40]). Of the overall concentration range (based on different degrees of ecological and human-health risk) presented in the text box, a range of 0.14 mg/kg for protection of wildlife to 0.3 mg/kg for protection of human health was selected as reasonable fish tissue PRGs. These values are based on site-specific risk calculations. The 0.3 mg/kg PRG is also the EPA National Recommended Water Quality criterion for methylmercury in fish tissue for the protection of humans consuming fish.

Preliminary Remediation Goals for Fish Tissue

Methylmercury is a bioaccumulative contaminant that was calculated to pose potential risks (i.e., hazard quotients above 1) to piscivorous birds, mammals, and humans consuming fish from Onondaga Lake. PRGs for mercury (as methylmercury) concentrations in fish tissue were developed for Onondaga Lake using risk-based methods. There are no federal or New York State cleanup standards for mercury in fish.

The concentrations of methylmercury for the PRGs for fish were calculated based on a hazard quotient of 1 for ecological receptors and non-cancer risk for humans. The hazard quotients for ecological receptors were based on both the no-observed-adverse-effect level (NOAEL), representing the highest CPOI concentration at which no adverse effects are seen, and the lowest-observed-adverse-effect level (LOAEL), representing the lowest CPOI concentration shown to produce adverse effects. The human health hazard quotient of 1 for individual CPOIs indicates the "threshold level" below which non-cancer effects are not expected to occur. The PRGs were calculated using the same exposure assumptions and toxicity values as the HHRA and BERA.

Mercury fish and wildlife PRGs range from 0.01 to 0.3 mg/kg wet weight (ww) (i.e., 0.01 to 0.3 parts per million [ppm]), depending on species and whether the NOAEL or LOAEL is used to set the target hazard quotient. Avian mercury target levels range from 0.01 to 0.3 mg/kg ww in fish tissue and mammalian target levels range from 0.01 to 0.2 mg/kg ww in fish tissue.

Human health mercury PRG fish tissue concentrations for the reasonable maximum exposure (RME) scenario are 0.2 mg/kg ww and 0.3 mg/kg ww for young children and adults, respectively. In January 2001, EPA released a methylmercury National Recommended Water Quality criterion of 0.3 mg/kg in fish tissue for the protection of human health for the consumption of organisms. This criterion, which is slightly higher than and equal to the two site-specific human-health PRGs based on the RME exposure (0.2 mg/kg for children and 0.3 mg/kg for adults), is also considered to be a human health fish tissue PRG.

In addition, BSQVs were developed as estimates of the concentrations of total mercury in the surface sediments in the lake needed to reach human and wildlife fish tissue target concentrations (see the text box on "Bioaccumulation-Based Sediment Quality Values" [page 41]). The selected BSQV for mercury of 0.8 mg/kg was based on the most sensitive ecological receptor for assessing bioaccumulation. This value is expected to be protective of other ecological receptors and adult human consumers of fish. This BSQV (0.8 mg/kg) will be used to assess whether additional areas of the lake (beyond that needed to address areas exceeding the toxicity-based cleanup criteria) would need to be addressed during remedy implementation in order to meet the fish tissue PRGs.

Bioaccumulation-Based Sediment Quality Values

Since a variety of dynamic factors affect mercury levels in fish, mercury bioaccumulation-based sediment quality values (BSQVs) were also developed for Onondaga Lake to estimate the sediment mercury concentrations associated with the fish tissue PRGs. These BSQVs were derived to be protective of human health and the environment by reducing the potential for mercury bioaccumulation from the sediments into fish. The first step entailed calculating site-specific biota-sediment accumulation factors (BSAFs) for fish fillets consumed by people and for whole fish consumed by wildlife using lakewide fish and surface sediment data. BSAFs were calculated by dividing the average mercury concentration in fish tissue by the lakewide average mercury concentration in sediment. Lakewide averages were used because fish were assumed to move over large areas of the lake (i.e., animals that bioaccumulate mercury, such as fish, are typically not limited to one location in the lake), and because the locations of fish tissue samples collected in the lake were not specified.

The mercury PRGs for fish based on human and wildlife fish consumption were divided by the BSAF to calculate the target concentration of mercury in sediments. The fish tissue PRG of 0.14 mg/kg ww for protection of the river otter, the most sensitive ecological receptor for assessing bioaccumulation, was used to calculate a LOAEL-based sediment target of 0.8 mg/kg. As the ecological-based target level was less than the human health concentration (i.e., also protective of adult human health), it was selected as the target BSQV against which surface-weighted average sediment concentrations will be compared.

PRG 3 – Surface Water

The surface water PRG (PRG 3) directly addresses RAO 5, which is to achieve surface water quality standards, to the extent practicable, associated with CPOIs. With the exception of mercury, surface water concentrations of most of the CPOIs do not currently consistently exceed applicable standards and guidance values. New York State surface water quality standards (6 NYCRR Part 703) for mercury (i.e., the standard for protection of wildlife of 2.6 nanograms per liter [ng/L] dissolved mercury and the standard for protection of human health [via fish consumption] of 0.7 ng/L dissolved mercury) are currently consistently exceeded in Onondaga Lake. These two standards are considered to be protective of wildlife and humans exposed to mercury via fish consumption. They therefore take into account bioaccumulation of mercury from water into fish tissue.

Higher concentrations of dissolved mercury in surface waters are found primarily in the hypolimnion in summer and early fall, where the anoxic conditions cause mercury to change into more soluble forms. Exceedances of the standards for protection of wildlife and human health are found almost exclusively in the anoxic hypolimnion, with a maximum dissolved mercury concentration of 24 ng/L at the north deep basin station in 1999 at a depth of 59 ft (18 m). Reductions in the releases of mercury into the hypolimnion and eliminating anoxic conditions would help to achieve this PRG.

It is also noted that the highest total mercury concentration found in the lake in surface waters was 595 ng/L from the water column immediately above the sediment surface in SMU 1 in 2000, while the highest total mercury concentration closer to the surface of the water column was 103 ng/L at the border of SMUs 1 and 7 in 1999. Concentrations of dissolved mercury in 1999 and 2000 from the epilimnion (including nearshore areas) ranged from 1 to 7.8 ng/L, with some samples exceeding the standard of 2.6 ng/L and all samples exceeding the lowest standard of 0.7 ng/L.

There have also been exceedances of applicable surface water standards for other CPOIs related to Honeywell, such as chlorobenzene and dichlorobenzenes. The highest concentration of chlorobenzene recorded in the RI report was 12 µg/L in SMU 1 near the border with SMU 2 in 1999. This concentration exceeds the NYSDEC (6 NYCRR Part 703) standard for the protection of aquatic life (chronic) of 5 µg/L. The highest concentration of dichlorobenzenes recorded in the RI report was 6.6 µg/L in this same sample. This concentration exceeds the NYSDEC (6 NYCRR Part 703) surface water standard for total dichlorobenzenes for the protection of aquatic life (chronic) of 5 µg/L. Remediation of the external sources and contaminated sediments and NAPLs in this area would be needed to achieve this PRG for these CPOIs.

The narrative water quality standards for several of the physical parameters listed in 6 NYCRR Part 703.2 (i.e., turbidity, suspended and settleable solids, oil and floating substances) are consistently exceeded in the lake for various reasons (e.g., due to NAPLs and ionic wastes). Remediation of sediments and NAPLs, as defined in the selected remedy, will aid in achieving these standards.

Attainment of any one individual PRG will not be sufficient to establish the success or failure of the remedial program for the lake, in part because a variety of dynamic factors affect levels of mercury and other CPOIs in each medium. Rather, as per the NCP, the success or failure of the Onondaga Lake remedial program, as assessed every five years, will be based on attainment of all PRGs.

Because of the importance of Onondaga Lake as a natural resource, and to ensure that the remedy complies with NYSDEC regulations, the protection of habitat through remediation and restoration has been an important consideration in the development of the various capping and dredging alternatives. Throughout the analysis of the various alternatives, the goal of reestablishing productive aquatic habitat in the lake has been considered along with the need to provide an effective and permanent remedy to the adverse impacts of contamination on the fish and wildlife resources of the lake. Of particular concern is the protection of shoreline habitat and the ecological integrity of the littoral zone. A lakewide habitat restoration plan will be required as part of the remedial design.

DESCRIPTION OF ALTERNATIVES

CERCLA §121(b)(1), 42 U.S.C. §9621(b)(1), mandates that remedial actions must be protective of human health and the environment, comply with ARARs, be cost-effective, and utilize permanent solutions, alternative treatment technologies, and resource recovery alternatives to the maximum extent practicable. Section 121(b)(1) also establishes a preference for remedial actions which employ, as a principal element, treatment to permanently and significantly reduce the volume, toxicity, or mobility of the hazardous substances, pollutants, and contaminants at a site. CERCLA §121(d), 42 U.S.C. §9621(d), further specifies that a remedial action must attain a level or standard of control of the hazardous substances, pollutants, and contaminants, which at least attains ARARs under federal and state laws, unless a waiver can be justified pursuant to CERCLA §121(d)(4), 42 U.S.C. §9621(d)(4).

Principal threat wastes are those source materials considered to be highly toxic and which present a significant risk to human health or the environment should exposure occur, or are highly mobile such that they generally cannot be reliably contained. The decision to treat these wastes is made on a site-specific basis through a detailed analysis of alternatives using the remedy selection criteria which are described below. This analysis provides a basis for making a statutory finding that the remedy employs treatment as a principal element.[5]

Detailed descriptions of the remedial alternatives for addressing the contamination associated with the site can be found in the FS report and the Proposed Plan. The FS report presents 14 lakewide alternatives. To facilitate the presentation and evaluation of these alternatives, the FS report alternatives were reorganized to formulate the seven remedial alternatives discussed below.[6] The alternatives presented below involve the following remedial technologies:

- Dredging (removal)
- Disposal and treatment at a sediment consolidation area (SCA)
- Isolation capping
- Thin-layer capping
- Oxygenation of the hypolimnion
- Monitored Natural Recovery (MNR)[7]

Each of the action alternatives also includes habitat improvement and/or restoration elements (i.e., habitat reestablishment and habitat enhancement). *Habitat reestablishment* is the restoration of habitat in areas where remediation substantially alters existing conditions. Reestablishment can be either restoring the same type of habitat that existed prior to remediation, or establishing a different type of habitat that has been deemed appropriate for the ecological conditions of the area. *Habitat enhancement* is improvement of habitat conditions in areas where CERCLA contaminants do not occur at levels that warrant active remediation, but where habitat impairment due to stressors has been identified as a concern. The design and construction of habitat improvement and restoration elements must be consistent with the substantive requirements for permits associated with disturbance to state and federal regulated wetlands (e.g., 6 NYCRR Part 663, Freshwater Wetlands Permit Requirements) and navigable waters (e.g., 6 NYCRR Part 608, Use and Protection of Waters). A comprehensive lakewide habitat restoration plan will be developed during the remedial design. Habitat reestablishment and habitat enhancement will be performed consistent with the lakewide habitat restoration plan. Any "habitat enhancement" actions performed at the site would be performed in conformance with the requirements of state law and not pursuant to the requirements of CERCLA or the NCP.

---

5 *A Guide to Principal Threat and Low Level Threat Wastes*, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, 9380.3-06FS, November 1991.

6 The descriptions of the remedial alternatives and the selected remedy presented below do not represent an offer of settlement by the State of the State's pending litigation claims concerning the lake or lake system.

7 MNR involves allowing natural processes to decrease a number of factors – the concentration, mobility, bioavailability, toxicity and/or exposure – involving chemicals, combined with a systematic monitoring program to ensure that the recovery process is proceeding appropriately. MNR can occur through a variety of processes including the degradation of organic compounds, the burial of sediments containing chemicals by incoming clean sediments (although much of the sediment deposition continues to originate from the Tully Valley, including the residual effects of solution mining), and the conversion of compounds to less toxic forms. Much of SMU 8 appears to exhibit the types of processes (for example, the continuing deposition of sediments and the limited resuspension of pollutants) and the chemical characteristics that support the progress of natural recovery.

Technologies

Dredging

Dredging would involve permanent removal of sediments and wastes from Onondaga Lake to a specific design depth. Sediments can be dredged hydraulically, mechanically, or by a combination of the two. While hydraulic dredging was selected as the representative process for detailed evaluation, the actual dredging method(s) would be determined during the design phase. In developing alternatives that incorporate removal of contaminated sediments, the following six potential removal options were considered. These potential removal options are not mutually exclusive. In other words, combinations of these options could be employed as part of a remedial alternative for addressing lake contamination. For all dredging options, the littoral zone in the vicinity of the dredging would be restored to reestablish appropriate habitat and function following removal of contaminated sediments.

- Targeted dredging in areas with high CPOI concentrations and high groundwater upwelling velocities. Targeted dredging would increase the effectiveness of an isolation cap.
- Dredging (prior to capping) to ensure that the placement of the isolation cap would result in no loss of lake surface area.
- Dredging for erosion protection and to reestablish habitat.
- Dredging to remove NAPL.
- Dredging to reduce CPOI concentrations prior to capping, which would result in removal of a significant mass of CPOIs.
- Dredging to remove materials in areas of hot spots within the ILWD.
- Dredging for full removal to an SEC.

Targeted dredging would be performed to increase long-term cap effectiveness through removal of contaminated sediments in nearshore areas where groundwater upwelling velocities are high. Groundwater modeling indicates that predicted upwelling velocities are at their greatest near shore, which may prevent the cap from providing complete chemical isolation.

Dredging (prior to capping) would be performed to ensure that the placement of the isolation cap would not result in the loss of lake surface area. Under this option, sufficient sediment would be removed so that there would be no loss of lake surface area following isolation cap placement.

Dredging for erosion protection and to reestablish habitat would consist of removal to an optimal depth for reducing the erosive forces on the cap and reestablishing littoral zone habitat. The reestablished habitat may differ from the pre-remediation habitat primarily due to a change in bathymetry or water depth (in addition to the elimination of contamination through the placement of clean material). As part of the remedial design, the final water depth would be designed to meet a particular natural resource goal for each particular SMU while also maintaining littoral zone function.

The isolation cap would be armored (as needed) to prevent erosion caused by wind-driven waves, ice scour, currents from tributaries, and scour from propeller wash. The influence from these effects tends to decrease with increasing water depths. Therefore, with regard to minimizing erosive forces, the goal under this option is to remove nearshore sediments to a depth where erosion is not significant, which allows minimal armoring.

Dredging to remove NAPL would target NAPL in sediments and waste, which constitute an ongoing source (and potential source) of contamination to other media in the lake. As such, they are "principal threat wastes."

This option includes a dredging/backfilling combination that removes material known, or anticipated, to contain NAPL, such as the southeast portion of SMU 2 (which is immediately adjacent to where NAPLs have accumulated in the shoreline area in the vicinity of the Honeywell causeway and where an onshore NAPL recovery IRM is underway). While NAPLs have been observed in the sediments (up to 13 ft [4 m]) in this area, the full extent is unknown. Based on the vertical extent of NAPLs in the NAPL recovery IRM area, the possibility exists that the NAPLs are as deep as 30 ft (9 m) below the top of the sediments. Accordingly, some of the alternatives assume a removal depth of 30 ft (9 m) in the area near the causeway, rather than the 13 ft (4 m) assumed for the other alternatives. As the depth estimates above are based on limited information, the actual areal and vertical extent of NAPL, as well as the volume of NAPL would be refined in the remedial design.

Dredging to reduce CPOI concentrations prior to capping, which would result in removal of a significant mass of CPOIs. The southern area of the lake near the Honeywell sites represents the largest repository of CPOIs within the lake, based on volume and CPOI concentrations. The removal of portions of the ILWD prior to isolation capping has the potential to greatly reduce the mass of CPOIs in SMU 1 and portions of SMUs 2 and 7, leaving behind significantly lower volumes and masses of wastes (and residual NAPLs) and significantly lower concentrations of CPOIs beneath the cap. The occurrence of "slumps," or slope failures, within the ILWD, as noted during side-scan sonar imaging of the lake bottom, as well as the generally soft nature of the wastes/sediments (resulting in very low shear strengths in certain areas), represents a major engineering concern in the consideration of capping in this area. Thus, dredging to improve slope stability of the ILWD as well as dredging to improve overall geotechnical conditions for cap placement is also an important considerations.

While the ILWD in SMU 1 has been defined based on historical photographs, the extent of elevated concentrations of CPOIs and the extent of Solvay waste, based on visual observations has not been fully determined. Based on the existing data, the ILWD may be as deep as 45 ft (14 m) below the top of the sediments and extends into nearby SMUs 2 and 7. As the depth and volume estimates are based on limited information, the full areal and vertical extent of the ILWD, the distribution of highly elevated CPOI concentrations, and the geotechnical characteristics of the wastes would need to be refined in the remedial design.

Dredging to remove hot spots in the ILWD would be performed to remove additional waste material which would be defined as those wastes/sediments that contain CPOIs above threshold concentrations. This is included in one of the alternatives discussed below. The purpose of this additional removal in hot spot areas is to improve capping effectiveness, by reducing the concentrations of contaminants in the sediments before the isolation cap is placed. The hot spot threshold concentrations that would trigger the additional dredging are as follows:

- Benzene – 208 mg/kg

- Chlorobenzene – 114 mg/kg
- Dichlorobenzenes – 90 mg/kg
- Naphthalene – 20,573 mg/kg
- Xylene – 142 mg/kg
- Ethylbenzene – 1,655 mg/kg
- Toluene – 2,626 mg/kg
- Mercury – 2,924 mg/kg

The hot spots are defined as those wastes/sediments that contain select CPOIs (based on their presence at significantly elevated concentrations in the ILWD materials and/or the compounds to which the cap model was most sensitive) above threshold concentrations. Based on existing data only chlorobenzene, dichlorobenzenes, and xylenes exceed their respective cap threshold values in the ILWD.

The above concentrations were derived using a cap model developed by Honeywell and represent the maximum concentrations that could be present in the wastes/sediments and not cause failure of a cap with a 2.5-ft-thick isolation layer assuming an upwelling rate of 2.4 inches/year (6 cm/year). Capping effectiveness is related to cap thickness, contaminant concentrations below the cap, and the upwelling rate (rate at which groundwater flows up through the capped sediments/wastes). With regard to the upwelling rate, Honeywell's cap model predicts that the cap would be effective based on an assumed upwelling rate of 0.8 inches/year (2 cm/year). This assumption relies upon the proper construction/operation of a hydraulic control system which would be installed (as part of the Wastebed B/Harbor Brook IRM) along the lakeshore adjacent to SMU 1. While the capping model assumes an upwelling rate of 0.8 inches/year (2 cm/year), the hot spot threshold concentrations would be based on a higher (2.4 inches/year [6 cm/year]) upwelling rate.

The use of a higher upwelling rate in the development of these values would result in lower (more conservative) hot spot threshold concentrations than would be developed by assuming lower (e.g., 0.8 inches/year [2 cm/year] or 1.6 inches/year [4 cm/year]) upwelling rates. The use of these threshold concentrations for identifying hot spots within the ILWD provides a method for increasing the effectiveness of capping at the site. As refined cap modeling would be performed during the remedial design, it is possible that these concentrations may be modified. However, the hot spot concentrations would be based on an assumed upwelling rate of 2.4 inches/year (6 cm/year).

Dredging to an SEC relies primarily on full removal of contaminated sediments down to the SEC selected as the cleanup criterion. Some backfill would be required to establish reasonable bottom contours (bathymetry) and to reduce the impact of any residual CPOIs.

Disposal

Large sediment-dredging projects require large areas for dredged materials management (which includes dewatering, treatment, and final disposal) of the dredged sediment. Typically, the dredged sediment from a remediation project is either consolidated in an on-site location such as an SCA, if sufficient land area is available, or is solidified and transported to an off-site permitted landfill.

The assessment of various management disposal options included hydraulic dredging with disposal in an SCA and mechanical dredging with off-site disposal (at one or more permitted landfills). On-site consolidation of the sediment in an SCA is the selected sediment management option. On-site management in an SCA, designed, constructed, and monitored in accordance with federal and state guidance, is a proven and reliable technology for sediment and waste management that is protective of human health and the environment.

Management of the dredged sediments in an SCA would also be more cost-effective than off-site disposal, especially at sediment volumes exceeding 100,000 cy (76,500 m^3). Therefore, all of the action alternatives in the ROD assume that the dredged sediments would be disposed in an SCA(s). More specifically, the FS report and the alternatives discussed in this ROD assume that such an SCA would be constructed on one or more of the Solvay wastebeds (e.g., Wastebed 13). Wastebed 13 could accommodate a large sediment volume (potentially 2,400,000 cy [1,800,000 m^3] or more, depending on final elevation), and its relatively remote location would minimize disruption to and impacts on the community during construction and operation of an SCA. However, the actual Solvay wastebed location(s) on which the SCA(s) would be constructed would be based on geotechnical testing and screening that would be performed during the remedial design. Potential SCA locations include Wastebeds 1 through 8, Wastebeds 9 through 11, and Wastebeds 12 through 15. The remedial design of the SCA would be undertaken in accordance with state and federal requirements and guidance and would include the installation of an impermeable liner, leachate collection and treatment, and a cap.

It is assumed that preloading and stabilization of the wastebed materials would be required prior to construction of the SCA, but the extent to which preloading and stabilization would be required, if any, would be determined during the remedial design.

In keeping with the statutory preference for treatment that reduces toxicity, mobility, or volume of contaminated media as a principal element of the remedy, the remedy would include treatment and/or disposal of the most highly contaminated materials (e.g., pure phase chemicals segregated during the dredging/handling process) at an off-site permitted facility.

Water Treatment

Hydraulic dredging in Onondaga Lake would be performed SMU by SMU. Silt barriers would be used to contain resuspended sediment within each SMU dredging work zone. Sediment slurry, containing approximately 10 percent solids by weight, would be transported via a pipeline to the SCA for consolidation and treatment of the entrained water to remove CPOIs (including NAPL).

Four different treatment options (primary treatment, enhanced primary treatment, enhanced primary treatment with multimedia filtration, and advanced treatment), providing incrementally higher degrees of treatment, were considered for the supernatant. The specific treatment process used will be developed during the remedial design after additional sampling and treatability testing. In order to be sure that the cost of treatment was not underestimated, this ROD assumes that "advanced treatment" would be used.

The treatment train for "advanced treatment" consists of enhanced primary treatment, multimedia filtration, air stripping, and granular activated carbon treatment for additional VOC removal. This option includes pH adjustment to promote chemical precipitation of metals, including mercury.

During the remedial design, NYSDEC will issue discharge limits that would need to be met by the treated water at the point of discharge (end of pipe) to the lake. It is assumed that supernatant water will require advanced treatment before discharge. However, the actual level of treatment needed to ensure compliance with discharge limits would be determined during the remedial design and might vary depending on the levels and types of contaminants present in lake sediments in various areas (or SMUs) of Onondaga Lake.

Isolation Capping

Isolation capping involves placement of an engineered cap on top of the contaminated sediment. This material helps to prevent or retard the movement of contaminated porewater into the water column and minimize exposure of benthic organisms to the contaminated sediments. Most of the alternatives involve capping portions of the lake bottom to meet the following objectives:

- Provide physical isolation of the impacted sediments from benthic organisms and other animals, and human contact.

- Physically stabilize the sediment to prevent resuspension, contaminant mobilization, and sediment transport.

- Provide chemical isolation of impacted sediments from advective or diffusive flux or resuspension into the overlying surface waters.

Specific factors that would be evaluated as part of the design of the engineered cap include erosion, bioturbation, chemical isolation, habitat protection, settlement, static and seismic stability, and placement techniques. Modeling performed for chemical isolation was used to produce preliminary cap designs (see the text boxes below entitled "Groundwater Flow Model" [page 49] and "Isolation Capping Model" [page 50]), to ensure that there would be no predicted exceedances of the PEC of any of the CPOIs that have been shown to exhibit acute toxicity on a lakewide basis or NYSDEC sediment screening criteria for benzene, toluene, and phenol.

The results of a preliminary capping evaluation were used to produce the cap designs presented in the alternatives. Since the cap would be designed such that none of the PECs for the individual CPOIs (or the NYSDEC sediment criteria for benzene, toluene, and phenol) would be exceeded in the bioturbation layer, the model-predicted mean PECQ of the surficial materials following cap placement would be less than 1. The modeling indicates that the chemical isolation component of these caps should be between 1 to 2.5 ft (0.3 to 0.76 m) thick, depending on the area of the lake.

To ensure protection of human health and the environment, the caps would be designed to be an additional 50 percent thicker as a safety factor, plus an additional 6 inches (15.2 centimeters) to address possible mixing with underlying sediment and uneven application, which results in a total thickness of 2 to 4.25 ft (0.6 to 1.3 m) for the various SMUs. Settlement analysis was incorporated into the preliminary cap design to estimate the final elevation of the cap following settlement due to the weight of the cap.

Evaluations of wind-generated waves, flood flows at the mouths of tributaries, propeller wash from vessels, and ice scour predict that a cap armor layer consisting of gravel or sand (depending on location and water depth) and armor stone along the shoreline would provide physical stability for the cap. A 6-inch "habitat/bioturbation" layer was assumed for cap modeling purposes in order to incorporate assumed mixing of contaminants in the top layer of the isolation cap by benthic invertebrates. Actual habitat restoration requirements were not considered in the model.

For the isolation cap to be effective in certain areas of the lake, hydraulic control systems would need to be in place to minimize upwelling velocities in these areas. Due to the elevated concentrations of CPOIs and unstable areas within the littoral zone, as well as concerns for fish and wildlife exposures, isolation capping (rather than thin-layer capping) is evaluated in the alternatives for all littoral-zone SMUs (0 to 30 ft [0 to 9 m] water depths). However, if the evaluation of data collected during remedial design identifies areas, within the deeper portion of the littoral zone (i.e., 6 to 9 m), where thin-layer capping would be effective at isolating the contaminated sediments, NYSDEC will consider the use of thin-layer capping in these areas.

Groundwater Flow Model

A groundwater flow model was developed using the software programs Groundwater Vistas and SEAWAT-2000 to simulate groundwater flow beneath and in the vicinity of the southern part of Onondaga Lake.

The groundwater flow model domain encompasses an area of approximately 13 sq mi (34 sq km) surrounding the southern shoreline of Onondaga Lake and centered on the Honeywell sites. The nine-layer model represents seven hydrogeologic units, which were identified through 216 soil borings. Estimates of hydraulic conductivity of the hydrogeologic units were derived from in situ conductivity tests, laboratory permeability tests, specific capacity tests, and pumping tests.

The density of groundwater influences groundwater flow, and therefore a rigorous representation of the groundwater density distribution was incorporated into the model. A major influence on groundwater density is salinity (measured by groundwater total dissolved solids concentrations). The range in total dissolved solids concentrations in the area of the lake (400 mg/L to almost 194,000 mg/L) is caused by the presence of both leachate from Honeywell's inactive Solvay wastebeds and naturally occurring salt brines.

The results of the groundwater flow model included an estimate of the amount and velocity of the groundwater that flows upward through the lake sediments in the various SMUs, both with and without the proposed groundwater barrier wall and collection system along the lakeshore in the southern corner. These results were used in the isolation capping model.

Thin-Layer Capping

Thin-layer capping is included in all of the action alternatives for portions of the profundal sediments of Onondaga Lake. The objective of thin-layer capping is to provide an immediate decrease in surface sediment concentrations by introducing clean substrate into the upper layer of sediment, rather than to isolate surface sediments. It is anticipated that construction of the thin-layer cap and subsequent natural processes, such as bioturbation and sedimentation, would mix the new substrate with the underlying material or cover contaminated sediments, thereby reducing the surface concentration of the profundal sediments and the potential for adverse effects associated with CPOIs. During the remedial design the appropriate thickness and type of substrate would be identified. A thin-layer cap thickness of 4 inches (10 cm) was used for cost estimating purposes. The suitability of thin-layer capping at the base of the ILWD in the profundal zone (SMU 8) would be reviewed during the remedial design based on extensive data to be collected as part of the pre-design program.

Isolation Capping Model

A model was developed to assess the effectiveness of in-situ isolation capping of the littoral sediments of Onondaga Lake. In-situ capping involves placement of an engineered cap over contaminated sediment to prevent or limit the movement of contaminated porewater from the sediment into the water column and minimize exposure of benthic organisms to the contaminated sediments. An isolation cap would consist of three layers:

1. An isolation layer, designed to prevent or limit vertical chemical migration.
2. An armor layer, designed to protect the isolation layer from erosional processes such as waves, ice scour, and propeller wash.
3. A habitat/bioturbation layer, designed to provide habitat for benthic macroinvertebrates and allow for bioturbation processes without exposure to contaminated sediment or disruption of the isolation layer material.

There are varying degrees of contamination in the sediments of each SMU; thus, each cap would need to be of a SMU-specific thickness to ensure that contaminants are contained. Therefore, the model was developed for each littoral zone SMU. The model was used to predict chemical concentrations in the habitat/bioturbation layer at steady state, with the primary means of contaminant transport within the isolation layer being through the processes of porewater advection and diffusion. This model assumes that the cap is armored, so that erosion of the cap is minimal and does not provide the primary means of contaminant migration. In addition, the bioturbation or biologically active zone is assumed to be confined to an approximately 6 inch (15 cm) layer above the chemical isolation layer, so that few contaminants are transported to the surface of the cap by organisms mixing the sediments.

The predicted concentrations of contaminants in sediments at the top of the cap were compared to the chemicals' PECs for the 23 CPOIs and NYSDEC sediment screening criteria* for benzene, toluene, and phenol to ensure that these concentrations would not be exceeded in the habitat/bioturbation layer in the future. The cap model was then used to determine the appropriate cap thickness in each littoral zone SMU and whether sediment removal is necessary in areas of high upwelling rates. The cap model will be re-run as part of the remedial design, incorporating any new remedial design data, and the cap design may be modified as appropriate.

* NYSDEC Technical Guidance for Screening Contaminated Sediments, January 1999.

Oxygenation

Oxygenation, as defined for this ROD, involves the introduction of oxygen into the hypolimnion to prevent the development of anoxic (no oxygen) conditions, which currently exist in summer and early fall (June through September). Oxygenation can be achieved using a number of methods including introducing pure oxygen, atmospheric air, or oxygen-enriched air to the water column. Maintaining oxygenated conditions in the hypolimnion is expected to reduce mercury methylation in the hypolimnion and reduce the concentrations of dissolved mercury. These effects, in turn, would be expected to result in decreased concentrations of mercury in fish tissue and decreased risk to fish consumers. Maintaining oxygenated conditions would also be expected to reduce the flux of methylmercury from profundal sediments.

A specific oxygenation system technology would be determined as appropriate, during the remedial design. The specific technology assumed for the purposes of the FS report involves a downflow contact oxygenation system that mixes pure oxygen bubbles with oxygen-depleted water inside a contact chamber so that no bubbles are released to the surrounding water column. This system uses a submersible pump, which draws water from the hypolimnion into the conical unit. Oxygen supplied from an onshore facility is injected at the top of the cone. The oxygenated water is then discharged back to the lake through a horizontal diffuser pipe at the same depth from which it was withdrawn. Oxygenation has been performed in other lakes and reservoirs, but not to specifically control methylmercury production. A pilot study would be performed to evaluate the potential effectiveness of oxygenation at reducing the formation of methylmercury in the water column, while preserving the normal cycle of stratification within the lake. An additional factor which would be considered during the design of the pilot study would be the effectiveness of oxygenation at reducing fish tissue methylmercury concentrations. If supported by the pilot study results, the pilot study would be followed by full-scale implementation of oxygenation in SMU 8. Furthermore, potential impacts of oxygenation on the lake system would be evaluated during the pilot study and/or the remedial design of the full-scale oxygenation system. Pilot testing may be coordinated, if feasible, with the Onondaga Lake Partnership, which is planning a similar pilot oxygenation study on the lake.

Monitored Natural Recovery

MNR is a sediment management tool that depends on a variety of physical, chemical, and biological processes that reduce chemical concentrations, exposure, and mobility. MNR requires a goal that defines the expected contaminant concentrations to be reached in a specified time period (assumed in the FS report to be 10 years following the remediation of upland sources, littoral sediments, and initial thin-layer capping in the profundal zone). The MNR alternative includes the completion of investigations during the remedial design to refine the application of a monitored natural recovery model (see the text box below entitled "Monitored Natural Recovery Model" [page 52]), long-term monitoring, and institutional controls to protect the integrity of the remedy and ensure long-term protectiveness of human health and the environment. Monitoring the effectiveness of natural recovery would be described in a long-term monitoring plan to be developed during the remedial design and would include evaluations of mercury and other CPOI concentrations in sediment, water, and fish over time.

Monitored Natural Recovery Model

Natural recovery can occur through a variety of physical, chemical, and biological processes that act singly or in combination to reduce contaminant concentrations, exposure, or mobility. This process can occur in various media at a site (e.g., water and sediments.

A one-dimensional, numerical model was developed using STELLA® Research software in order to determine whether MNR is a feasible technology for remediating the contaminated profundal sediments in Onondaga Lake which represent an important sink for contaminants and a potential exposure pathway to organisms. The primary purpose of the MNR model is to understand how natural recovery might occur (or fail to occur) in the future based on what is known about the lake system. The output or results from the model are presented in terms of expected mercury concentrations in surface sediments in the profundal areas of the lake. The model looks at present-day conditions and predicts how those conditions are expected to change several years in the future.

Another purpose of the model is to provide information on how sediment surfaces might react during and after remedial actions. The model focuses on changes in the sediment surface and provides information on reactions to inputs such as isolation or thin-layer caps. Thin-layer capping is a remediation technique (along with MNR) that is evaluated for profundal sediments. The model was used to assess the long-term solid and dissolved contaminant fate and transport associated with natural recovery by simulating the diffusion, bioturbation, groundwater mediated advection, settling, burial, and degradation mechanisms likely to be present at the Onondaga Lake site. By assessing these mechanisms over time, a prediction of contaminant concentrations and fluxes in the future was obtained. Using the sediment data currently available (primarily from 1992 for the profundal sediments), the model predicts that any area that had an observed total mercury concentration of 6.7 mg/kg or less in 1992 would be expected to achieve the mercury PEC of 2.2 mg/kg by 2014. Thus, the model suggests that most of the profundal zone would be amenable to MNR as a remedial alternative. However, additional MNR modeling would need to be performed during the remedial design phase based upon additional sampling that would take place prior to remediation.

Description of Lakewide Alternatives

The No-Action Alternative and all other alternatives assume that controls of upland sources of hazardous substances will be implemented separately pursuant to CERCLA and the state Superfund law. Costs for remediating upland sources are not included in the costs for these alternatives. With the exception of the No-Action Alternative, all alternatives for the littoral zone (SMUs 1 through 7) include varying amounts of dredging, isolation capping, NAPL removal, and habitat reestablishment and enhancement. With the exception of the No-Action Alternative, all alternatives for the profundal zone (SMU 8) include oxygenation, MNR, and varying amounts of thin-layer capping. Table 14 presents the littoral- and profundal-specific alternatives for each SMU for each alternative.

Alternative 1 – No Action

Dredged Volume (cy):	0
Capital Cost:	$0
Average O&M Annual Costs:	$0
Present-Worth O&M Costs:	$0
Present-Worth Cost:	$0
Construction Time:	0 years

The Superfund program requires that the "no-action" alternative be considered as a baseline for comparison with the other alternatives. The no-action remedial alternative does not include any physical remedial measures that address the problem of sediment contamination at the site.

Because this alternative would result in contaminants remaining on site above levels that allow for unlimited use and unrestricted exposure to site media, CERCLA requires that the site be reviewed at least once every five years. If justified by the review, remedial actions may be implemented to remove, treat, or contain the contaminated sediments.

Alternative 2 – Dredging for No Loss of Lake Surface Area and Erosion Protection and to Reestablish Habitat, and Isolation Capping in SMUs 1 to 7; Targeted Dredging to 4 m (13 ft) for NAPL Removal in SMU 2; Targeted Dredging in SMUs 3 and 6; and Phased Thin-Layer Capping, Oxygenation, and Monitored Natural Recovery in SMU 8.

Dredged Volume (cy):	1,207,000
Capital Cost:	$275,000,000
Annual O&M Costs:	$3,000,000
Present-Worth O&M Costs:	$37,000,000
Present-Worth Cost:	$312,000,000
Construction Time:	4 years

Under this alternative, all areas of the lake where the surface sediments exceed a mean PECQ of 1 or the mercury PEC (2.2 mg/kg) would be addressed (see Figure 7). This alternative includes:

- Dredging of an estimated 354,000 cy (271,000 m^3) of sediment in SMU 1, prior to capping, to minimize erosive forces on the cap, prevent a loss of lake surface area, and reestablish habitat. Capping of approximately 84 acres in SMU 1.

- Dredging of an estimated 169,000 cy (129,000 m^3) of sediment in SMU 2, prior to capping, to remove NAPL to a 13-ft (4-m) depth in the vicinity of the causeway, minimize erosive forces on the cap, prevent a loss of lake surface area, and reestablish habitat. Capping of approximately 16 acres in SMU 2.

- Dredging of an estimated 75,000 cy (57,000 m^3) of sediment in SMU 3, prior to capping, to maintain cap effectiveness in the absence of hydraulic containment, to minimize erosive forces on the cap, prevent a loss of lake surface area, and reestablish habitat. Capping of approximately 29 acres in SMU 3.

- Dredging of an estimated 135,000 cy (103,000 m^3) of sediment in SMU 4, prior to capping, to minimize erosive forces on the cap, prevent a loss of lake surface area, and reestablish habitat. Capping of approximately 75 acres in SMU 4.

- Dredging of an estimated 140,000 cy (107,000 m^3) of sediment in SMU 5, prior to capping, to minimize erosive forces on the cap, prevent a loss of lake surface area, and reestablish habitat. Capping of approximately 60 acres in SMU 5.

- Dredging of an estimated 245,000 cy (187,000 m^3) of sediment in SMU 6, prior to capping, to maintain cap effectiveness in the absence of hydraulic containment, to minimize erosive forces on the cap, prevent a loss of lake surface area, and reestablish habitat. Capping of approximately 123 acres in SMU 6.

- Dredging of an estimated 89,000 cy (68,000 m^3) of sediment in SMU 7, prior to capping, to minimize erosive forces on the cap, prevent a loss of lake surface area, and reestablish habitat. Construction/operation of a hydraulic control system along the SMU 7 shoreline to maintain cap effectiveness. Capping of approximately 38 acres in SMU 7.

- Isolation capping over an estimated 425 acres of the littoral zone, as noted for each littoral SMU above.

- Thin-layer capping over an estimated 154 acres of the profundal area (SMU 8) based on the current extent of exceedances of mean PECQ of 1.

- Oxygenation of the hypolimnion (SMU 8) to reduce methylation of mercury, reduce dissolved mercury concentrations, and reduce methylmercury flux from profundal sediments, thereby reducing mercury bioaccumulation in fish tissue.

- MNR in the profundal area (SMU 8), with a contingency of additional capping.

- Treatment and/or disposal of the most highly contaminated materials (e.g., pure phase chemicals segregated during the dredging/handling process) at an off-site permitted facility. Consolidation of the balance of the dredged sediments in one or more SCAs constructed on one or more of the Honeywell wastebeds.[8] The SCA(s) will include, at a minimum, the installation of a liner, a cap, and a leachate collection and treatment system.

- Treatment of water generated by sediment dewatering, produced at the SCA(s) through sediment consolidation, prior to discharge of the water back to Onondaga Lake.

---

[8] Wastebed 13, which was evaluated in the FS report, could accommodate a large sediment volume (potentially 2,400,000 cy [1,800,000 m^3] or more, depending on final elevation). The actual Solvay wastebed location(s) on which the SCA(s) would be constructed would be determined during the remedial design and be based on an evaluation of the potential impacts on the local community, geotechnical stability of the wastebeds, SCA construction requirements, wastebed size, the means for transporting dredged materials to the SCA, costs, etc.

- Institutional controls including the notification of appropriate government agencies with authority for permitting potential future activities which could impact the implementation and effectiveness of the remedy.

This alternative would also include habitat enhancement along an estimated 1.5 mi (2.4 km) of shoreline (SMU 3) and over approximately 23 acres (SMU 5) to stabilize calcite deposits and oncolites and promote submerged macrophyte growth.[9]

The dredging and capping components of this alternative would occur over a period of approximately four years.

Because this alternative would result in contaminants remaining on site above levels that allow for unlimited use and unrestricted exposure to site media, CERCLA requires that the site be reviewed at least once every five years. If justified by the review, additional remedial actions may be implemented to remove, treat, or contain the contaminated sediments.

Alternative 3 – Dredging of the ILWD to 2 m (6.5 ft) and Isolation Capping in SMU 1; Dredging for No Loss of Lake Surface Area and Erosion Protection and to Reestablish Habitat, and Isolation Capping in SMUs 2 to 7; Targeted Dredging to 4 m (13 ft) for NAPL Removal in SMU 2; Targeted Dredging in SMUs 3 and 6; and Phased Thin-Layer Capping, Oxygenation, and Monitored Natural Recovery in SMU 8.

Dredged Volume (cy):	1,868,000
Capital Cost:	$333,000,000
Annual O&M Costs:	$3,000,000
Present-Worth O&M Costs:	$37,000,000
Present-Worth Cost:	$370,000,000
Construction Time:	4 years

This alternative is the same as Alternative 2, except for how it addresses the ILWD in SMU 1. Under this alternative, dredging would be performed to a depth of 6.5 ft (2 m) on average in the ILWD prior to capping, resulting in an additional 661,000 cy (505,000 m^3) waste/sediment being removed. This alternative would result in the dredging of 1,868,000 cy (1,427,000 m^3) of sediments and the capping of 579 acres.

Because this alternative would result in contaminants remaining on site above levels that allow for unlimited use and unrestricted exposure to site media, CERCLA requires that the site be reviewed at least once every five years. If justified by the review, additional remedial actions may be implemented to remove, treat, or contain the contaminated sediments.

---

9 This component of the remedy is not intended to satisfy the requirements of CERCLA or the NCP, but is included in order to address requirements of state law.

Alternative 4 – Dredging of the ILWD to 2 m (6.5 ft); Removal in Areas of Hot Spots in the ILWD to a Maximum Depth of 3 m (10 ft) and Isolation Capping in SMU 1; Dredging for No Loss of Lake Surface Area and Erosion Protection and to Reestablish Habitat, and Isolation Capping in SMUs 2 to 7; Targeted Dredging to 9 m (30 ft) for NAPL Removal in SMU 2; Targeted Dredging in SMUs 3 and 6; and Phased Thin-Layer Capping, Oxygenation, and Monitored Natural Recovery in SMU 8.

Dredged Volume (cy):	2,653,000
Capital Cost:	$414,000,000
Annual O&M Costs:	$3,000,000
Present-Worth O&M Costs:	$37,000,000
Present-Worth Cost:	$451,000,000
Construction Time:	4 years

This alternative is the same as Alternative 2 except that it includes the performance of additional dredging of the ILWD to reduce average CPOI concentrations in sediments/wastes remaining under the cap, as well as additional dredging in SMU 2 to remove NAPLs.

Under this alternative, dredging would be performed to a depth of 6.5 ft (2 m) on average in the ILWD, as for Alternative 3; however, dredging would also be performed to remove material from hot spot areas to a depth of 3.3 ft (1 m) below the 6.5 ft (2 m) dredge cut for a total depth of removal of up to 10 ft (3 m) in hot spot areas. The hot spots would be defined as those wastes/sediments that contain CPOIs above threshold concentrations. The purpose of this additional removal in hot spot areas would be to improve capping effectiveness. The hot spot threshold concentrations that would trigger the additional dredging are as follows:

- Benzene – 208 mg/kg
- Chlorobenzene – 114 mg/kg
- Dichlorobenzenes – 90 mg/kg
- Naphthalene – 20,573 mg/kg
- Xylene – 142 mg/kg
- Ethylbenzene – 1,655 mg/kg
- Toluene – 2,626 mg/kg
- Mercury – 2,924 mg/kg

Capping effectiveness is related to cap thickness, contaminant concentrations below the cap, and the upwelling rate at which groundwater flows upward through the capped sediments/wastes. These concentrations, which were developed using the cap model developed by Honeywell, represent the maximum concentrations that could be present in the wastes/sediments and not cause failure of a cap with a 2.5-ft-thick isolation layer, assuming an upwelling rate of 2.4 inches/year (6 cm/year).

The remedy would include additional dredging, if needed, to address geotechnical concerns with the ILWD.[10] Accordingly, up to 10 ft (3 m) on average of the ILWD would be removed under this alternative prior to capping and would result in an additional 1,212,000 cy (927,000 m^3) of waste/sediment being removed (relative to Alternative 2) from the ILWD.

Under this alternative, NAPLs would be removed from SMU 2 to an estimated depth of 30 ft (9 m). However, the actual depth of removal would be determined during the remedial design based on the extent of NAPLs delineated as a result of remedial design sampling. This would include the NAPL removal described in Alternative 2, as well as the removal of the NAPL which may be present within the marl unit beneath the lake sediments. Accordingly, this alternative would result in an additional 234,000 cy (179,000 m^3) of additional sediments/marl being removed (relative to Alternative 2) from SMU 2.

Because this alternative would result in contaminants remaining on site above levels that allow for unlimited use and unrestricted exposure to site media, CERCLA requires that the site be reviewed at least once every five years. If justified by the review, additional remedial actions may be implemented to remove, treat, or contain the contaminated sediments.

Alternative 5 – Dredging of the ILWD to 5 m (16.4 ft) and Isolation Capping in SMU 1; Dredging for No Loss of Lake Surface Area and Erosion Protection and to Reestablish Habitat, and Isolation Capping in SMUs 2 to 7; Targeted Dredging to 9 m (30 ft) for NAPL Removal in SMU 2; Targeted Dredging in SMUs 3 and 6; and Phased Thin-Layer Capping, Oxygenation, and Monitored Natural Recovery in SMU 8.

Dredged Volume (cy):	3,724,000
Capital Cost:	$499,000,000
Annual O&M Costs:	$3,100,000
Present-Worth O&M Costs:	$38,000,000
Present-Worth Cost:	$537,000,000
Construction Time:	4 years

This alternative is the same as Alternative 2, except that it includes the performance of additional dredging in the ILWD in SMU 1 to reduce average CPOI concentrations in sediments/wastes remaining under the cap, as well as additional dredging of the NAPL-contaminated sediments in SMU 2. Specifically, under this alternative, approximately 16.4 ft (5 m) of the ILWD would be removed prior to capping and would result in an additional 2,283,000 cy (1,745,000 m^3) of waste/sediment being removed from SMU 1. In addition, 403,000 cy (308,000 m^3) of NAPL and other contaminated sediments would be removed from SMU 2 (as would be done under Alternative 4).

Because this alternative would result in contaminants remaining on site above levels that allow for unlimited use and unrestricted exposure to site media, CERCLA requires that the site be reviewed

[10] The nature of the wastes, as well as geophysical evidence of historical failures (i.e., underwater slumping or “landslides” associated with the ILWD) might require the removal of additional wastes to ensure the long-term stability of the cap.

at least once every five years. If justified by the review, additional remedial actions may be implemented to remove, treat, or contain the contaminated sediments.

Alternative 6 – Dredging for Full Removal (based on mean PECQ of 1 and the mercury PEC criteria) in SMUs 1 to 4, 6, and 7; Dredging for No Loss of Lake Surface Area and Erosion Protection and to Reestablish Habitat, and Isolation Capping in SMU 5; and Phased Thin-Layer Capping, Oxygenation, and Monitored Natural Recovery in SMU 8.

Dredged Volume (cy):	12,184,000++
Capital Cost:	$1,292,000,000
Average O&M Annual Cost:	$2,800,000
Present-Worth O&M Costs:	$35,000,000
Present-Worth Cost:	$1,327,000,000
Construction Time:	10 years

Alternative 6 differs from Alternative 2 by utilizing dredging to remove all sediments in all SMUs (except 5 and 8) that exceed the mean PECQ of 1 or the mercury PEC. This alternative includes dredging for no loss of lake surface area, for erosion protection, and for habitat reestablishment prior to isolation capping in SMU 5. This alternative includes thin-layer capping in SMU 8 to the same criteria.

This alternative involves dredging approximately 10,977,000 cy (8,400,000 m^3) more than Alternative 2, for a total of 12,184,000 cy (9,315,300 m^3) from 385 acres of the littoral zone, and capping 60 acres in SMU 5. This amount of dredging would require placement of roughly 8,200,000 cy (6,270,000 m^3) of backfill material to maintain reasonable water depths and bathymetry.

Because this alternative would result in contaminants remaining on site above levels that allow for unlimited use and unrestricted exposure to site media, CERCLA requires that the site be reviewed at least once every five years. If justified by the review, additional remedial actions may be implemented to remove, treat, or contain the contaminated sediments.

Alternative 7 – Dredging for Full Removal (based on ER-L criteria) in SMUs 1 to 4, 6, and 7; Dredging for No Loss of Lake Surface Area and Erosion Protection and to Reestablish Habitat, and Isolation Capping in SMU 5; and Thin-Layer Capping and Oxygenation in SMU 8.

Dredged Volume (cy):	20,121,000
Capital Cost:	$2,086,000,000
Average O&M Annual Cost:	$5,700,000
Present-Worth O&M Costs:	$71,000,000
Present-Worth Cost:	$2,157,000,000
Construction Time:	17 years

This alternative is based on remediating areas of the lake where sediments exceed the ER-Ls (rather than the mean PECQ of 1 and the mercury PEC). It is included to evaluate removal and capping based on a more protective site-specific SEC.

Alternative 7 differs from Alternative 2 by dredging in the littoral zone to the ER-L (except for SMU 5) of any of the CPOIs shown to exhibit a relationship with benthic toxicity on a lakewide basis (see Figure 8). The remediation of the lake to the ER-L expands upon Alternative 2 by capping an additional 289 acres in SMU 5 (for a total of 349 acres in the littoral zone). This alternative includes dredging for no loss of lake surface area, for erosion protection, and for habitat reestablishment prior to isolation capping in SMU 5. An additional 1,826 acres in the profundal zone (for a total of 1,980 acres in the profundal zone) exceed the ER-L criteria (instead of the mean PECQ criteria) and would be capped. This alternative would include dredging an additional 18,914,000 cy (14,461,000 m^3) of sediment (for a total of 20,121,000 cy [15,384,000 m^3]) from the littoral zone. This would require more than 14,600,000 cy (11,163,000 m^3) of backfill material to maintain reasonable water depths and bathymetry. In addition, the entire bottom of the lake in SMU 8 would be covered with a thin-layer cap.

Because this alternative would result in contaminants remaining on site above levels that allow for unlimited use and unrestricted exposure to site media, CERCLA requires that the site be reviewed at least once every five years. If justified by the review, additional remedial actions may be implemented to remove, treat, or contain the contaminated sediments.

COMPARATIVE ANALYSIS OF ALTERNATIVES

In selecting a remedy, NYSDEC and EPA considered the factors set out in CERCLA Section 121, 42 USC §9621, by conducting a detailed analysis of the viable remedial alternatives pursuant to the NCP, 40 CFR §300.430(e)(9), and OSWER Directive 9355.3-01 (*Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA: Interim Final*, October 1988). The detailed analysis consisted of an assessment of the individual alternatives against each of nine evaluation criteria and a comparative analysis focusing upon the relative performance of each alternative against those criteria.

The following "threshold" criteria are the most important and must be satisfied by any alternative in order to be eligible for selection:

1. *Overall protection of human health and the environment* addresses whether or not a remedy provides adequate protection and describes how risks posed through each exposure pathway (based on a reasonable maximum exposure scenario) are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls.

2. *Compliance with ARARs* addresses whether or not a remedy would meet all of the applicable or relevant and appropriate requirements of federal and state environmental statutes and regulations or provide grounds for invoking a waiver. Other federal or state advisories, criteria, or guidance are TBCs. TBCs are not required by the NCP, but may be very useful in determining what is protective of a site or how to carry out certain actions or requirements.

The following "primary balancing" criteria are used to make comparisons and to identify the major tradeoffs between alternatives:

3. *Long-term effectiveness and permanence* refers to the ability of a remedy to maintain reliable protection of human health and the environment over time, once cleanup goals have been met. It also addresses the magnitude and effectiveness of the measures that may be required to manage the risk posed by treatment residuals and/or untreated wastes.

4. *Reduction of toxicity, mobility, or volume through treatment* is the anticipated performance of the treatment technologies, with respect to these parameters, a remedy may employ.

5. *Short-term effectiveness* addresses the period of time needed to achieve protection from any adverse impacts on human health and the environment that may be posed during the construction and implementation period until cleanup goals are achieved.

6. *Implementability* is the technical and administrative feasibility of a remedy, including the availability of materials and services needed to implement a particular option.

7. *Cost* includes estimated capital, O&M, and present-worth costs. Present-worth cost is the total cost of an alternative over time in terms of today's dollar value. Cost estimates are expected to be accurate within a range of +50 to -30 percent.

The following "modifying" criteria are used in the final evaluation of the remedial alternatives after the formal comment period, and may prompt modification of the preferred remedy that was presented in the Proposed Plan:

8. *Support Agency acceptance* indicates whether, based on its review of the RI/FS reports and Proposed Plan, NYSDOH concurs with, opposes, or has no comments on the selected remedy.

9. *Community acceptance* refers to the public's general response to the alternatives described in the RI/FS report, RI/FS report addendum (if any), and Proposed Plan.

A comparative analysis of these alternatives based upon the evaluation criteria noted above, follows.

Overall Protection of Human Health and the Environment

Alternative 1, the no-action alternative, would not be protective of human health and the environment, since it would not actively address the contaminated sediments and water in Onondaga Lake. The "active" remediation alternatives would be more protective of human health and the environment than the no-action alternative, since they would, to varying degrees, meet the RAOs and PRGs for the littoral and profundal areas and would result in residual risks less than the no-action alternative. With regard to eliminating or reducing releases of contaminants from the ILWD and other littoral areas around the lake (RAO 2), Alternatives 2 through 7, which result in dredging to depths ranging from 1 to 8 m in the ILWD, would result in progressively greater reduction in the concentration and mass of CPOIs prior to capping.

Alternatives 2 through 6 are equally protective of fish and wildlife by eliminating or reducing existing and potential future adverse ecological effects on fish and wildlife resources and are equally protective of human health by eliminating or reducing potential risks to humans (RAO 4), achieve CPOI concentrations in fish tissue that are protective of humans and wildlife that consume fish (PRG 2), reduce methylation of mercury in the hypolimnion (RAO 1), reduce releases of mercury from profundal sediments (RAO 3), and achieve surface water quality standards (RAO 5 and PRG 3), to the extent that they also meet RAO 2. With regard to achieving applicable and appropriate SECs for CPOIs and the BSQV for mercury (PRG 1), Alternatives 2 through 6 are equally proficient, however, they are not predicted, in the short-term, to achieve the BSQV for mercury on a lakewide basis or in SMU 8.

Since Alternative 7 includes thin-layer capping throughout all of SMU 8, as well as oxygenation, it would be the most effective alternative in achieving RAOs 1 and 3. In addition, Alternative 7 would meet the BSQV for mercury on a lakewide basis and in SMU 8, and it would be the most effective at meeting RAOs 2, 4, and 5 and PRGs 1, 2, and 3, since it would address all areas exceeding the ER-L.

Modeling performed for chemical isolation was used to produce preliminary cap designs to ensure that there would be no predicted exceedances of the PEC of any of the CPOIs that have been shown to exhibit acute toxicity on a lakewide basis or NYSDEC sediment screening criteria for benzene, toluene, and phenol. All of the alternatives which employ capping would be protective to the extent that the cap functions properly. If the cap fails via contaminant breakthrough and/or a catastrophic event (e.g., slope failure), the cap would need to be repaired and sediments contaminated by the release would need to be remediated (e.g., removed, capped in place). In the event of failure, the impacts would be expected to be greatest under those alternatives that involve capping of the greatest mass/highest concentrations of contaminants. Accordingly, Alternative 4 provides more protection than Alternatives 2 and 3. While Alternative 5 would remove more material than Alternative 4, similar concentrations would remain. In addition, Alternative 4 includes cap enhancement in residual hot spot areas and additional dredging, if needed, to address geotechnical concerns with the ILWD. These components of Alternative 4, which are not components of Alternative 5, provide Alternative 4 with greater cap reliability relative to Alternative 5. Alternative 6 would provide greater protection than Alternative 5, and Alternative 7 would be the most protective alternative, because it would result in the further reduction of surface concentrations.

Alternatives 3, 4, and 5 address (through dredging to various depths in the ILWD and removal of NAPL-contaminated sediments in SMU 2) the masses and concentrations of the CPOIs that would remain under the cap in SMUs 1 and 2. While the cap under Alternative 2 would be protective based on modeling studies, reducing the masses and concentrations increases the reliability of and, therefore, the protectiveness of the cap. Accordingly, with regard to the ILWD, the level of protectiveness increases progressively from Alternative 2 through Alternative 7 (with the exception of Alternative 5 discussed above).

With regard to contaminant mass removal, Alternatives 2 and 3 also address a portion of the NAPL within SMU 2. The information currently available indicates that the NAPL present in sediments in the area of the causeway in SMU 2 extends to a depth of approximately 13 ft (4 m), and the corresponding volume of sediment that would be required to remove this NAPL along with other contaminated sediments (under Alternatives 2 and 3) is about 169,000 cy (129,000 m^3). Alternatives 4 and 5 provide for greater mass removal in SMU 2 relative to Alternatives 2 and 3, as they include the NAPL removal described above, as well as the removal of the NAPL which may be present within the marl unit beneath the lake sediments. This would provide greater protectiveness by preventing the NAPL from further impacting the environment.

For Alternatives 6 and 7, which consist of full removal to the cleanup criteria for the littoral zone SMUs (with the exception of SMU 5), an additional level of long-term protectiveness would be achieved through sediment removal, instead of capping.

Compliance with ARARs

Since there are currently no federal or state promulgated standards for contaminant levels in sediments, the ER-Ls, mean PECQ of 1, and mercury PEC have been used in this ROD as TBC criteria. New York State has promulgated surface water standards which are enforceable standards for various surface water contaminants. In addition, EPA publishes water quality criteria under the authority of Section 304(a) of the Clean Water Act (CWA) based solely on data and scientific judgments about the relationship between pollutant concentrations and environmental and human health effects. CWA Section 303©) and its implementing regulations require states and authorized tribes to adopt water quality criteria to protect designated uses in their water quality standards.

In general, Alternatives 2, 3, 4, 5, 6, and 7 would be expected to comply with all of the designated chemical-specific ARARs, while Alternative 1 (no action) would not, since there would be no active remediation associated with the sediments. However, it may not be feasible to meet the New York State surface water quality standards for mercury (i.e., the standard for protection of wildlife of 2.6 ng/L dissolved mercury and the standard for protection of human health [via fish consumption] of 0.7 ng/L dissolved mercury). Oxygenation of the hypolimnion, as proposed in all of the active alternatives, would change the lake's anoxic chemical conditions, which is a primary cause of high concentrations of dissolved mercury (total mercury as well as methylmercury). While this, along with a reduction in inputs of mercury, would substantially reduce the frequency and magnitude of the exceedances of these two standards, it is possible that these standards would not be met all of the time during the post-remediation period. If the post-remediation monitoring indicates that it would be technically impracticable to consistently meet these standards, an ARAR waiver might be needed.

Alternative 7 would be expected to reduce water column concentrations to a greater degree than would Alternatives 2, 3, 4, 5, and 6.

During remedy implementation, any short-term exceedances of surface water ARARs in the lake due to dredging or capping would be expected to be limited to the area in the vicinity of the work zone. Sufficient engineering controls would need to be put in place during dredging and capping to prevent or minimize exceedances of surface water ARARs outside of the work zone. Furthermore, compliance with the discharge limits (to be established by NYSDEC) should ensure that there are no exceedances of surface water ARARs caused by the supernatant discharge from the SCA.

The principal location-specific ARARs applicable to the remediation are Environmental Conservation Law (ECL) Article 24 Freshwater Wetlands, ECL Article 15 Use and Protection of Waters, and CWA Section 404. For freshwater wetlands, 6 NYCRR Part 663 regulates activities conducted in or adjacent to regulated wetlands. Article 15 is implemented by 6 NYCRR Part 608, which regulates alterations to protected waters, such as dredging and filling. The design and construction of the remedy must meet the substantive requirements for permits associated with disturbance to state and federal regulated wetlands (e.g., 6 NYCRR Part 663, Freshwater Wetlands

Permit Requirements) and navigable waters (e.g., 6 NYCRR Part 608, Use and Protection of Waters).

CWA Section 404 includes requirements related to the discharge of dredged or fill material into navigable waters of the United States and prohibits activities which adversely affect an aquatic ecosystem, including wetlands. In addition, Superfund actions must be taken in accordance with 40 CFR Part 6, Appendix A, "Statement of Procedures on Floodplain Management and Wetlands Protection," Executive Order 11990, "Protection of Wetlands," Executive Order 11988, Floodplain Management, EPA's 1985 Policy on Floodplains and Wetland Assessments for CERCLA Actions, and the Fish & Wildlife Coordination Act. 40 CFR Part 6, Appendix A sets forth EPA policy and guidance for carrying out Executive Orders 11990 and 11988. Executive Order 11990 requires federal agencies conducting certain activities to avoid, to the extent possible, the adverse impacts associated with the destruction or loss of wetlands if a practicable alternative exists, and to avoid adverse impacts or minimize them if no practicable alternative exists. Executive Order 11988 requires federal agencies to evaluate the potential effects of actions they may take in a floodplain to avoid, to the extent possible, adverse effects associated with direct and indirect development of a floodplain, and to avoid adverse impacts or minimize them if no practicable alternative exists.

EPA's 1985 Policy on Floodplains and Wetland Assessments for CERCLA Actions discusses situations that require preparation of a floodplains or wetlands assessment, and the factors that should be considered in preparing an assessment, for response actions taken pursuant to Section 104 or 106 of CERCLA. In addition, it requires that in cases where a proposed remedial action will take place within or affect wetlands or the 100-year and 500-year floodplains, a Statement of Findings be prepared to document this decision in the ROD. This statement must include: the reasons why the proposed action must be located in or affect the floodplain or wetlands; a description of significant facts considered in making the decision to locate in or affect the floodplain or wetlands including alternative sites and actions; a statement indicating whether the proposed action conforms to applicable state or local floodplain/wetland protection standards; a description of the steps taken to design or modify the proposed act to minimize the potential harm to or within the floodplain or wetlands; and a statement indicating how the proposed action affects the natural or beneficial values of the floodplains or wetlands. The Statement of Findings has been attached as Appendix V of this ROD.

The Fish & Wildlife Coordination Act requires that whenever the waters of any stream or other body of water are proposed or authorized to be impounded, diverted, the channel deepened, or the stream or other body of water otherwise controlled or modified for any purpose, by any department or agency of the United States, such department or agency first shall consult with the United States Fish and Wildlife Service (USFWS), Department of the Interior, and with the head of the agency exercising administration over wildlife resources of the particular state in which the impoundment, diversion or other control facility is to be constructed, with a view to the conservation of wildlife resources by preventing loss of and damage to such resources. Consultation with the USFWS will be undertaken during the remedial design.

In addition, the National Historic Preservation Act (NHPA) has also been determined to be an ARAR for this project. The NHPA requires that remedial actions must take into account effects on properties in or eligible for inclusion in the National Registry of Historic Places. Cultural resource investigations conducted pursuant to the NHPA are ongoing. A draft Phase 1A Cultural Resource Assessment for the project area was produced in October 2004; this report noted the likelihood that the proposed project might encounter both recorded and unrecorded prehistoric and historic resources. Consequently, it is likely that once the area of remedial impact becomes established, additional cultural resource investigations will be required before the remedy is implemented.

Since all of the alternatives except the no-action alternative include dredging and/or capping within the lake, the final design of the remedy must meet the substantive requirements of the regulations (e.g., ECL Article 15). Alternatives that reestablish appropriate littoral zone habitat and function, that do not result in unacceptable changes in water depth or the loss of lake surface area, and do not result in a diminishment of natural resource values throughout the lake would more readily meet the requirements. All of the alternatives except the no-action alternative would be designed to comply with all of the designated location-specific and action-specific ARARs. The development of a lakewide habitat restoration plan is essential to provide a comprehensive evaluation of the selected alternative's ability to meet the requirements of Articles 15 and 24 and to develop appropriate bathymetry and habitat reestablishment requirements for each SMU.

Long-Term Effectiveness and Permanence

Permanence of the Remedial Alternative

Since Alternative 1 would involve no active remedial measures, it would not be effective in the long-term in controlling exposure.

Alternatives 6 and 7 provide the greatest long-term effectiveness and permanence by removal of all of the sediment that exceeds the cleanup criteria from SMUs 1 through 7 (with the exception of SMU 5). For SMU 8 (profundal zone), all of the action alternatives include MNR and/or thin-layer capping to remediate the contaminated sediments and oxygenation to maintain the proper chemical conditions (and, hence, greatly reduce the methylation of mercury) in the hypolimnion. Oxygenation of the hypolimnion would need to be actively maintained for Alternatives 2, 3, 4, 5, 6, and 7 to be effective. If the oxygenation system was suspended during the summer months, the oxygen demand of the profundal sediments would rapidly cause the loss of oxygen in the hypolimnion. This would result in the resumption of mercury methylation in the hypolimnion, and could adversely impact biota acclimated to the oxygenated conditions in the profundal zone.

Alternatives 2, 3, 4, and 5 incorporate the removal of increasing volumes of contaminated sediments prior to capping. These alternatives include an isolation cap in the littoral zone, which is a key component of these alternatives' protectiveness. Consolidation and disposal in an aboveground containment area (i.e., SCA) is more proven, more easily maintained, and more easily monitored than capping of wastes and contaminated sediments in an underwater environment, thereby making it more permanent and more reliable. Therefore, as the volume of material being removed increases, the permanence of the alternative increases.

For the contaminated sediments that would be left in the lake, the isolation cap would be designed to ensure long-term chemical isolation, including the ability to prevent ice scour and other types of erosion and to ensure its structural integrity. The integrity of the cap would be maintained through active operation and maintenance of an on-shore groundwater barrier wall and collection system along SMUs 1 and 2 (which will be installed as IRMs associated with the Willis Avenue, Semet Residue Ponds, and Wastebed B/Harbor Brook upland sites) and SMU 7 to prevent upwelling of contaminants through the sediment cap. In addition, the development and implementation of a monitoring and maintenance program to ensure that cap integrity and effectiveness is maintained would be included.

With regard to SMU 2, Alternatives 4 and 5 would remove sediments/marl contaminated with NAPL down to a depth of approximately 30 ft (9 m) and would be more effective in satisfying EPA's preference for treatment of principal threat waste than would Alternatives 2 and 3, which would remove and treat contaminated NAPL down to a depth of approximately 13 ft (4 m).

Reduction of Residual Risk

Residual risk in Onondaga Lake can be evaluated on the basis of direct toxicity, bioaccumulation, and potential for recontamination.

Since Alternative 1 would involve no active remedial measures, it would not, therefore, be effective in reducing residual risk.

Alternatives 2, 3, 4, 5, and 6 would remediate all areas of the lake that exceed either the mean PECQ of 1 or the mercury PEC. These cleanup criteria address acute sediment toxicity to benthic macroinvertebrates. For those areas that are capped and covered with a clean substrate layer, it is expected that the concentrations of CPOIs in the clean substrate overlying the isolation cap would remain low enough to reduce chronic toxicity. Alternative 7 would remediate all areas of the lake exceeding the ER-Ls and, therefore, would result in the lowest residual risk of acute and chronic toxicity.

A mercury concentration goal in sediments of 0.8 mg/kg was developed for the site to address bioaccumulation concerns (see the text box entitled "Bioaccumulation-Based Sediment Quality Values" [page 41]). In order to evaluate alternatives with respect to the bioaccumulation goal, the estimated post-remediation surface area-weighted average concentration (SWAC) in each SMU corresponding to each respective alternative was compared to the 0.8 mg/kg goal, since animals that bioaccumulate mercury, such as fish, are not limited to one location in the lake.

An analysis of the SWACs predicted to remain in the lake after the remediation indicates that all alternatives other than the no-action alternative would be protective for the littoral zone as a whole (SMUs 1 to 7). The residual mercury concentrations in the profundal zone (SMU 8) surface sediments are predicted to drop significantly from the 1992 concentrations. However, based on the 10-year MNR modeling with oxygenation, they may not reach the 0.8 mg/kg value throughout the profundal sediments under Alternatives 2 through 6, and may therefore require additional remedial measures (e.g., thin-layer capping). Under Alternative 7, the 0.8 mg/kg goal would be attained throughout the profundal sediments. Measuring the progress toward meeting the 0.8 mg/kg BSQV, along with the fish tissue PRGs (upon which the BSQV is based), will be one of the goals of the monitoring program.

Adequacy and Reliability of Controls

Since Alternative 1 would involve no active remedial measures, the migration of contaminants would continue.

Alternatives 6 and 7 provide the greatest long-term effectiveness and reliability of controls, since these alternatives would remove the largest volumes of contaminated sediment and place them in a secure SCA. The technology used in constructing containment facilities, such as the SCA, is well established and dependable. Since the contamination would be removed from the environment, the control and maintenance of the contained material is highly reliable, and monitoring of the SCA and treatment systems would be easily accomplished.

The progressive removal of additional contaminated sediments from the lake under Alternatives 2, 3, 4, and 5 provides increasing reliability, since each alternative relies progressively less on an isolation cap in order to be protective. Therefore, the greater the amount of sediment that is removed, the more permanent and reliable is the alternative. For the contaminated sediments left in the lake, reliability would be addressed through installation of a cap designed to ensure long-term chemical isolation, prevent ice scour and other types of erosion, and provide long-term stability. The integrity of this cap would be maintained through active operation and maintenance of an on-shore groundwater barrier wall and collection system along SMUs 1, 2, and 7 to prevent upwelling of contaminants through the sediment. All of the removed sediments would be permanently secured.

All of the action alternatives include oxygenation and thin-layer capping in SMU 8. An oxygenation system would have to be actively maintained in order to oxygenate the hypolimnion. The system's ability to address the mercury methylation in Onondaga Lake would need to be assessed as part of a pilot study during the remedial design phase. Alternatives 2 through 6 also include MNR in the profundal zone. Areas that do not achieve the mercury BSQV of 0.8 mg/kg and the PRGs for fish during the MNR period would require additional remedial measures. This may include thin-layer capping beyond the initial estimate of 154 acres, which is based on current exceedances of the mean PECQ of 1, if monitoring indicates it has been effective in reducing surface sediment concentrations.

Reduction of Toxicity, Mobility, or Volume through Treatment

Degree of Expected Reduction in Toxicity, Mobility, or Volume Through Treatment

Alternative 1 (no action) would provide no reduction in toxicity, mobility, or volume through treatment or otherwise. For the action alternatives, the dredging of contaminated sediments and their placement in a secure, lined SCA would result in a reduced mobility for these materials, as would in-lake capping. In addition, those NAPLs removed from the dredged material would be treated and/or disposed of off site.

Oxygenation, which is included in Alternatives 2, 3, 4, 5, 6, and 7, is expected to reduce the toxicity of mercury in SMU 8 by reducing methylation and the degree to which mercury is dissolved in the hypolimnion. Although thin-layer capping and MNR are expected to reduce the surface sediment concentrations in the profundal zone under all of the action alternatives, the volume of mercury and other key CPOIs in profundal sediments would not be reduced, since there would be no sediment removal prior to thin-layer capping. However, a combination of all three remedial components (oxygenation, MNR, and thin-layer capping),along with control of upland sites and remediation of the littoral zone, would be expected to reduce the overall bioavailability and mobility of contaminants in the profundal zone and hypolimnion.

Degree to Which Treatment Would Be Irreversible

For the NAPLs that are treated, the treatment would be irreversible and permanent.

Oxygenation of the hypolimnion would need to be actively maintained for Alternatives 2, 3, 4, 5, 6, and 7 to be effective. If the oxygenation system was suspended during the summer months, the oxygen demand of the profundal sediments would rapidly cause the loss of oxygen in the hypolimnion and would result in the resumption of mercury methylation in the hypolimnion. Thus, the treatment afforded by oxygenation is reversible. As a result, the overall irreversibility of this treatment in the hypolimnion would be low, but equivalent, in Alternatives 2, 3, 4, 5, 6, and 7.

Type and Quantity of Residuals

Alternatives 6 and 7 would remove all contaminated sediments down to their respective cleanup criteria in the littoral zone, except for areas within SMU 5 which would be capped. Alternatives 2, 3, 4, and 5 would isolate littoral sediments using an engineered isolation cap and would also progressively remove higher concentrations and/or masses of CPOIs in the ILWD and the NAPL in SMU 2, with Alternative 2 removing the least volume and Alternative 5 removing the greatest volume. Alternatives 2, 3, 4, 5, and 6 would address contamination in the profundal sediments through oxygenation, thin-layer capping, and MNR.

All of the action alternatives would generate treatment residuals which would have to be appropriately handled.

EPA Preference for Treatment as a Principal Remedy

The treatment and/or disposal of NAPLs at an off-site facility and oxygenation in the hypolimnion are critical components of the alternatives that meet EPA's treatment preference. The larger the volume of NAPLs that are removed from the lake and treated, the more an alternative satisfies this EPA preference for treatment.

EPA's statutory preference for treatment of principal threat materials has been considered as part of this remedy. Given the extraordinary volume of materials being evaluated (e.g., greater than 4,000,000 cy [3,060,000 m^3] of sediments and wastes within the ILWD, some of which contain NAPLs), treatment of all principal threat wastes (which are present in various portions of the ILWD) is impracticable. However, the implementation of any of these alternatives would include the off-site treatment and/or disposal of all NAPLs that were segregated during the dredging/handling process.

Short-Term Effectiveness

Alternative 1 (no action) does not include any physical construction measures in any areas of contamination and, therefore, would not present any potential adverse impacts to on-site workers, the environment, or the community as a result of its implementation.

Alternatives 2 through 7 could present some limited adverse impacts to on-site workers through dermal contact and inhalation related to dredging activities. Noise from the dredging work and from the on-site treatment processes could present some limited adverse impacts to on-site workers and nearby residents. In addition, post-dredging sampling activities could pose some risk to on-site workers. Another potential adverse impact associated with dredging would be odors associated with the dredged sediments. The risks to on-site workers and nearby residents under all of the alternatives would, however, be mitigated by following appropriate health and safety protocols, by exercising sound engineering practices, and by utilizing proper protective equipment.

Alternatives 2 through 7 would require the transport of significant volumes of capping and backfill material, which may involve use of local roadways and would cause an increase in traffic. Alternatives 6 and 7 would result in the greatest amount of traffic related to the transport of these materials. If mechanical dredging is used, the amount of traffic on local roads would increase commensurate with the amount of dredging. However, during the remedial design, various means would be evaluated for minimizing potential adverse impacts (e.g., traffic, odors associated with dredged sediments) on the community.

Under Alternatives 2, 3, 4, 5, and 6, MNR would take up to 10 years to achieve objectives in the profundal area, while oxygenation would be expected to produce immediate benefits in terms of methylmercury reduction. Since no activities would be performed under the no-action alternative, no time would be required to implement this alternative. Construction activities associated with the implementation of Alternatives 2, 3, 4, and 5 would be completed within four years. Implementation of Alternatives 6 and 7 would take significantly longer because of the increased dredging volumes, requiring 10 and 17 years, respectively.

Short-term impacts to the ecological community from implementation of all of the alternatives, except the no-action alternative, would include temporary loss of lake habitat and aquatic communities. The impact duration could be significantly greater for the implementation of Alternatives 6 and 7 because of the additional dredging and backfilling required under these alternatives, which could substantially increase the time before the area could be recolonized. However, if the construction was phased (i.e., not performed over the entire lake at once), this impact would be decreased.

The public would be excluded from the work areas of the lake during the time they are under remediation. The impact duration would be significantly greater for the implementation of Alternatives 6 and 7 because of the 10- to 17-year estimated construction durations, respectively.

Implementability

Reliability of Technology

Alternative 1 would be the easiest to implement, as there are no activities to undertake. Aquatic capping (isolation and thin-layer), dredging, treatment of segregated NAPLs (if employed), oxygenation, and MNR are all implementable technologies that have been used at other sites. However, aquatic capping presents challenges not typically associated with capping of upland sites (e.g., landfills). These issues would be addressed during the remedial design. SCA-type facilities have been successfully constructed and operated at numerous sites. Furthermore, the application of oxygenation (to address mercury methylation within Onondaga Lake) would require pilot testing before full-scale implementation.

Reliability (in terms of being able to construct and operate the technology) of the remedial components to be used in all of the alternatives is high. All of the action alternatives can be constructed and operated; however, Alternatives 6 and 7 would involve dredging and containing a much larger volume of sediments than the other alternatives. Construction of the SCA under Alternatives 6 and 7 would be challenging because of its size (i.e., approximately 282 and 442 acres, respectively, with 50 ft [15 m] high dikes). The large volumes of sediment involved in these alternatives might stretch the limits of the ability to contain the dredge spoils on nearby Honeywell properties. For Alternatives 2, 3, 4, and 5, there would be sufficient capacity at the proposed SCA location(s) on one or more the Solvay wastebeds to contain the sediment generated. Alternative 5, while implementable, would be more difficult to implement than Alternative 4 due to the removal of an additional 1,071,000 cy associated with Alternative 5.

All of the action alternatives include near-shore capping. As a result, institutional controls would be required. Institutional controls would include notification of appropriate government agencies with authority for permitting potential future activities which could impact the implementation and effectiveness of the remedy. Institutional controls would be needed to ensure long-term effectiveness of alternatives containing a capping component. The duration of these institutional controls would be dependent on lake conditions and the specifics of the institutional control.

Ability to Monitor Effectiveness of Remedy

A monitoring program would be developed during the design that would be used to assess remedy effectiveness. Monitoring to ensure that the remedial technologies are performing as specified in the design (e.g., cap integrity) would also be a component of the monitoring program. Monitoring programs would be needed for each of the action alternatives and are expected to include, at a minimum, sampling of biological tissue (e.g., fish, invertebrates), surface water, and sediments within the lake before, during, and following remediation; sampling of the aquatic cap to determine its integrity (chemically and structurally); determining the effectiveness of the thin-layer cap; and sampling of the SCA to determine its integrity (chemically and structurally). The specific monitoring programs required to evaluate remedy effectiveness would depend on the specific alternative. The scope of the program, including sampling and analytical details, would be determined during the remedial design.

The monitoring program, although comprehensive and broad in scope, would be comprised of sampling and analytical methods that should be readily implementable. Since direct visual inspections of the aquatic cap may be complicated by underwater conditions, alternative methods to determine cap structural integrity would need to be developed during the remedial design.

Ease of Undertaking Additional Remedial Actions as Needed

The remedial technologies to be utilized as part of the alternatives, generally, do not preclude other remedial actions from being implemented as needed. For example, settling of the cap could potentially necessitate adding more material to maintain suitable littoral water depths. In addition, capped materials could be excavated, if necessary, or additional cap material could be placed. However, such additional remedial actions would need to comply with ARARs (e.g., 6 NYCRR Part 608).

Ability to Obtain Approvals from Other Agencies

It is expected that the necessary administrative approvals from other agencies can be acquired for all alternatives.

Availability of Adequate On-Site or Off-Site Treatment, Storage Capacity, and Disposal Services

There would be sufficient capacity at the SCA to contain the sediment generated under Alternatives 2, 3, 4, and 5. However, due to the large volume of sediment removal associated with Alternatives 6 and 7, it is possible that the capacity at the SCA would be inadequate and that additional containment cells would need to be constructed or that a significant volume of material would have to be disposed of at an off-site facility.

Availability of Necessary Equipment and Personnel

The technology, equipment, subcontractors, personnel, and facilities required to successfully complete all alternatives are available in the environmental marketplace.

Cost

The cost estimates presented in this ROD are based upon capital (construction) costs and the present-worth of the annual O&M costs calculated using a discount rate of 7 percent and a 30-year time interval. The actual costs will vary depending on the specifications contained in the detailed remedial design. Further, the actual costs will also vary because the cost estimates provided are developed conservatively and have an accuracy of +50 percent to -30 percent, in compliance with the 1988 EPA guidance document, "Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA."

The estimated capital, operation, maintenance, and monitoring (OM&M), and present-worth costs for each of the alternatives are presented below.

Lakewide Alternative	Capital Costs	Average O&M Annual Cost	Present-Worth O&M Costs	Present-Worth Costs
1	$0	$0	$0	$0
2	$275,000,000	$3,000,000	$37,000,000	$312,000,000
3	$333,000,000	$3,000,000	$37,000,000	$370,000,000
4	$414,000,000	$3,000,000	$37,000,000	$451,000,000
5	$499,000,000	$3,100,000	$38,000,000	$537,000,000
6	$1,292,000,000	$2,800,000	$35,000,000	$1,327,000,000
7	$2,086,000,000	$5,700,000	$71,000,000	$2,157,000,000

As can be seen by the cost estimates, in general, the cost of each alternative increases with increases in the area of the lake bottom remediated and with the amount of sediment removed.

There is no cost associated with Alternative 1, the no-action alternative. Alternatives 2, 3, 4, and 5, which include the use of dredging and capping technologies to address sediments that exceed a mean PECQ of 1 or the mercury PEC, as well as significant removals in the ILWD and in SMU 2, range in estimated present-worth cost from $312,000,000 (for Alternative 2) to $537,000,000 (for Alternative 5). Alternatives 6 and 7, which depend upon full removal in the littoral zone with the exception of SMU 5 (versus partial removal and capping) to the appropriate cleanup criteria, range in estimated present-worth cost from $1,327,000,000 to $2,157,000,000, respectively.

Support Agency Acceptance

EPA has determined that the remedy selected by NYSDEC, the lead agency for this site, meets the requirements for remedial action set forth in CERCLA Section 121, 42 USC §9621. EPA has adopted this remedy's selection by cosigning this ROD. NYSDOH concurs with the selected remedy; its letter of concurrence is attached (see Appendix IV).

Community Acceptance

Comments received during the public comment period indicate that the public, generally, supports the selected remedy. The public's comments are summarized and addressed in the Responsiveness Summary, which is attached as Appendix VI to this document.

The Onondaga Nation asserted a lack of coordination with it regarding the proposed remedy and the timing of the public comment period. However, EPA Region 2 and NYSDEC have had five meetings with the Onondaga Nation since the NRRB meeting concerning the Proposed Plan and intend to continue discussions with the Onondaga Nation throughout the design phase of the project. The concerns raised by the Onondaga Nation are further discussed in the Responsiveness Summary.

PRINCIPAL THREAT WASTE

The NCP establishes an expectation that EPA will use treatment to address the principal threats posed by a site wherever practicable (NCP Section 300.430 (a)(1)(iii)(A)). The “principal threat” concept is applied to the characterization of “source materials” at a Superfund site. A source material is material that includes or contains hazardous substances, pollutants, or contaminants that act as a reservoir for the migration of contamination to groundwater, surface water, or air, or act as a source for direct exposure. Principal threat wastes are those source materials considered to be highly toxic or highly mobile that generally cannot be reliably contained, or would present a significant risk to human health or the environment should exposure occur. The decision to treat these wastes is made on a site-specific basis through a detailed analysis of alternatives, using the remedy selection criteria which are described below. This analysis provides a basis for making a statutory finding that the remedy employs treatment as a principal element.

Elevated contaminant concentrations and visual evidence (e.g., liquids, droplets, sheens) indicate that NAPL (e.g., chlorinated benzenes, which were manufactured and released as a waste by Honeywell) exists throughout the ILWD and in an area off the Honeywell causeway. Based on data collected during the RI/FS, it was determined that the NAPLs and highly-contaminated waste materials in these areas of the lake are highly mobile, at least when disturbed, have high concentrations of toxic compounds, and present a significant risk to human health and the environment should exposure occur; therefore, they are characterized as principal threat wastes.

EPA’s statutory preference for treatment of principal threat materials has been considered as part of this remedy. Given the extraordinary volume of materials being evaluated (e.g., greater than 4,000,000 cy [3,060,000 m^3] of sediments and wastes within the ILWD, some of which contain NAPLs), treatment of all principal threat wastes (which are present in various portions of the ILWD) is impracticable. However, the implementation of any of these alternatives would include the off-site treatment and/or disposal of all NAPLs that would be segregated during the dredging/handling process. The appropriate means for collecting and handling these sediments and materials would be determined during the remedial design.

SELECTED REMEDY

Summary of the Rationale for the Selected Remedy

Based upon consideration of the requirements of CERCLA, the detailed analysis of the alternatives, and public comments, NYSDEC and EPA have determined that Alternative 4 (Dredging of the ILWD to 2 m [6.5 ft]; Removal in Areas of Hot Spots in the ILWD to a Maximum Depth of 3 m [10 ft] and Isolation Capping in SMU 1; Dredging for No Loss of Lake Surface Area and Erosion Protection and to Reestablish Habitat, and Isolation Capping in SMUs 2 to 7; Targeted Dredging to 9 m (30 ft) for NAPL Removal in SMU 2; Targeted Dredging in SMUs 3 and 6; and Phased Thin-Layer Capping, Oxygenation, and Monitored Natural Recovery in SMU 8) best satisfies the requirements of CERCLA Section 121, 42 U.S.C. §9621, and provides the best balance of tradeoffs among the remedial alternatives with respect to the NCP's nine evaluation criteria, 40 CFR §300.430(e)(9).

Alternatives 2 through 6 address the same surface area of contaminated lake bottom sediments. The major difference between Alternatives 2 through 6 is how each respective alternative would address SMU 1. In general, the alternatives call for successively greater depths of excavation and, therefore, increasing volumes of waste to be removed. Specifically, Alternatives 2, 3, 4, 5, and 6 call for removal depths of up to 0.8, 2, 3, 5, and 8 meters, respectively, within the ILWD. The long-term effectiveness of the alternatives for the ILWD increases with increasing amounts of removal, since less waste would be contained in the aquatic environment. The reliability of the aquatic cap is enhanced with removal of the more highly concentrated wastes. Therefore, Alternative 4, which includes hot spot removals to a depth of 3 m (10 ft) below grade, provides a greater degree of reliability than Alternatives 2 and 3. The highest concentrations of the majority of CPOIs, on average, are found in the upper 3 m (10 ft) of the ILWD. While Alternative 5 includes approximately 2 m (6.5 ft) of additional removal within SMU 1 (relative to Alternative 4), this removal does not target hot spot areas. Therefore, it does not increase cap reliability commensurate with the increased $86 million in estimated present-worth costs over Alternative 4. In addition, unlike Alternative 5, Alternative 4 includes cap enhancements in any residual hot spot areas. Since the cap enhancements would be placed over the most highly-contaminated sediments, this component of Alternative 4 provides greater cap reliability than does Alternative 5.

Another significant difference among Alternatives 2 through 6 relates to SMU 2. Alternatives 4, 5, and 6 would remove NAPLs to a depth of 9 m (30 ft) in the vicinity of the causeway (the assumed area of NAPLs is shown on Figure 4.26 of Honeywell's November 2004 FS report) and, thus, result in a greater reduction in the concentrations and masses of CPOIs prior to capping than would Alternatives 2 and 3, thus, providing greater long-term effectiveness and cap reliability. Since Alternatives 4, 5, and 6 would remove and treat a larger volume of NAPLs than Alternatives 2 and 3 would, they would satisfy the NCP's preference for treatment of principal threat waste to a greater degree than Alternatives 2 and 3.

Under Alternatives 6 and 7, an estimated 11 million and 18.9 million additional cy of material, respectively, would be removed from the lake, compared to Alternative 2. While Alternatives 6 and 7 would provide greater long-term effectiveness than Alternative 4, the greater volumes of material to be removed and disposed would likely exceed the capacity for a single SCA. Multiple containment cells would likely be needed or, alternatively, significant volumes of material would have to be disposed of at an off-site facility. The $876,000,000 and $1,706,000,000 in incremental costs over Alternative 4 associated with the additional removals called for under Alternatives 6 and 7, respectively, would not be cost effective. A properly designed and constructed aquatic cap, together with the other elements of Alternative 4, would provide a similar degree of protection offered by Alternatives 6 and 7 at significantly less cost, in less time and with greater ease of implementation.

Alternative 4 would remove up to 3 m (10 ft) of some of the most highly-concentrated wastes from the ILWD. This removal would facilitate construction of a structurally-stable cap and would result in the removal of substantial quantities of the principal threat waste. The residual waste could be effectively contained under the engineered cap. The sediments removed from the lake could be contained in one or more SCAs on one or more of Honeywell's Solvay wastebeds. Finally, continued OM&M of the cap would ensure its continued effectiveness. For all of these reasons, Alternative 4 is protective of human health and the environment, provides long-term effectiveness, is able to achieve the ARARs more quickly, or as quickly, as the other alternatives, is cost-effective, and offers the best balance of tradeoffs among the alternatives.

Therefore, the selected remedy will provide the best balance of tradeoffs among alternatives with respect to the evaluation criteria. NYSDEC and EPA believe that the selected remedy will treat principal threat wastes, be protective of human health and the environment, comply with ARARs, be cost-effective, and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. The selected remedy also will meet the statutory preference for the use of treatment as a principal element.

Description of the Selected Remedy

The selected remedy (Alternative 4) will address all areas of the lake where the surface sediments exceed a mean probable effect concentration (PEC) quotient of 1 or the mercury PEC of 2.2 mg/kg (see Figure 7). The selected remedy will also attain a 0.8 mg/kg bioaccumulation-based sediment quality value (BSQV) for mercury on an area-wide basis for the lake and for other applicable areas of the lake to be determined during the remedial design. The selected remedy is also intended to achieve lakewide fish tissue mercury concentrations ranging from 0.14 mg/kg, which is for protection of ecological receptors, to 0.3 mg/kg, which is based on EPA's methylmercury National Recommended Water Quality criterion for the protection of human health for the consumption of organisms. The remedy includes dredging prior to isolation capping in SMUs 1 to 7 to a depth that will prevent the loss of lake surface area, ensure cap effectiveness, remove NAPLs, reduce contaminant mass, allow for erosion protection, and reestablish habitat. Dredging will also be performed as needed in the ILWD (which largely exists in SMU 1) to remove materials within areas of hot spots and to ensure stability of the cap. Most of the dredging will be performed in the ILWD (which largely exists in SMU 1) and in SMU 2. In SMU 8, the remedy calls for phased thin-layer capping, oxygenation, and MNR. The littoral zone in the vicinity of the dredging/capping will be restored to reestablish appropriate habitat and function following removal of contaminated sediments.

The selected remedy (see Figure 9) will include the dredging of as much as an estimated 2,653,000 cy (2,030,000 m^3) of sediments and/or wastes from the littoral zone, with most of the dredging (approximately 75 percent) being performed in SMUs 1 and 2. It will also include the use of isolation capping over an estimated 425 acres (approximately 42 percent) of the littoral zone (between SMUs 1 to 7). An estimated 154 acres (approximately 8 percent) of the profundal zone (SMU 8) will receive a thin-layer cap. Specifically, the components of the selected remedy within each SMU include:

- **SMU 1** – Dredging of an estimated 1,566,000 cy (1,197,000 m^3) of sediments and/or wastes from the ILWD, prior to capping, to prevent a loss of lake surface area, reduce average CPOI concentrations in sediments and/or wastes remaining under the cap, for erosion protection, and to reestablish habitat. Capping of the entire SMU (approximately 84 acres). Capping effectiveness will rely upon the proper functioning of the hydraulic control system which will be installed, operated, monitored and maintained as part of the Wastebed B/Harbor Brook Barrier IRM.

  Dredging will be performed to remove sediments and/or wastes to an average depth of 6.5 ft (2 m) prior to capping. This will provide an adequate water depth to allow for the establishment of a productive habitat after capping, reduce average CPOI concentrations in sediments and/or wastes remaining under the cap, and allow for erosion protection for the cap. While the average dredge cut across SMU 1 will be 6.5 ft (2 m), the actual depth of dredging in the various portions of SMU 1 will be determined during the remedial design. The determination will be based on various factors, including contaminant distribution, habitat needs, and erosional concerns.

  In areas defined as hot spots, dredging will also be performed to remove an additional 3.3 ft (1 m) of sediments and/or wastes (below the dredge cut described above). The hot spots will be defined as those sediments and/or wastes that contain CPOIs above threshold concentrations. The purpose of this additional removal in hot spot areas is to improve capping effectiveness. The hot spot threshold concentrations that will trigger the additional dredging are as follows:

  - Benzene – 208 mg/kg
  - Chlorobenzene – 114 mg/kg
  - Dichlorobenzenes – 90 mg/kg
  - Naphthalene – 20,573 mg/kg
  - Xylene – 142 mg/kg
  - Ethylbenzene – 1,655 mg/kg
  - Toluene – 2,626 mg/kg
  - Mercury – 2,924 mg/kg

  As refined modeling will be performed during the remedial design, it is possible that these concentrations may be modified. However, the hot spot concentrations will be based on an assumed upwelling rate of 2.4 inches/year (6 cm/yr).

  If during the remedial design or construction it becomes apparent that concentrations (hot spots) exceeding these threshold values are present at depths greater than 3.3 ft (1 m) below the dredge cut, NYSDEC and EPA will evaluate the need for additional remediation (e.g., increase the cap thickness to contain those CPOIs to ensure cap effectiveness) in these areas of the ILWD.

The removal of an average of 6.5 ft (2 m) of materials and deeper removal in the area of the hot spots is expected to improve the reliability of capping of the ILWD. This removal will likely reduce the average contaminant concentrations, as well as the maximum concentrations of some of the contaminants, in the residual waste. Furthermore, the available data indicate that the remedy will result in the removal of a significant portion of the contaminant mass present within the ILWD.

The remedy will include additional dredging, if needed, to address geotechnical concerns with the ILWD. The nature of the sediments and/or wastes, as well as geophysical evidence of historical failures (i.e., underwater slumping or "landslides" associated with the ILWD), might require the removal of additional sediments and/or wastes or other engineering measures to ensure the long-term stability of the cap. Adequate data will be gathered during the remedial design to enable the determination of appropriate measures to ensure that the cap will be structurally sound and otherwise effective in all areas of the lake slated for remediation.

As the ILWD extends to some extent beyond SMU 1's boundary into SMUs 2 and 7, the removal and capping of the ILWD sediments and/or wastes in the adjacent SMUs will be performed in a similar fashion to SMU 1.

- **SMU 2** – Dredging of an estimated 403,000 cy (308,000 m^3) of sediments and/or wastes prior to capping. This includes dredging to remove NAPL to an estimated 30-ft (9-m) depth in the vicinity of the causeway (the assumed area of NAPLs is shown on Figure 4.26 of Honeywell's November 2004 FS), as well as dredging to shallower depths in other areas to prevent a loss of lake surface area, for erosion protection and to reestablish habitat. Dredging will also be performed to remove sediments and/or wastes from the portion of the ILWD which extends into SMU 2. The removal of these ILWD materials in SMU 2 will be performed consistent with how these materials will be addressed in SMU 1.

  Capping of approximately 16 acres in SMU 2. Capping effectiveness will rely upon the proper functioning of the hydraulic control system which will be installed, operated, monitored, and maintained as part of the Willis/Semet Barrier IRM (the design of which is underway).

- **SMU 3** – Dredging of an estimated 75,000 cy (57,000 m^3) of sediments and/or wastes prior to capping to maintain cap effectiveness (targeted dredging) in the absence of a hydraulic control system, to prevent a loss of lake surface area, for erosion protection and to reestablish habitat. Capping of approximately 29 acres.

  If data collected as part of the remedial design of the Onondaga Lake remediation indicate that the construction/operation of a hydraulic control system along the SMU 3 shoreline to maintain cap effectiveness (in lieu of the portion of dredging described above that is otherwise necessary to maintain cap effectiveness) would be at least as effective as the dredging described above, NYSDEC may allow the construction/operation of a hydraulic control system in place of a portion (that required to maintain cap effectiveness) of the dredging described above.

- **SMU 4** – Dredging of an estimated 135,000 cy (103,000 m^3) of sediments and/or wastes prior to capping to prevent a loss of lake surface area, for erosion protection and to reestablish habitat. Although mercury does not exceed the PEC in the surface sediment interval at all of the sampling stations in SMU 4, concentrations of mercury exceed the PEC at sediment intervals just below the surface in the top 3.3 ft (1 m) at all stations in this SMU. Since these surface sediments are subject to erosion, it is assumed that all of SMU 4 (approximately 75 acres) will require capping.

- **SMU 5** – Dredging of an estimated 140,000 cy (107,000 m^3) of sediments and/or wastes prior to capping to prevent a loss of lake surface area, for erosion protection and to reestablish habitat. Capping of approximately 60 acres.

  In SMU 5, there were a limited number of sampling locations where CPOI concentrations in sediment exceeded either the mean PECQ of 1 or the mercury PEC. The above remedial actions are proposed to address the estimated areas represented by these sample results. During remedial design, an additional investigation of the sediments in the vicinity of these locations will be conducted to delineate the extent of the actual sediment areas and volumes exceeding the mean PECQ of 1 or the mercury PEC. This further delineation will be used to determine the scope and extent of capping and/or dredging activities needed to address these limited areas.

- **SMU 6** – Dredging of an estimated 245,000 cy (187,000 m^3) of sediments and/or wastes prior to capping to maintain cap effectiveness (targeted dredging) in the absence of a hydraulic control system, to prevent a loss of lake surface area, for erosion protection and to reestablish habitat. Capping of approximately 123 acres.

  If data collected as part of the remedial design of the Onondaga Lake remediation indicate that the construction/operation of a hydraulic control system along the SMU 6 shoreline to maintain cap effectiveness (in lieu of the portion of the dredging described above that is otherwise necessary to maintain cap effectiveness) would be at least as effective as the dredging described above, NYSDEC may allow the construction/operation of a hydraulic control system in place of a portion (that required to maintain cap effectiveness) of the dredging described above.

- **SMU 7** – Dredging of an estimated 89,000 cy (68,000 m^3) of sediments and/or wastes prior to capping, to prevent a loss of lake surface area, for erosion protection and to reestablish habitat. Dredging will also be performed to remove sediments and/or wastes from the portion of the ILWD which extends into SMU 7. The removal of these ILWD materials will be performed consistent with how these materials will be addressed in SMU 1. The selected remedy also includes the construction/operation of a hydraulic control system along the SMU 7 shoreline to maintain cap effectiveness. Capping of approximately 38 acres.

  If data collected as part of the remedial design of the Onondaga Lake remediation indicate that targeted dredging in SMU 7 (in lieu of the construction/operation of a hydraulic control system described above) would be at least as effective as the hydraulic control system, NYSDEC may allow targeted dredging in place of a hydraulic control system for SMU 7.

- **SMU 8** – Thin-layer capping over an estimated 154 acres (approximately 8 percent) of the profundal area. The appropriate thickness and type of substrate for thin-layer capping will be determined during the remedial design. The suitability of thin-layer capping at the base of the ILWD in the profundal zone (SMU 8) will be reviewed during the remedial design based on extensive data to be collected as part of the pre-design program. An MNR program will be performed in the profundal area, as discussed further below.

A pilot study will be performed to evaluate the potential effectiveness of oxygenation at reducing the formation of methylmercury in the water column, while preserving the normal cycle of stratification within the lake. An additional factor which will be considered during the design of the pilot study will be the effectiveness of oxygenation at reducing fish tissue methylmercury concentrations. If supported by the pilot study results, the pilot study will be followed by full-scale implementation of oxygenation in SMU 8. Furthermore, potential impacts of oxygenation on the lake system will be evaluated during the pilot study and/or the remedial design of the full-scale oxygenation system.

- The isolation caps that will be constructed in the littoral zone (SMUs 1 through 7) will consist of various layers each of which serves a specific purpose. The first layer on top of the sediments is referred to as the mixing layer. The mixing layer addresses the fact that mixing takes place between sediments and the initial layer of cap material during actual cap placement. Above the mixing layer is the chemical isolation layer which "isolates" contaminants in the sediments below the cap. The chemical isolation layer will be a minimum of 12 inches (30 cm) thick. The thickness of the chemical isolation layer is determined, based on computer modeling, such that concentrations of contaminants within the sediments do not result in unacceptable levels of exposure to aquatic life . For any given contaminant, a concentration greater than the PEC of any of the CPOIs that have been shown to exhibit acute toxicity on a lakewide basis or NYSDEC sediment screening criteria for benzene, toluene, and phenol, is considered an unacceptable level of exposure. During the remedial design the actual thickness of the chemical isolation layer will be determined, based on additional sediment sampling and additional cap modeling.

  Above the chemical isolation layer is the habitat restoration layer. The habitat restoration layer will consist of a minimum thickness of 12 inches (30 cm) of suitable habitat material. The specific thickness(es) and type(s) of substrate material to be used for the habitat layer will be determined as part of the remedial design based on the comprehensive lakewide habitat restoration plan.

  Because of the limitations of computer modeling and other factors associated with cap construction, a 50 percent buffer or safety layer will be added during cap construction. The thickness of the overall cap is thereby increased by a thickness equal to 50 percent of the thickness of the chemical isolation layer. As part of the remedial design, a decision will be made as to what portion of the buffer layer will be considered part of the habitat restoration layer. The remaining portion of the buffer layer will be added to the modeled chemical isolation layer to represent the actual chemical isolation layer portion of the cap.

  An erosion (armor) layer will be included in the cap design/construction, where needed, and at a location between the chemical isolation layer and the habitat restoration layer.

  The point of compliance, with respect to ensuring that the isolation portion of the cap is effective in preventing unacceptable concentrations of contaminants (i.e. a concentration greater than the PEC of any of the CPOIs that have been shown to exhibit acute toxicity on a lakewide basis or NYSDEC sediment screening criteria for benzene, toluene, and phenol) from entering the habitat restoration layer portion of the cap, will be at the bottom of the habitat restoration layer.

  The remedial design will include flexibility in dredge depth (with regard to hot spot threshold concentrations as they may be modified as a result of the additional cap modeling that will be performed during the remedial design) and cap thickness so that cap effectiveness and cost effectiveness can be attained.

Predicted settlement of the cap will be determined based on pre-design sampling. The estimated settlement will be evaluated to determine if additional removal beyond that contained in the ROD is necessary in order to maintain an acceptable water depth.

The cap in the areas in front of Ninemile Creek and other tributaries will be designed to meet multiple objectives, including protecting against erosion forces from the tributary and from within the lake, providing a natural transition between fish and wildlife habitats in the lake and tributary, and ensuring that the cap will not disrupt the water flow into Onondaga Lake, including under 100-year-flow conditions. If it is determined during the pre-design investigation that the flow would be affected, additional dredging will be included to ensure that the impact to the flow is minimized to the extent practicable.

- Habitat reestablishment will be performed in areas where dredging/capping will occur. The habitat restoration layer with a minimum thickness of 12 inches (30 cm) will be placed on all areas capped within the littoral zone. The specific thickness(es) and type(s) of substrate material to be used for the habitat layer in these areas will be determined during the remedial design as part of the comprehensive lakewide habitat restoration plan.

- The design and construction of the remedy, including the habitat restoration layer, will need to meet the substantive requirements for permits associated with disturbance to state and federal regulated wetlands (e.g., 6 NYCRR Part 663, Freshwater Wetlands Permit Requirements) and navigable waters (e.g., 6 NYCRR Part 608, Use and Protection of Waters). The details for habitat restoration will be developed as part of the lakewide habitat restoration plan.

- The majority of the dredged sediments will be disposed in one or more SCAs constructed on one (or more) of the Solvay wastebeds. Based on evaluations to be conducted during the design, as well as during construction, it is likely that a portion of the dredged materials (e.g., NAPLs) will be treated and/or disposed of at an off-site permitted facility rather than at the SCA. The appropriate means for collecting and handling these sediments and materials will be determined during the remedial design. The FS report assumed that the SCA would be constructed on Wastebed 13 based on its capacity, as well as other factors. However, the actual Solvay wastebed location(s) on which the SCA(s) will be constructed will be determined during the remedial design and be based on an evaluation of the potential impacts on the local community, geotechnical stability of the wastebeds, SCA construction requirements, wastebed size, the means for transporting dredged materials to the SCA, costs, etc. This ROD assumes that preloading and stabilization of the wastebed materials will be required prior to construction of the SCA, but the extent to which preloading and stabilization will be required, if any, will be determined during the remedial design. The remedial design of the SCA will be undertaken in accordance with state and federal requirements and guidance and will include, at a minimum, the installation of an impermeable liner, leachate collection and treatment, and a cap.

- Treatment of water generated by the dredging/sediment handling processes as a result of dewatering of the sediments at the SCA. During the remedial design, NYSDEC will issue discharge limits (that will be protective of Onondaga Lake) that will need to be met by the treated water prior to its discharge (end of pipe) back to the lake. It is assumed that the water will require “advanced treatment” (which includes enhanced primary treatment, multimedia filtration, air stripping, and granular activated carbon treatment for additional VOC removal, and pH adjustment as defined in the FS report) in order to meet discharge limits. However, the actual treatment technologies needed to ensure compliance with discharge limits will be determined during the remedial design and might vary depending on the levels and types of contaminants present in lake sediments in various areas (or SMUs) of Onondaga Lake.

- Implementation of institutional controls including notification of appropriate government agencies with authority for permitting potential future activities which could impact the implementation and effectiveness of the remedy.

- Implementation of a long-term OM&M program to monitor and maintain the effectiveness of the remedy. The long-term monitoring will be performed to assess the effectiveness of the remedy in achieving the RAOs and PRGs and to ensure that the remedial technologies are performing as specified in the remedial design. The program will be designed to monitor and evaluate the effectiveness of the various remedy components including containment at the SCA, isolation capping, thin-layer capping, effectiveness of the groundwater control structures, oxygenation, MNR, and habitat reestablishment and enhancement. Types of monitoring which will likely be employed include sampling within the lake before, during, and following remediation, including sampling of biological tissue (e.g., fish, invertebrates), measurements of the effects on the environment (e.g., toxicity testing, community analysis), and sampling of surface water and sediments; sampling of the aquatic cap to determine its integrity (chemically and structurally), and sampling of the SCA to determine its integrity (chemically and structurally).

It will be certified on an annual basis that the institutional controls are in place and that remedy-related OM&M is being performed.

The selected remedy also includes habitat enhancement, an improvement of habitat conditions in areas where CERCLA contaminants do not occur at levels that warrant active remediation, but where habitat impairment due to stressors has been identified as a concern. Habitat enhancement will be utilized along an estimated 1.5 mi (2.4 km) of shoreline (SMU 3) and over approximately 23 acres (SMU 5) to stabilize calcite deposits and oncolites and promote submerged macrophyte growth. The habitat enhancement will be performed consistent with the lakewide habitat restoration plan. This component of the remedy is not intended to satisfy the requirements of CERCLA or the National Oil and Hazardous Substances Pollution Contingency Plan, but is included in order to address requirements of state law.

As part of the remedy, the BSQV of 0.8 mg/kg for mercury will be applied on an area-wide basis. The BSQV is a means to assess areas of the lake that may be contributing to exceedances of the fish tissue PRGs, which range from 0.14 to 0.3 mg/kg mercury. An additional investigation will be conducted during the remedial design to determine the appropriate areas within the lake for applying the BSQV and to determine whether the SWACs of mercury predicted to remain in the sediments following remediation of SMUs 1 through 7 and at the end of the 10-year MNR period will meet the BSQV. If this investigation indicates that mercury in surficial sediments in the applicable areas will exceed 0.8 mg/kg, then additional remedial measures (e.g., additional thin-layer capping in SMU 8 beyond the estimated 154 acres) will be implemented, as needed, during construction so that (after remediation in SMUs 1 through 7, and at the end of the 10-year MNR period in SMU 8) surficial sediment concentrations of mercury are predicted to meet 0.8 mg/kg on an area-wide basis.

The remedy will include MNR in SMU 8 to achieve the mercury PEC of 2.2 mg/kg in the profundal zone and to achieve the BSQV of 0.8 mg/kg on an area-wide basis within 10 years following the remediation of upland sources, littoral sediments, and initial thin-layer capping in the profundal zone. An investigation will be conducted during the remedial design to refine the application of an MNR model and determine any additional remedial measures (e.g., additional thin-layer capping) needed in the profundal zone.

The remedial design will include the collection of additional site data (e.g., sediment cores) to delineate in detail the various areas in which remedial activities will be performed, dredging areas and volumes, capping areas, etc. While hydraulic dredging was assumed for the purpose of the detailed evaluation in the FS report and this ROD, the actual dredging method(s) will be determined during the design.

During the remedial design, treatability studies (e.g., water treatment) will be performed if necessary.

The remediation of the Onondaga Lake subsite will need to be coordinated with upland remedial activities. The control of contamination migrating to the lake from the various upland sites (e.g., Willis Avenue, Semet Residue Ponds, Wastebed B/Harbor Brook, LCP Bridge Street, and Geddes Brook/Ninemile Creek) is an integral part of the overall cleanup of Onondaga Lake. To prevent the recontamination of lake sediments, active sources of contamination to a given portion of the lake will need to be shut off prior to performing cleanup activities in that area of the lake. For example, the hydraulic control systems which will be installed/operated as part of the Wastebed B/Harbor Brook and Willis/Semet Barrier IRMs will address the ongoing releases of contaminants from these upland areas to SMUs 1 and 2, respectively. These systems will need to be constructed and operating prior to cleanup activities commencing in this part of the lake.

Furthermore, the effectiveness of the capping of SMUs 1 and 2 will rely upon the proper functioning of these hydraulic control systems. Likewise, the effectiveness of capping in SMU 7 will rely upon the proper functioning of the hydraulic control system which will be installed along the lakeshore as part of the remedy for this portion of the lake. Therefore, the timing of remedial activities in Onondaga Lake will need to be coordinated with the remedial work which will be performed as part of the interim and final remedies at these upland sites.

Cultural resource investigations conducted pursuant to the NHPA are ongoing. A draft Phase 1A Cultural Resource Assessment for the project area was produced in October 2004; this report noted the likelihood that the proposed project might encounter both recorded and unrecorded prehistoric and historic resources. Consequently, it is likely that once the area of remedial impact becomes established, additional cultural resource investigations will be required before the remedy is implemented.

A draft wetlands & floodplains assessment for this project was completed in October 2004, the first step towards a comprehensive wetlands and floodplains assessment as described under EPA's Policy on "Floodplains & Wetlands Assessments for CERCLA Actions" (1985). Since various project elements had not been designed and other wetlands and floodplains impacts were still being assessed at that time, the report will need to be updated as appropriate during the remedial design.

The updated assessment will be included as an appendix to the final remedial design document in its entirety.

Because this remedy would result in contaminants remaining on site above levels that allow for unlimited use and unrestricted exposure to site media, CERCLA requires that the site be reviewed at least once every five years. The five-year review will evaluate the results from monitoring programs established as part of this remedy to ensure that the remedy remains protective of human health and the environment.

Summary of the Estimated Remedy Costs

The cost for the selected remedy is $451,000,000. This total cost estimate is comprised of capital costs of $414,000,000 and annual O&M costs of $3,000,000 (or $37,000,000 in O&M present-worth costs).

The cost estimates presented in this ROD are based upon capital (construction) costs and the present-worth of the annual O&M costs calculated using a discount rate of 7 percent and a 30-year time interval. The actual costs will vary depending on the specifications contained in the detailed remedial design. Further, the actual costs will also vary because the cost estimates provided are developed conservatively and have an accuracy of +50 percent to -30 percent, in compliance with the 1988 EPA guidance document, "Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA."

In addition to the preceding information, see Tables 15 and 16 entitled "Cost Estimate Input Data for Selected Remedy" and "Cost Summary for Selected Remedy," respectively.

Expected Outcomes of the Selected Remedy

The results of the HHRA indicate that the site, if left unremediated, presents an unacceptable noncancer hazard and an increased cancer risk to recreational users of the lake due to consumption of contaminated fish and may present unacceptable cancer risks for some recreational visitors exposed to nearshore sediment in the lake. The results of the BERA indicate that comparisons of measured tissue concentrations and modeled doses of chemicals to toxicity reference values show exceedances of hazard quotients for site-related chemicals throughout the range of the point estimates of risk. Site-specific sediment toxicity data indicate sediments are toxic to benthic macroinvertebrates on both an acute and chronic basis.

The State of New York, Onondaga County, and the City of Syracuse have jointly sponsored the preparation of a land-use master plan to guide future development of the Onondaga Lake area (Reimann-Buechner Partnership, 1991). The primary objective of land-use planning efforts is to enhance the quality of the lake and lakeshore for recreational and commercial uses. Implementation of the remedy will aid this long-term planning effort by reducing or eliminating concerns related to human exposure to contaminated sediments and surface water.

Under the selected remedy, it is estimated that concentrations of contaminants in fish will be reduced within ten years following completion of remedial activities. Potential risks to humans who consume fish and existing and potential future adverse ecological effects on fish and wildlife resources will be eliminated or reduced as contaminant levels fall. Fish tissue data from post-remedial monitoring can be used to document improvements in the lake, and to support reevaluation of the NYSDOH fish consumption advisory.

STATUTORY DETERMINATIONS

Under CERCLA Section 121 and the NCP, the lead agency must select remedies that are protective of human health and the environment, comply with ARARs (unless a statutory waiver is justified), are cost-effective, and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. Section 121(b)(1) also establishes a preference for remedial actions which employ treatment to permanently and significantly reduce the volume, toxicity, or mobility of the hazardous substances, pollutants, or contaminants at a site.

For the reasons discussed below, NYSDEC and EPA have determined that the selected remedy meets these statutory requirements.

Protection of Human Health and the Environment

The selected remedy will be protective of human health and the environment in that all RAOs and PRGs will be met through the implementation of this remedy in combination with the remediation of the upland subsites and impacted tributaries both directly and indirectly by reducing the external inputs to the lake, reducing and isolating the contaminant inventories in the lake, and by eliminating or reducing internal processes (e.g., methylation in the anoxic waters, resuspension of contaminated wastes/sediments) in the lake. While a mechanistic model does not exist to predict the behavior of mercury and other CPOIs in the lake after remediation, the predicted reductions (on the order of 90 percent) in inputs and inventories are expected to reduce the exposures and uptake of contaminants in humans and wildlife. BSQVs were developed for Onondaga Lake to provide a conservative total mercury concentration in sediments below which bioaccumulation is expected to be low enough to result in mercury concentrations in fish that are protective for human and wildlife consumption. These values are based on the average littoral zone and lakewide mercury sediment concentrations, since fish are mobile and may be exposed to various locations in the lake. A BSQV of 0.8 mg/kg for mercury based on the most sensitive receptor, the river otter, is considered protective of all adult human and ecological receptors modeled in the Onondaga Lake risk assessments.

Following implementation of the selected remedy, the average mercury concentration in the littoral zone, the primary foraging area for birds and mammals, is predicted to be about 0.5 mg/kg, a reduction of 86 percent from the current average mercury concentration in the littoral zone (3.5 mg/kg). On a lakewide basis, the average mercury concentration is predicted to be about 1 mg/kg, a reduction of 67 percent from the current average mercury concentration for the entire lake (2.9 mg/kg). While this concentration is higher than the BSQV of 0.8 mg/kg, it should be noted that virtually all data on mercury surface sediment concentrations used to establish baseline conditions for the profundal zone are from 1992 and therefore would not account for reductions in mercury concentrations attributable to natural recovery from 1992 to the present. Therefore, following implementation of the selected remedy, the average lakewide mercury concentration may be less than 1 mg/kg. Additional data will be collected as a part of the remedial design process, and these data will be used in future predictions of natural recovery. Additional remedial measures (e.g., additional thin-layer capping) will be implemented in profundal areas that do not achieve acceptable goals (e.g., achieving the mercury BSQV of 0.8 mg/kg, achieving PRGs for fish ranging from 0.14 to 0.3 mg/kg) during the 10-year MNR period or sooner if data indicate this goal will not be achieved as anticipated.

The implementation of the selected remedy will not pose unacceptable short-term risks or cross-media impacts that cannot possibly be mitigated.

Compliance with ARARs and Other Environmental Criteria

Since there are currently no federal or state promulgated standards for contaminant levels in sediments, the ER-Ls, mean PECQ of 1, and mercury PEC were used as "To-Be-Considered" criteria. A summary of action-specific, chemical-specific, and location-specific ARARs, as well as TBCs, which will be complied with during implementation of the selected remedy, is presented below.

Action-Specific ARARs:

- National Emissions Standards for Hazardous Air Pollutants (40 CFR Parts 51, 52, and 60)
- 6 NYCRR Part 257, Air Quality Standards
- 6 NYCRR Part 200, New York State Regulations for Prevention and Control of Air Contamination and Air Pollution
- 6 NYCRR Part 376, Land Disposal Restrictions
- Resource Conservation and Recovery Act (42 U.S.C. § 6901, *et seq.*)
- Clean Water Act Sections 301-304 and 307
- Clean Water Act Section 404
- Rivers and Harbors Act Section 10
- Fish and Wildlife Coordination Act, 16 USC § 662

Chemical-Specific ARARs:

- Safe Drinking Water Act (SDWA) MCLs and nonzero MCL Goals (40 CFR Part 141)
- 6 NYCRR Parts 700-705 Groundwater and Surface Water Quality Regulations
- 6 NYCRR Part 703, New York State Surface Water Quality Standards

Location-Specific ARARs:

- Fish and Wildlife Coordination Act, 16 U.S.C. 661
- New York State Environmental Conservation Law, Article 24, Freshwater Wetlands
- 6 NYCRR Part 663, Freshwater Wetlands Permit Requirements Regulations
- New York State Environmental Conservation Law, Article 15, Use and Protection of Waters
- 6 NYCRR Part 608, Use and Protection of Waters
- EPA's 1985 Policy on Floodplains and Wetland Assessments for CERCLA Actions
- EPA's Protection of Wetlands Executive Order 11990
- EPA's Floodplain Management Executive Order 11988
- National Historic Preservation Act

Other Criteria, Advisories, or Guidance TBCs:

- New York Guidelines for Soil Erosion and Sediment Control
- New York State Air Cleanup Criteria, January 1990
- SDWA Proposed MCLs and nonzero MCL Goals
- NYSDEC Technical and Operational Guidance Series 1.1.1, November 1991
- NYSDEC Guidelines for the Control of Toxic Ambient Air Contaminants, DAR-1, November 12, 1997
- NYSDEC Technical Guidance for Screening Contaminated Sediments, January 1999

A summary of the action-specific, chemical-specific, and location-specific ARARs, as well as TBCs, is also presented in Tables 17 through 22.

Cost-Effectiveness

A cost-effective remedy is one whose costs are proportional to its overall effectiveness (NCP §300.430(f)(1)(ii)(D)). Overall effectiveness is based on the evaluations of: long-term effectiveness and permanence; reduction in toxicity, mobility, and volume through treatment; and short-term effectiveness. Based on the comparison of overall effectiveness (discussed above) to cost, the selected remedy meets the statutory requirement that Superfund remedies be cost-effective in that for a reasonable increase in cost, it affords a greater degree of permanence and reliability than does the lower-cost action alternatives, and it will achieve the remediation goals in a reasonable time frame.

Each of the alternatives has undergone a detailed cost analysis. In that analysis, capital and annual O&M costs have been estimated and used to develop present-worth costs. The cost estimates presented in this ROD are based upon capital (construction) costs and the present-worth of the annual O&M costs calculated using a discount rate of 7 percent and a 30-year time interval.

Utilization of Permanent Solutions and Alternative Treatment Technologies to the Maximum Extent Practicable

NYSDEC and EPA have determined that the selected remedy represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a practicable manner at the site. Of the alternatives that are protective of human health and the environment and comply with ARARs, NYSDEC and EPA have determined that the selected remedy provides the best balance of trade-offs in terms of the five balancing criteria set forth in NCP §300.430(f)(1)(i)(B), while also considering the statutory preference for treatment as a principal element and the bias against off-site disposal without treatment and further considering support agency and community acceptance.

Implementation of the selected remedy will greatly reduce the mass of mercury and other CPOIs in the sediments and lower the average contaminant concentrations in surface sediments, which in turn will reduce contaminant levels in the water column and fish and other biota, thereby reducing the level of risk to humans and ecological receptors.

Preference for Treatment as a Principal Element

EPA's statutory preference for treatment of principal threat materials has been considered as part of this remedy. Given the extraordinary volume of materials being evaluated (e.g., greater than

4,000,000 cy [3,060,000 m^3] of sediments and wastes within the ILWD, some of which contain NAPLs), treatment of all principal threat wastes (which are present in various portions of the ILWD) is impracticable. However, the off-site treatment and/or disposal of all NAPLs that will be segregated during the dredging/handling process (The appropriate means for collecting and handling these materials will be determined during the remedial design), and oxygenation in the hypolimnion to address mercury methylation in the lake, are critical components of the selected remedy which meet EPA's treatment preference.

Five-Year Review Requirements

Because this remedy will result in hazardous substances, pollutants, or contaminants remaining on site above levels that allow for unlimited use and unrestricted exposure to site media, a statutory review will be conducted within five years after initiation of remedial action. The five-year review will evaluate the results from monitoring programs established as part of this remedy to ensure that the remedy remains protective of human health and the environment.

DOCUMENTATION OF SIGNIFICANT CHANGES

The Proposed Plan, released for public comment on November 29, 2004, identified Alternative 4 (Dredging the In-Lake Waste Deposit to an average 2 m [6.5 ft] depth with Additional Removal in Areas of Hot Spots [to an additional 1 m [3.3 ft] in depth] in the In-Lake Waste Deposit, Isolation Capping of the In-Lake Waste Deposit; /Dredging for No Loss of Lake Surface Area and for Erosion Protection and to Reestablish Habitat, Isolation Capping in SMUs 2-7; Targeted Dredging to 9 m (30 ft) depth for NAPL removal in SMU 2; Targeted Dredging in SMUs 3 and 6; and Phased Thin Layer Capping, Oxygenation, Monitored Natural Recovery in SMU 8) as the preferred remedy. Based upon review of the written and oral comments submitted during the public comment period, NYSDEC and EPA determined that no significant changes to the remedy, as originally identified in the Proposed Plan, were necessary or appropriate.

LIST OF REFERENCES USED IN RECORD OF DECISION AND RESPONSIVENESS SUMMARY

Addess, J.M. 1990. Methane Cycling in Onondaga Lake, NY. Master's Thesis, College of Environmental Science and Forestry, State University of New York. Syracuse, NY.

Aku, P.M., L.G. Rudstam, and W.M. Tonn. 1997. Impact of hypolimnetic oxygenation on the vertical distribution of cisco (*Coregonus artedi*) in Amisk Lake, Alberta. Can. J. Fish. Aquat. Sci. 54(9):2182-2195.

Clarke, D.G., M.R. Palermo, and T.C. Sturgis. 2001. Subaqueous cap design: Selection of bioturbation profiles, depths, and rates. DOER Technical Notes Collection (ERDC TN-DOER-C21), US Army Engineer Research and Development Center, Vicksburg, MS. Web site: http://www.wes.army.mil/el/dots/doer.

Cunningham, P.B, D.D. Reible, J.F. Fleeger, K.T. Valsaraj, and L.J. Thibodeaux. 1999. Assessment of the Effects of Bioturbation in Contaminated Sediments, Proceedings of the 1999 Conference on Hazardous Waste Research, St. Louis, Missouri, May 24-27, 1999. Web site: http://www.engg.ksu.edu/ HSRC/99Proceed/rieble.pdf.

Empire State Chapter Soil and Water Conservation Society (ESCSWCS). 1997. New York Guidelines for Urban Erosion and Sediment Control. Syracuse, New York.

ENSR International, Tetra Tech, and General Environmental Systems. 2004. Preliminary Experimental Design Plan Report For Phase I of the Onondaga Lake Oxygenation Demonstration Project, Onondaga County, New York, Final Report. Prepared for: US Army Corps of Engineers, Buffalo District. August.

Gbondo-Tugbawa, S., R. Montione, M.L. Spera, and E. Garvey. 2005. Dynamics of Mercury in Onondaga Lake, New York. Presented at the Third International Conference on the Remediation of Contaminated Sediments. New Orleans, LA. January.

Hairston, N.G. Jr., L.J. Perry, A.J. Bohonak, M.W. Fellow, and C.M. Kearns. 1999. Population biology of a failed invasion: paleolimnology of *Daphnia exilis* in upstate New York. Limnology and Oceanography 44.3:477-486.

Hazardous Substance Research Centers (HSRC). 2005. Summary of Contaminated Sediment Capping Projects. Web site: http://www.sediments.org. Accessed March.

Ingersoll, C. 2004. Columbia Environmental Research Center, USGS. Personal communication via telephone with H. Chernoff et al., TAMS/Earth Tech. January 9.

Ingersoll, C., D. MacDonald, N. Wang, J. Crane, L.J. Field, P. Haverland, N. Kemble, R. Lindskoog, C. Severn, and D. Smorong. 2000. Prediction of Sediment Toxicity Using Consensus-based Freshwater Sediment Quality Guidelines. EPA 905/R-00/007. June.

Kappel, W. and W. McPherson. 1998. Remediation of Mudboil Discharges in the Tully Valley of Central New York. USGS Fact Sheet FS 143-07.

Krabbenhoft, D.P., J.G. Wiener, W.G. Brumbaugh, M.L. Olson, J.F. DeWild, and T. J. Sabin. 1999. A National Pilot Study of Mercury Contamination of Aquatic Ecosystems along Multiple Gradients. USGS Toxic Substances Hydrology Program. Proceedings of the Technical Meetings. Charleston, SC. Water Res. Invest. Report. 99-4018 B. pp. 147-160.

MacDonald, D.D., C.G. Ingersoll, and T. Berger. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. Arch Environ Contam Toxicol 39:20-31.

Magar, V.S., J.A. Ickes, L. Cumming, W. Trulli, C. Albro, and T. Lyons. 2002. Survey of contaminated sediment resuspension during capping. In: M. Pellei, A. Porta, and R.E. Hinchee, eds. Management of Contaminated Sediments: Proceedings of the First International Conference on Remediation of Contaminated Sediments. Venice, Italy.

Martens, C.S., G.W. Kipphut, and J.V. Klump. 1980. Sediment-water chemical exchange in the coastal zone traced by in-situ radon-222 flux measurements. Science 4: 208:285-288.

Martens, C.S. and J.V. Klump. 1980. Biogeochemical cycling in Cape Lookout Bight – I. Methane sediment-water exchange processes. Geochim. Cosmochim. Acta. 44: 471-490.

Matinvesi. 1995. Microbiological gas formation altering top sediment composition, its relation to the internal nutrient load in eutrophic lakes. Dissertation for the degree of Doctor of Technology. Laboratory of Environmental Protection Technology, Kelsinki University of Technology, Espoo, 1995. 37pp.

Matthews, D.A. and S.W. Effler. 2004. Improvements in Onondaga Lake. I. Reductions in Hypolimnetic Accumulations of Hydrogen Sulfide and Methane. Presented at the Onondaga Lake Scientific Forum, Syracuse, NY.

McAlear, J.A. 1996. Concentrations and fluxes of total mercury and methylmercury within a wastewater treatment plant.

McDowell, S., E. Tobey, and P. Walter.2001. Palos Verdes Shelf pilot capping: suspended sediment plume monitoring during cap placement. In: Proceedings of the Western Dredging Association Twenty-First Technical Conference, Houston, Texas, June 24–27.

Monroe County Health Department, Bureau of Environmental Quality. 2002. The State of Irondequoit Bay 2002 Final Report. Rochester, NY. October 24.

Moore, C. 1991. Personal communication via telephone conversation with T. Michelson, PTI Environmental Services, Bellevue, WA. Onondaga County Department of Parks and Recreation, Liverpool, NY. March 2005.

New York State Department of Environmental Conservation (NYSDEC). 1994. Fish and wildlife impact analysis for inactive hazardous waste sites (FWIA). New York State Department of Environmental Conservation, Division of Fish and Wildlife, Albany, NY.

NYSDEC. 2004. Onondaga Lake Bottom Subsite of the Onondaga Lake Superfund Site Proposed Plan. November 29.

New York State Department of Health (NYSDOH). 1995. Public Health Assessment. Onondaga Lake, City of Syracuse, Towns of Salina and Geddes, Onondaga County, New York. New York State Department of Health, Albany, NY.

NYSDOH. 2005. Chemicals in Sportfish and Game, 2005-06 Health Advisories. NYSDOH, Albany, NY. April.

Niemi, G.J., P. DeVore, N. Detenbeck, D. Taylor, J.D. Yount, A. Lima, J. Pastor, and R.J. Naiman. 1990. Overview of case studies on recovery of aquatic systems from disturbance. Environmental Management 14: 571-588.

Office of Solid Waste and Emergency Response (OSWER). 1988. Community Relations During Enforcement Activities and Development of the Administrative Record. November.

Ohle, W. 1958. The dynamics of lake metabolisms in relation to the gas ebullition of muds. Vom Wasser, 25:127-149.

Owens, E.M. and S.W. Effler. 1996. Hydrodynamics and transport. In: Limnological and Engineering Analysis of a Polluted Urban Lake. S.W. Effler (ed). Springer-Verlag, New York, NY. pp. 200–262.

Palermo, M.R., J. Miller, S. Maynord, and D. Reible. 1998. Assessment and Remediation of Contaminated Sediments (ARCS) Program Guidance for In Situ Subaqueous Capping of Contaminated Sediments. EPA 905/B-96/004. Prepared for USEPA, Great Lakes National Program Office, Chicago, Illinois. Web site: http://www.epa.gov/glnpo/sediment/iscmain.

Palermo, M.R. 2001. Personal communication. United States Army Corps of Engineers, as referenced in the Onondaga Lake Feasibility Study Report, Parsons, 2004.

Parsons. 2004. Onondaga Lake Feasibility Study Report. Draft Final. Prepared by Parsons, Liverpool, NY in association with Anchor Environmental and Exponent for Honeywell. November.

Pickhardt, P.C., C.L. Folt, C.Y. Chen, B. Klaue, and J.D. Blum. 2004. Impacts of zooplankton composition and algal enrichment on the accumulation of mercury in an experimental freshwater food web. In: Science of the Total Environment 339 (2005) 89 – 101. July 22.

PTI Environmental Services (PTI). 1991. Onondaga Lake RI/FS Work Plan. Prepared for AlliedSignal, Inc., Solvay, NY. PTI Environmental Services, Bellevue, WA.

PTI. 1992. Onondaga Lake RI/FS Geophysical Survey Report. Prepared for AlliedSignal, Inc., Solvay, NY. PTI Environmental Services, Waltham, MA.

Reible, D. 2004. Personal observation of Anacostia River cap demonstration project, as referenced in the Onondaga Lake Feasibility Study Report, Parsons, 2004.

Reimann-Buechner Partnership. 1991. 1991 Onondaga Lake development plan.

Rowell, H.C. 1992. Paleolimnology, Sediment Stratigraphy, and Water Quality History of Onondaga Lake, Syracuse, NY. Dissertation. State University of New York, College of Environmental Science and Forestry, Syracuse, NY.

Service Environmental & Engineering. 2002. Draft Geology-Hydrogeology Report for St. Louis River/Interlake/Duluth Tar Site (SLRIDT), Duluth, Minnesota. January 29, 2002. Web site: http://www.slridt.com. Accessed October 2002.

Service Environmental & Engineering. 2004. Web site: http://www.serviceenv.com /slridt/documents.htm. Accessed March 2005.

Sharpe, C. 2004. Mercury Dynamics of Onondaga Lake and Adjacent Wetlands. Thesis submitted for Master of Science Degree in Environmental Engineering in the Graduate School of Syracuse University.

Spada, M.E., N.H. Ringler, S.E. Effler, and D.A. Matthews. 2002. Invasion of Onondaga Lake, New York, by the Zebra Mussel (*Dreissena polymorpha*) following Reductions in N Pollution. Upstate Freshwater Institute. Journal of the North American Benthological Society 21(4): 634-650.

Syracuse Department of Water (SDW), City of Syracuse. 2000. Water newsletter home page. Web site: www.syracuse.ny.us/syrmayor/Services/Departments/waterreport.html. Accessed May.

TAMS. 2002a. Onondaga Lake Baseline Ecological Risk Assessment. Original document prepared by Exponent, Bellevue, Washington, for Honeywell, East Syracuse, New York. Revision prepared by TAMS, New York, New York and YEC, Valley Cottage, New York, for New York State Department of Environmental Conservation, Albany, New York. December.

TAMS. 2002b. Onondaga Lake Human Health Risk Assessment. Original document prepared by Exponent, Bellevue, Washington, for Honeywell, East Syracuse, New York. Revision prepared by TAMS, New York, New York and YEC, Valley Cottage, New York, for New York State Department of Environmental Conservation, Albany, New York. December.

TAMS. 2002c. Onondaga Lake Remedial Investigation. Original document prepared by Exponent, Bellevue, Washington, for Honeywell, East Syracuse, New York. Revision prepared by TAMS, New York, New York and YEC, Valley Cottage, New York, for New York State Department of Environmental Conservation, Albany, New York. December.

ThermoRetec Consulting Corporation. 2001. Cap Demonstration Project – BP Soda Lake Site, Casper, Wyoming. Prepared for British Petroleum. Seattle, Washington.

United States Environmental Protection Agency (USEPA). 1973. Report of Mercury Source Investigation, Onondaga Lake, New York and Allied Chemical Corporation, Solvay, New York. Prepared by National Field Investigations Center Cincinnati and USEPA Region II, New York. USEPA Office of Enforcement and General Counsel. April.

USEPA. 1985. Policy on Floodplains and Wetlands Assessments for CERCLA Actions.

USEPA. 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA. Interim Final. October.

USEPA. 1989. Risk Assessment Guidance for Superfund (RAGS): Human Health Evaluation Manual, Part A. US Environmental Protection Agency, Office of Solid Waste and Emergency Response. EPA/540/1-89/002. OSWER Directive 9285.701A.

USEPA. 1991a. Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals). Interim Report. US Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, DC.

USEPA. 1991b. Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual Supplemental Guidance. Standard Default Exposure Factors. Interim Final. OSWER Directive 9285.6-03. US Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, DC.

USEPA, 1991c. A Guide to Principal Threat and Low Level Threat Wastes, US Environmental Protection Agency, Office of Solid Waste and Emergency Response, 9380.3-06FS. November.

USEPA. 1992. Community Relations in Superfund: A Handbook. EPA 540-R-92-009. January.

USEPA. 1997. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments. EPA 540-R-97-0C5. US Environmental Protection Agency, Solid Waste and Emergency Response, Washington, DC.

USEPA. 1998a. Guidelines for Ecological Risk Assessment. Risk Assessment Forum, US Environmental Protection Agency, Washington, DC. EPA/630/R-95/002F. April.

USEPA. 1998b. Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual (Part D, Standardized Planning, Reporting, and Review of Superfund Risk Assessments). Interim Report. EPA 540-R-97-033. US Environmental Protection Agency, Office of Emergency Response and Remedial Response, Washington, DC.

USEPA. 1999. Issuance of Final Guidance: Ecological Risk Assessment and Risk Management Principles for Superfund Sites. OSWER Directive 9285.28P. US Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, DC.

Wetzel, R.G. 1983. Limnology. Second Edition. Saunders College Publishing, Philadelphia, PA.

APPENDIX I

FIGURES

APPENDIX II

TABLES

APPENDIX III

ADMINISTRATIVE RECORD INDEX

APPENDIX IV

NYSDOH LETTER OF CONCURRENCE

APPENDIX V

STATEMENT OF FINDINGS: FLOODPLAINS AND WETLANDS

APPENDIX VI

RESPONSIVENESS SUMMARY

(under separate cover)

APPENDIX VII

TRANSCRIPTS FOR
JANUARY 12, 2005 AND FEBRUARY 16, 2005
PUBLIC MEETINGS